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INDEX COVERAGE

Volume:7 Issue:4 July 2024

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CONTENTS
Volume 7 – Issue 4
ARTICLES

ORIGINAL ARTICLE

Akshaya JOSHİ[1], Sandeep SHİNDE[*2] and Pooja JAİN[2]
Estimation of Patellofemoral Joint Dysfunction in Obese Post menopausal Women.....712-720

Dindin ABIDIN[*1], Arisman ARISMAN[2] and Aan WASAN[3]
The Influence of Social Media on Millennial Generation Community Participation in Sports Activities…….721-729

Norma ANGGARA[1], Endang PRATIWI[*2], Mastri JUNIARTO[3], Y. Tauvan Juni SAMODRA[4], Sunarno BASUKI[1], Eka Purnama INDAH[1], Maria Herlinda Dos SANTOS[5], DEFLIYANTO[6], Eka Fitri Novita SARI[3] and Muhammad ASPAR[7]
Implementation of Manipulative Basic Movement Learning Model Development for Students aged 5-6 years…….730-740

Kadir YILDIZ[*1], Hakan GÜLER[1], Şahan BALABAN[2], Nkatha MUTHOMI[3], Daniel NJENGA[3], Florence GITAU[3], Caroline Achieng AJOWI[3] and Jonathan ROTICH[3]
A Comparative Study on Participation Motives and Psychological Well-being of Female University Student-Athletes in Kenya and Türkiye……...741-752

Karlina DWIJAYANTI[*1], Arif Rohman HAKIM[1], Untung NUGROHO[1] Agustanico Dwi MURYADI[1], Mokhammad FIRDAUS[2] and Hilmy ALIRIAD[3]
Effects of Aerobic Exercise and Yoga on Blood Pressure in Women Between the Ages of 30 and 40 Years……..753-764

Teejay D. PANGANİBAN[*1]
SPIKES: Skills and Performance Inventory as Kinesiological Assessment for Empowerment of Sepaktakraw Athletes…….765-774

Krit SRIRUNGRANGCHAI[*1], Natthawee SRIKET[1] and Mantira PHONGAMPAI[1]
The Effect of Velocity-Based Contraction Strength Training on Performance in Female 400m Athletes…….775-781

M. Haris SATRIA[*1], Juhanis JUHANIS[2], Mohamad DA'I[3], Lalu Moh Yudha ISNAINI[4], Khaerul ANAM[5] and Karlina DWIJAYANTI[6]
Effectiveness of Circuit and Fartlek Exercises to Increase Aerobic Endurance in Adolescent Futsal Players…….782-795

Abdullah MERT[*1]
Effect of Self-Differentiation on Trait Anxiety and Authenticity of University Students……..796-803

Remzi GÜLEÇ[*1] and Erol YILDIRIM[2]
Effects of Sensory-Motor Perception and Movement Trainings in 2-6 Years Old Children Having Developmental Problems on Development Area and Emotional and Behavioral Problems……....……804-815

H. Bayram TEMUR [*1], Hüseyin ESEN[2], O. Bilge İNCİ[3] and Hüseyin KARADAĞ[4]
Examining the Relationship between Foot Medial Arch Height and Short and Medium Distance Running Performances and Some Variables in Athletes……...816-824

Zila Özlem KIRBAŞ[1*] and Elif Odabaşı AKTAŞ [2]
Sexual Developmental Characteristics of Intellectually Disabled Adolescents in Türkiye: A Cross-Sectional Analysis……...825-833

Joana Marie Carina M. GABUNILAS[*1], Jayson F. CRUZ[2] and Salve A. FAVILA[3]
Intents and Actualities of Health Optimizing Physical Education (HOPE) Curriculum Implementation: A Sequential Exploratory……834-841

Sinan SEYHAN[*1]
The Effect of Biomechanical and Viscoelastic Properties of Gastrocnemius (Lateral-Medial) Muscle and Achilles Tendon on Jumping Performance in Professional Soccer Players…….842-847

M. Abdulbaki KARACA[*1]
Investigation of Burnout Levels of Special Education Teacher Candidates…….....848-858

Andun SUDIJANDOKO[*1] and Roy Januardi IRAWAN[1]
The Preventive Efficacy of Selenium Supplements on Muscle Soreness Post Heavy Eccentric Exercise……..859-866

Atakan GÜRGAN[1] and Ömer ŞEVGİN [*2]
Effect of Ergonomic Training and Exercise in Esports Players: A Randomized Controlled Trial…….867-876

Mohammed Yakdhan SALEH[*1], Ayad Mohammed ABDULLAH[1] and Ahmed Abdulgani TAHA[1]
Effects of Tapering of Three Different Percentages on Physiological Variables Among Futsal Players…….877-885

Khaled QADOUME[1*], Hamed SALAMEH[1], Ali QADOUME[1], Motasem ABUALIA[1], Loai HANON[2] and Riadh KHALIFA[3]
The Relationship Between Some Anthropometric Measurements and Pulmonary Volumes to the Numerical Achievement of 800-Meter Event Runners in Palestine……..886-895

Ilham Sanusi DAI[1], Anggi Setia LENGKAN[*1], Dinar DINANGSIT[1] and Razali RAZALI[2]
Athletes' Sleep Quality: Performance Study in Football Clubs Aged 13-15 Years……...896-904

Martinus MARTINUS[*1], Jujur Gunawan MANULLANG[2], Hilmy ALIRIAD[3], I Bagus ENDRAW[1], Karlina DWIJAYANTI[5], Naimatul JAMALIAH[6] and M. Fransazeli MAKOROHI[1]
Approach to the Game Take the Ball to Practice Swimming Skills for Beginners in Physical Education…….905-913

REVİEW

Muhammad Nur ALIF[1], Komarudin KOMARUDIN[*2], Tatang MUHTAR[2] and Mulyana MULYANA[3]
Positive Youth Development (PYD) in Martial Arts Activities: Literature Review…….....914-922

Muhammad Alkauthar HARUN[1,2], Saiful Adlı BUKRY[*2], Mohd Iqbal MOHD NOOR[3], Norazmir MD NOR[2] Ummi Mohlisi MOHD ASMAWI[4] and Haidzir MANAF[2]
Low Back Pain Risk Among Athlete: A Scientometric Study……...923-936

Ali IKEN[*1], Samia KARKOURI[2], Ismail ZEROUAL[1] and Houda EL MOUDANE[1]
Effect of Duration of Pain Neuroscience Education on Pain Catastrophizing and Kinesiophobia in Patients with Chronic Low Back Pain: A Systematic Review of the Literature……....937-954

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RESEARCH ARTICLE

Estimation of Patellofemoral Joint Dysfunction in Obese Post menopausal Women

Akshaya JOSHİ[1], Sandeep SHİNDE[*2] and Pooja JAİN[2]

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Abstract

Purpose: The purpose of this research was to estimate Patellofemoral Joint Dysfunction in obese postmenopausal women. Methods: Depending on selection criteria, 100 obese postmenopausal women were selected by simple random sampling method. Written consent was taken and a detailed outcome assessment was done by using a Numerical Pain Rating Scale for pain assessment, Range of motion of hip, knee, ankle joint, Waldron Test, Eccentric Step-down Test, and Quadriceps angle. Statistical analysis was done and results were obtained. Findings: Among the 100 participants, 63% of women experienced pain during their daily activities. The mean pain intensity at rest was 2.25 ± 1.91, and during activity, it increased to 3.28 ± 2.606 (p value < 0.0001). The range of motion in the hip, knee, and ankle joints was reduced compared to that of individuals in the same age group without pain. Specifically, Hip extension-adduction, knee extension, and ankle plantarflexion-inversion-eversion had a p value of <0.0001. For hip flexion-abduction-medial and lateral rotation, knee flexion, and ankle dorsiflexion, the p values were 0.0003, 0.1952, 0.0001, 0.003, 0.0392, and 0.0333. Additionally, 35% of women had quadriceps angles greater than 18 degrees, while the remaining 65% had angles less than 18 degrees. 63% of women exhibited crepitus during activities like stair climbing and walking. 52% of women tested positive on the Waldron Test. 60% of women showed positive findings on the Eccentric Step-down Test. Conclusion: It concluded that there is significant Patellofemoral Joint Dysfunction in obese postmenopausal women.

Keywords
Menopause, Obesity, Patello-Femoral Pain, Patello-Femoral Dysfunction, Osteoarthritis

INTRODUCTION

One of the most incongruent joints is the patellofemoral joint. The distal femur and the posterior patella articulate at the patellofemoral joint. The patellofemoral joint, which can be subjected to forces up to two to three times the body weight during daily activities, plays a crucial role in the function of the knee by increasing the extensor torque by 30%at the end of the range of motion (Arrebola et al., 2020). It was observed that the patellofemoral joint is at the highest risk of dysfunction due to abnormal joint pathomechanics of muscle weakness or pull from vastus lateralis muscle, such as increased pressure on the lateral facets of the patella, lateral subluxation and lateral dislocation (Powers, 2003). Research indicates that females with narrower femoral notch, higher body mass, more laxity, and increased Q-angle have higher lateral force on the patella, causing pain and discomfort on the lateral side of the knee and progressive deterioration of joint cartilage (Kadav et al., 2023). Dysfunction is caused by a variety of reasons such as obesity, menopause, and hormonal

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imbalance, the presence of comorbidities, unhealthy lifestyle, and irregular diet. The dysfunction of the patellofemoral joint has been associated witha variety ofphysiological, psychological and physical variables. In particular, muscle strength and range of motion compromise in Patellofemoral Joint Dysfunction. Additionally, a higher BMI has been determined as a clinical indicator of Patellofemoral Joint Dysfunction (Arrebola et al., 2020; Powers, 2003; Ferreira et al., 2020)

A condition known as obesity is distinguished by an excessive quantity of body fat (Rajan P, 2011). Recently, there has been an increase in the percentage of obese women, particularly in developing nations, making this group more susceptible to Patellofemoral Joint Dysfunction. This is due to an increase in body mass and related metabolic factors. It may increase the mechanical demand and generate excessive stress on the knee's articular cartilage causing degenerative changes and further dysfunction (Arrebola et al.,2020; Ferreira AS et al.,2020). Following menopause, hormonal changes lead to the body fat being redistributed, increaseshealth risks and also decreased physical activity. Obesity is the second biggest cause of degenerative joint disease, osteoarthritis, disability and dysfunction (Arrebola et al., 2020; Ferreira et al.,2020; Foss et al.,2012).

Permanent cessation of menstruation is termed as menopause. Menopause is a physiological and normal life event. Menopause often starts between the ages of 48 and 52 years, with 49 being the average age (Karmakar et al., 2017). At menopause, the production of estrogen is reduced by 66%.The connective tissue and skeleton of the female body depends on estrogen.During the menopausal period's the lack of estrogen has a detrimental effect on the health of bone, muscle, ligament, tendon, cartilage and synovial membrane; these changes are closely related to ageing. There is increase risk of Patellofemoral Joint Dysfunction if there is early menopause. The degradation of the cartilage in the knee joint is linked to menopause over time (Karmakar et al., 2017; Khadilkar, 2019; Cunha-Henriques et al., 2011; Lou et al., 2016).

The musculoskeletal health of women is becoming more and more ofathreat to their health at the midline and beyond. It was observed that a reduction in bone mineral density, due to a decrease in bone mass, is termed as osteoporosis which is highly prevalent in postmenopausal women. Another condition such as sarcopenia is the agerelated loss of muscle mass and function. Sarcopenia is prevalent in women at the age of 50 years. Osteoarthritis is a joint inflammation that develops slowly and can be brought on by cartilage deterioration. It is now known that cartilage degeneration can result from a decrease in estrogen during menopause. Degeneration of the cartilage, synovial inflammation and thickening of the capsule resulting in joint deformity and stiffness (Cunha-Henriques et al., 2011; Lou et al.,2016).

Pain is an unpleasant feeling. Pain serves a crucial physiological function by either stimulating or interfering with the motor system while simultaneously shielding tissue from an actual or perceived threat of harm (Bhore & Shinde et al., 2023). In Patellofemoral Joint Dysfunction, anterior knee pain is most commonly seen. Pain is usually non- traumatic. There is diffused knee pain which is experienced during activities that cause the loading of joints in activities such as running, jumping, squatting, and stair climbing etc (Smith et al., 2018). The Patellofemoral joint dysfunction, which is common in women, results in anterior knee pain with obvious anatomical abnormalities, such as an elevated Q angle or notable articular cartilage pathologies. Other related symptoms include a functional impairment and crepitus. Some authors claim that the patellofemoral joint dysfunction will ultimately result in osteoarthritis (Petersen et al., 2014).

It was observed that ascending and descending stairs can induce or worsen pain in more severe conditions. Climbing stairs necessitates a concentric contraction of the quadriceps, which may not cause discomfort in less severe cases. However, because descending stairs places more compressive pressure on the articular cartilage, it necessitates an eccentric contraction that may cause pain. On the other hand, reports of pain are typically multi-factorial; a larger lateral valgus vector in women may contribute to the increased occurrence of patellofemoral pain in women when compared to men (Manske & Davies, 2016).

Menopause and obesity together have negative consequences on joint health. There is a need for research because patellofemoral joint dysfunction is a common musculoskeletal condition that can significantly impact the quality of life in individuals, particularly obese postmenopausal women. Due to multiple causes of Patellofemoral Joint Dysfunction diagnosis, inspection and

treatment are challenging. In this research, we are going to assess the Patellofemoral Joint with the help of six outcome measures. However, there is limited research available on the estimation and risk factors of this condition in this specific population group. This study aims to fill this research gap by estimating Patellofemoral Joint Dysfunction. In order to develop target-specific management following individual demands, it is crucial to estimate the Patellofemoral Joint.The purpose of this research is to estimate Patellofemoral Joint Dysfunction in obese postmenopausal women.

MATERIALS AND METHODS

Hundred women participants were randomly selected for this cross-sectional study, which wascarried out using the computerized SPSS software. The study included obese women with having body mass index of 30 to 40 and postmenopausal women, with age criteria between 45 to 55 years. This study excluded participants possessing a lower body mass index than30, and participants having recent fractures and lower limb surgery. This research followed ethical standards and received approval from the Institutional Ethical Committee of Krishna Vishwa Vidyapeeth, KIMSDU dated 19/05/2023 and numbered 616/2022-2023. Participant provided informed consent, with the volunteer form covering research details, risks, benefits, confidentiality, and participant rights. The research strictly adhered to the ethical principles of the Declaration of Helsinki, prioritizing participant's rights and well-being in design, procedures, and confidentiality measures. The goal of the study was explained to the participants,and they were informed about the procedure. Each participant was evaluated for pain using the Numerical Pain Rating Scale (NPRS), Crepitus, Range of motion of hip, knee, ankle joint, Waldron Test, Eccentric Step-down Test ,and quadriceps angle.

Data Collection Tools

Numerical Pain Rating Scale (NPRS)–

The Numerical Pain Rating Scale (NPRS) is frequently employed to measure pain intensity, in which patients are asked to select a number (from 0 to 10) to represent their pain severity. Test-retest reliability was ICC=0.991(Alghadir et al., 2018).

Range of Motion

Range of motion of hip, knee, and ankle joints was taken using a universal goniometer. The starting position of the women was relaxed supine lying on the plinth. Hip movements including flexion, extension, abduction, adduction, medial and lateral rotation and knee movements including flexion, extensionand ankle movements including dorsiflexion, plantarflexion, inversion and eversion were assessed.

Quadricep Angle (Q angle)

The Q angle is the angle between a line connecting the anterior superior iliac spine to the midpoint of the patella and a line connecting the tibial tuberosity and the midpoint of the patella.The participants were lying in a supine position with their hips and knees in a neutral position and extended, their feet in a neutral position, and their quadriceps femoris muscles contracted isometrically. A manual goniometer was used. Its axis was positioned over the center of the right patella, with the distal arm over the center of the tibial tuberosity and the proximal arm over the anterior-superior iliac spine.The reliability of goniometry-based Q angle is ICC= 0.88 (Weiss et al., 2013).

Waldron Test

During the Waldron test, the examiner evaluates the patellofemoral joint by palpating the patella while the patient undergoes slow, deep knee bends. Throughout this range of motion (ROM), the examiner focuses on various aspects. The examiner checks for the presence of crepitus, which refers to a crackling or grating sensation felt or heard during movement. Crepitus is deemed significant only if it accompanies pain. I f crepitus is detected, the examiner determines where it occurs within the ROM, whether it's at the beginning, middle, or end of the movement.The examiner assesses the patient's pain level during the movement. Pain may arise in conjunction with crepitus or independently. The examiner looks for any catching sensation or poor tracking of the patella as the knee moves through the ROM. This may indicate issues with patellar alignment or instability. If pain and crepitus coincide during the movement, the test is considered positive, suggesting potential pathology or dysfunction within the patellofemoral joint.Reliability is ICC =0.81 (Ferrari et al.,2014).

Eccentric Step-down Test

The test aims to assess the presence of pain or dysfunction during a controlled eccentric (lengthening) contraction of the lower limb muscles, particularly the quadriceps, hamstrings, and gluteal muscles, while stepping down from a

raised surface.The participant stands on the 15 cm high stool or step platform.The participant places her hands on her hips for stability.The participant is instructed to slowly and steadily lower one foot down from the stool to the ground, controlling the movement with the muscles of the lower limb.The therapist closely observes the participant's movement quality, particularly focusing on the knee joint for any signs of instability, excessive movement, or pain.The test is considered positive if the participant experiences pain during the test, indicating potential dysfunction or pathology in the lower extremity musculature or joint structures.The test should be performed under the supervision of a qualified healthcare professional.Participants with known lower extremity injuries or conditions should be carefully evaluated before performing the test to ensure safety and appropriate modifications as needed.Test-retest reliability was ICC = 0.94 (Loudon et al., 2002).

Statistical Analysis

Data collected was registered in an excel sheet and the statistical analysis was conducted using SPSS 26.0 for Windows (SPSS Inc., Chicago, IL, USA). For the purpose of describing the characteristics of the research sample, descriptive statistics were used. Participants descriptive data are presented as mean, percentage, standard deviation, p value calculation of pain assessment and range of motion. Also, the descriptive statistics was used as bar diagrams, tables and percentages. The threshold for statistical significance was established at $p < 0.05$.

RESULTS

This cross-sectional study was carried out among 100 participants.

Table1. Demographic variables

Variables	No. of individuals (%)
Age (Years)	
45-50	35 (35%)
51-55	65 (65%)
Body mass index (BMI)	
Obesity Grade 1	70 (70%)
Obesity Grade 2	20 (20%)
Obesity Grade 3	10(10%)
Comorbid conditions	
Hypertension	32 (32%)
Diabetes	43 (43%)
No any comorbidities	25 (25%)
Completed months of menopause	
Less than 6 months	30 (30%)
More than 6 months	70 (70%)

Interpretation

Table1 interprets that among the 100 participants, 35 % of women aged between 45-50 years, and 65% of womenaged between 51-55 years. Participants were categorized according to grades of obesity. 70 % of women had grade 1 obesity, 20 % of women had grade 2 obesity and 10 % of women had grade 3obesity. On the other hand, comorbidities were additionally taken into account. Among100 participants, 32% had hypertension, 43% women had diabetesand25 % women had noco-morbidities. 30 % of women had completed less than 6 months of menopause. 70% of women had completed their menopause for more than 6 months.

Pain assessment

Table 2. Pain according to numerical pain rating scale

	At rest	On activity
Mean	2.25	3.28
Standard deviation	1.914	2.606
P value	<0.0001	<0.0001

Interpretation

Hundredwomen were assessed, and 63% of women had pain. Among those 63% of women 49 % had pain in the retro patellar region and the remaining 14 % had anterior knee pain. The pain

assessment was carried out by usinga Numerical Pain Rating Scale at rest and during activity. The mean of pain at rest was 2.25±1.914 and during activity was 3.28±2.606 which shows a pvalue (<0.0001) on rest and during activity. These findings indicate significant mild intensity of pain at p<0.05 experienced by women. Participants reported pain during activities like climbing or descending stairs, stepping up and down, prolonged sitting, squattingand getting up from a chair.

Range of motion

Table 3. Range of Motion

	Mean	Standard Deviation	p value
Hip joint			
Flexion	116.18	10.780	0.000303
Extension	20.8	2.913	<0.0001
Abduction	41.54	5.327	0.195112
Adduction	20.35	3.849	<0.0001
Medial Rotation	31.97	2.204	0.00014
Lateral Rotation	32.71	2.564	0.003356
Knee joint			
Flexion	129.74	12.707	0.039237
Extension	8.32	3.133	<0.0001
Ankle joint			
Dorsiflexion	11.875	1.893	0.0033
Plantarflexion	42.26	4.019	<0.0001
Inversion	25.62	3.601	<0.0001
Eversion	12.42	1.793	<0.0001

Interpretation

The average values for the hip, knee and ankle range of motion are shown in the Table No. 3. A goniometer was used to assess the range of motion of the hip, knee and ankle joint. According to this study, Range of motion of the hip, knee and ankle joint were somewhat reduced when compared with the range of motion of joints of the normal individuals of thesame age group. It was observed that, obesityand the presence of pain significantly reduced the range of motion of joints.

Quadricep angle

Table 4. Quadricep angle

	No.of individuals (%)
Quadriceps angle $>18^0$	35 (35%)
Quadriceps angle $<18^0$	65 (65%)

Interpretation

According to research, it was observed that 35% of women have quadriceps angles of more than 18 degrees and the remaining 65% have quadriceps angles of less than 18 degrees. Q angle of more than 18 degrees is considered an indicator of Patellofemoral Joint Dysfunction.

Crepitus

Research revealed that 63% of women had shown positive findings for crepitus during activities like squatting, stair climbing and walking and 37% had shown negative findings for crepitus.

Waldron Test

After analyzing thedataitwas revealed that 52% ofwomentested were positive and 48% showed negative results (Figure 1).

Eccentric step-down Test

After analyzing the datait is revealed that 60% of women are showing positive findings and the remaining 40% showing negative findings (Figure).

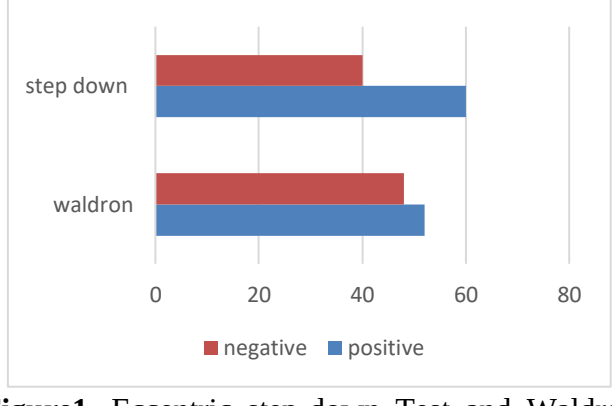

Figure1. Eccentric step-down Test and Waldron test

DISCUSSION

The purpose of this study is to estimate Patellofemoral Joint Dysfunction in obese postmenopausal women. In this study, 100 obese postmenopausal women were approached. After the selection of participants as per the criteria of the study, they were informed about thestudyand written consent was taken. Our investigations examined Patellofemoral Joint Dysfunction usingaNumericalPain Rating Scale for pain assessment, Range of motion of hip, knee, ankle joint, Quadriceps angle assessment, Waldron Test, and Eccentric Step-down Test. The tests have proven reliability and validity.

According toGao et al., 2013, 743 women between the ages of 35 and 64 were involved in this study, and 31.0% reported having knee discomfort regularly. In comparison to premenopausal women, postmenopausal women had a noticeably greater prevalence of musculoskeletal symptoms as per this study. Early menopause was the time when the prevalence of musculoskeletal problems peaked. Due to postmenopausal changes, body fat mass (kg) increases in women by 0.4 kg/year until the age of 50, at which point it increases more quickly until the age of 59, and then it slightly decreases after that. (Sahasrabuddhe et al., 2021) Along with increasing age the prevalence of joint stiffness and knee discomfort dramatically increased. Higher body mass index were linked to higher rates of joint stiffness and knee discomfort. The conclusion was that while musculoskeletal problems are known to rise with menopause, age and body mass index should also be taken into account.

Patellofemoral Joint Dysfunction suggests that the joint is afflicted by some sort of pathology. This illness could be caused by biomechanical reasons or physiological ones, including obesity or menopause related estrogen hormone insufficiency. Increased Patellofemoral Joint stress and subsequent articular cartilage wear and tear are linked with obesity and menopause, according to a widely accepted theory, that the etiology of Patellofemoral Joint Dysfunction results in Patellofemoral Joint pain. Commonly, people with Patellofemoral Joint problems experience pain during activities of daily living.

Several other studies have shown that Patellofemoral Joint Dysfunction is associated with pain in the retropatellar region. It is commonly observed that individuals with patellofemoral problems experience pain when climbing or descending stairs, when stepping up and down and with prolonged sitting when squatting and when getting up from a chair. According to Smith Be et. al., (2018), Patellofemoral pain (PFP) is one of the most common types of knee pain , with a prevalence reported to range from 15% to 45% . Knee pain is the second most common condition. It is characterized as non-traumatic and manifests as a diffused anterior knee discomfort during joint-loading movements including running, crouching and climbing and descending stairs. Crossley et al., (2004), mentioned that Numerical Pain Rating Scale assessment is reliable and valid and responsive in the assessment of Patellofemoral Joint Dysfunction.

In this study, we asked participants aboutpain, the location of pain, and activities that aggravate the pain. In this study it was observed that 63% of women had pain. Among those 49 % had pain in the retro patellar region and the remaining 14 % had anterior knee pain. Participants reported pain during activities like climbing or descending stairs, stepping up and down, prolonged sitting, squattingand getting up from a chair. Ersoz & Ergun (2003), concluded that hip range of motion is observed to be reduced by an increase in body mass index. It was found that hip rotation was higher in females than in males. It was found that,33 out of 40 knees evaluated (82.5%) in a sample of individuals with primary knee OA aged 44 to 76 reported extension limits ranging from 1 degree to 14 degrees. The results showed that, in contrast to the findings, the passive knee flexion range of motion was smaller in female subjects than in male subjects of the same age. On average, women's knee flexion was only 2 degrees less than men's.The women's lower knee flexion may have resulted from their higher BMI than the men's. According to Lichtenstein et al., (2000), among 647 community participants, it was discovered that those with higher BMIs had less range of motion in their knees than those with lower BMIs. Compared to their non-obese counterparts, subjects who were severely obese had an average loss of 13 degrees of knee flexion range of motion. The researchers found that for every unit increase in BMI, there was a loss of knee range of motion of at least 1 degree.

Nunes et al., (2013) reported that the patellar tilt and squatting test showed evidence of supporting a diagnosis of Patellofemoral Joint Dysfunction. Nunes et al., (2013) concluded that

clinical tests have more diagnostic accuracy in evaluating Patello femoral Joint Dysfunction. In this study we assessed individuals for special tests, Our findings showed 52% positive results for the Waldron Test and 60 % positive results for the Eccentric Step-down Test.

Dysfunction of the arch can cause the gait deformity, postural imbalance and other muscular imbalance (Sawant & Shinde, 2021). Ekim et al., (2017), concluded that a high Q angle was related with cartilage thickness which may further causePatellofemoral Joint Dysfunction. He used ultrasonography to measure Q angle. It was observed that high Q angle is a predictor for patellofemoral problems. The innate propensity of the patella to track laterally during dynamic motions is known as the law of valgus. The quadricep muscle linked to the femur is the cause of this valgus angulation. When compared to a smaller Q angle, a greater Q angle may result in a larger lateral vector and possibly a stronger inclination to lateral tracking. In our study, it was observed that 35 % of individuals had a Q angle of more than 18degree showing significant Patellofemoral Joint Dysfunction. 65% of individuals have a Q angle of less than 18degree. Grelsamer et al., (2005), concluded that a Q angle greater than 18 degrees is considered as Patellofemoral Joint Dysfunction.

Based on the findings, we can say that there is significant Patellofemoral Joint Dysfunction in obese postmenopausal women. We recommend that Patellofemoral Joint Dysfunction should be taken into account when treating knee joint related problems and an appropriate treatment program should be planned. The presence of pain and crepitus causes activity limitations which results in a decreased range of motion. An increase in Q angle may also cause significant impairments. All of these factors may affect the quality of life.

Activities of daily living may become painful. Sitting cross-leg, climbing ascending and descending stairs, squatting causes severe pain. With the help of assessment, range of motion assessment we can plan treatment. We can improve the quality of life of women so that they can perform their daily activities with more ease.

Limitations of this study were a smaller sample size and a smaller geographical area. In this study postmenopausal women were selected, so further attempts can select premenopausal women and future research should use larger samples to be better generalizability.

Clinical Implications

It provides an organised approach for medical professionals to identify and treat knee-related problems in this population, enhancing patient outcomes. The results may help prevent the advancement of joint dysfunction by providing targeted rehabilitation programmes to address the biomechanical issues faced by obese postmenopausal women. Through better care delivery and a contribution to the field of musculoskeletal health research, the study promotes functional independence and an enhanced quality of life.

Suggestions

Further studies can be conducted to determine patellofemoral dysfunction in postmenopausal women from other regions. Additional investigations could use more profound outcomes, such as X-rays (Knee Skyline Laurin View), to rule out patellar position for more accurate results.

Conclusion

According to the findings of this study, there was a significant Patellofemoral Joint Dysfunction in obese postmenopausal women. Along with retropatellar pain and crepitus, some participants reported anterior side of the knee pain. Significantly less lower limb range of motion was observed. Pain and high body mass index have been shown to limit the joint range of motionand an increased quadriceps angleindicate Patellofemoral Joint Dysfunction.The Eccentric Step-down Test and the Waldron Test both yielded positive results. The therapist must incorporate the research findings into the treatment plan to improve the patient's quality of life.

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Conflict of İnterest

Authors declare no conflict of interest.

Ethics Statement

This research followed ethical standards and received approval from the Institutional Ethical Committee of Krishna Vishwa Vidyapeeth, KIMSDU dated 19/05/2023 and numbered 616/2022-2023.

Author Contributions

Study Design, PJ and SD; Data Collection, AJ; Statistical Analysis, SD; Data Interpretation, AJ and SD; Manuscript Preparation, PJ and SD; Literature Search, PJ, and AJ. All authors have read and agreed to the published version of the manuscript.

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RESEARCH ARTICLE

The Influence of Social Media on Millennial Generation Community Participation in Sports Activities

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Abstract

Purpose: The purpose of this research was to estimate Patellofemoral Joint Dysfunction in obese postmenopausal women. Methods: Depending on selection criteria, 100 obese postmenopausal women were selected by simple random sampling method. Written consent was taken and a detailed outcome assessment was done by using a Numerical Pain Rating Scale for pain assessment, Range of motion of hip, knee, ankle joint, Waldron Test, Eccentric Step-down Test, and Quadriceps angle. Statistical analysis was done and results were obtained. Findings: Among the 100 participants, 63% of women experienced pain during their daily activities. The mean pain intensity at rest was 2.25 ± 1.91, and during activity, it increased to 3.28 ± 6.60 (p value < 0.0001). The range of motion in the hip, knee, and ankle joints was reduced compared to that of individuals in the same age group without pain. Specifically, Hip extension-adduction, knee extension, and ankle plantarflexion-inversion-eversion had a p value of <0.0001. For hip flexion-abduction-medial and lateral rotation, knee flexion, and ankle dorsiflexion, the p values were 0.0003, 0.1952, 0.0001, 0.003, 0.0392, and 0.0333. Additionally, 35% of women had quadriceps angles greater than 180 degrees, while the remaining 65% had angles less than 180 degrees. 63% of women exhibited crepitus during activities like stair climbing and walking. 52% of women tested positive on the Waldron Test. 60% of women showed positive findings on the Eccentric Step-down Test. Conclusion: It concluded that there is significant Patellofemoral Joint Dysfunction in obese postmenopausal women.

Keywords
Learning Models, Basic Manipulative Movements, Early Childhood

INTRODUCTION

One of the most incongruent joints is the patellofemoral joint. The distal femur and the posterior patella articulate at the patellofemoral joint. The patellofemoral joint, which can be subjected to forces up to two to three times the body weight during daily activities, plays a crucial role in the function of the knee by increasing the extensor torque by 30%at the end of the range of motion (Arrebola et al., 2020). It was observed that the patellofemoral joint is at the highest risk of dysfunction due to abnormal joint pathomechanics of muscle weakness or pull from vastus lateralis muscle, such as increased pressure on the lateral facets of the patella, lateral subluxation and lateral dislocation (Powers, 2003). Research indicates that females with narrower femoral notch, higher body mass, more laxity, and increased Q-angle have higher lateral force on the patella, causing pain and discomfort on the lateral side of the knee and progressive deterioration of joint cartilage (Kadav et al., 2023). Dysfunction is caused by a variety of reasons such as obesity, menopause, and hormonal imbalance, the presence of comorbidities, unhealthy lifestyle, and irregular diet. The dysfunction of the patellofemoral joint has been associated witha variety ofphysiological,

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psychological and physical variables. In particular, muscle strength and range of motion compromise in Patellofemoral Joint Dysfunction. Additionally, a higher BMI has been determined as a clinical indicator of Patellofemoral Joint Dysfunction (Arrebola et al., 2020; Powers, 2003; Ferreira et al., 2020)

A condition known as obesity is distinguished by an excessive quantity of body fat (Rajan P, 2011). Recently, there has been an increase in the percentage of obese women, particularly in developing nations, making this group more susceptible to Patellofemoral Joint Dysfunction. This is due to an increase in body mass and related metabolic factors. It may increase the mechanical demand and generate excessive stress on the knee's articular cartilage causing degenerative changes and further dysfunction (Arrebola et al.,2020; Ferreira AS et al.,2020). Following menopause, hormonal changes lead to the body fat being redistributed, increaseshealth risks and also decreased physical activity. Obesity is the second biggest cause of degenerative joint disease, osteoarthritis, disability and dysfunction (Arrebola et al., 2020; Ferreira et al.,2020; Foss et al.,2012).

Permanent cessation of menstruation is termed as menopause. Menopause is a physiological and normal life event. Menopause often starts between the ages of 48 and 52 years, with 49 being the average age (Karmakar et al., 2017). At menopause, the production of estrogen is reduced by 66%.The connective tissue and skeleton of the female body depends on estrogen.During the menopausal period's the lack of estrogen has a detrimental effect on the health of bone, muscle, ligament, tendon, cartilage and synovial membrane; these changes are closely related to ageing. There is increase risk of Patellofemoral Joint Dysfunction if there is early menopause. The degradation of the cartilage in the knee joint is linked to menopause over time (Karmakar et al., 2017; Khadilkar, 2019; Cunha-Henriques et al., 2011; Lou et al., 2016).

The musculoskeletal health of women is becoming more and more ofathreat to their health at the midline and beyond. It was observed that a reduction in bone mineral density, due to a decrease in bone mass, is termed as osteoporosis which is highly prevalent in postmenopausal women. Another condition such as sarcopenia is the agerelated loss of muscle mass and function. Sarcopenia is prevalent in women at the age of 50 years. Osteoarthritis is a joint inflammation that develops slowly and can be brought on by cartilage deterioration. It is now known that cartilage degeneration can result from a decrease in estrogen during menopause. Degeneration of the cartilage, synovial inflammation and thickening of the capsule resulting in joint deformity and stiffness (Cunha-Henriques et al., 2011; Lou et al.,2016).

Pain is an unpleasant feeling. Pain serves a crucial physiological function by either stimulating or interfering with the motor system while simultaneously shielding tissue from an actual or perceived threat of harm (Bhore & Shinde et al., 2023). In Patellofemoral Joint Dysfunction, anterior knee pain is most commonly seen. Pain is usually non- traumatic. There is diffused knee pain which is experienced during activities that cause the loading of joints in activities such as running, jumping, squatting, and stair climbing etc (Smith et al., 2018). The Patellofemoral joint dysfunction, which is common in women, results in anterior knee pain with obvious anatomical abnormalities, such as an elevated Q angle or notable articular cartilage pathologies. Other related symptoms include a functional impairment and crepitus. Some authors claim that the patellofemoral joint dysfunction will ultimately result in osteoarthritis (Petersen et al., 2014).

It was observed that ascending and descending stairs can induce or worsen pain in more severe conditions. Climbing stairs necessitates a concentric contraction of the quadriceps, which may not cause discomfort in less severe cases. However, because descending stairs places more compressive pressure on the articular cartilage, it necessitates an eccentric contraction that may cause pain. On the other hand, reports of pain are typically multi-factorial; a larger lateral valgus vector in women may contribute to the increased occurrence of patellofemoral pain in women when compared to men (Manske & Davies, 2016).

Menopause and obesity together have negative consequences on joint health. There is a need for research because patellofemoral joint dysfunction is a common musculoskeletal condition that can significantly impact the quality of life in individuals, particularly obese postmenopausal women. Due to multiple causes of Patellofemoral Joint Dysfunction diagnosis, inspection and treatment are challenging. In this research, we are going to assess the Patellofemoral Joint with the help of six outcome measures. However, there is limited research available on the estimation and risk

factors of this condition in this specific population group. This study aims to fill this research gap by estimating Patellofemoral Joint Dysfunction. In order to develop target-specific management following individual demands, it is crucial to estimate the Patellofemoral Joint.The purpose of this research is to estimate Patellofemoral Joint Dysfunction in obese postmenopausal women.

MATERIALS AND METHODS

Hundred women participants were randomly selected for this cross-sectional study, which wascarried out using the computerized SPSS software. The study included obese women with having body mass index of 30 to 40 and postmenopausal women, with age criteria between 45 to 55 years. This study excluded participants possessing a lower body mass index than30, and participants having recent fractures and lower limb surgery. This research followed ethical standards and received approval from the Institutional Ethical Committee of Krishna Vishwa Vidyapeeth, KIMSDU dated 19/05/2023 and numbered 616/2022-2023. Participant provided informed consent, with the volunteer form covering research details, risks, benefits, confidentiality, and participant rights. The research strictly adhered to the ethical principles of the Declaration of Helsinki, prioritizing participant's rights and well-being in design, procedures, and confidentiality measures. The goal of the study was explained to the participants,and they were informed about the procedure. Each participant was evaluated for pain using the Numerical Pain Rating Scale (NPRS), Crepitus, Range of motion of hip, knee, ankle joint, Waldron Test, Eccentric Step-down Test ,and quadriceps angle.

Data Collection Tools

***Numerical Pain Rating Scale* (*NPRS*)–**

The Numerical Pain Rating Scale (NPRS) is frequently employed to measure pain intensity, in which patients are asked to select a number (from 0 to 10) to represent their pain severity. Test-retest reliability was ICC=0.991(Alghadir et al., 2018).

Range of Motion

Range of motion of hip, knee, and ankle joints was taken using a universal goniometer. The starting position of the women was relaxed supine lying on the plinth. Hip movements including raised surface.The participant stands on the 15 cm high stool or step platform.The participant places flexion, extension, abduction, adduction, medial and lateral rotation and knee movements including flexion, extensionand ankle movements including dorsiflexion, plantarflexion, inversion and eversion were assessed.

Quadricep Angle (Q angle)

The Q angle is the angle between a line connecting the anterior superior iliac spine to the midpoint of the patella and a line connecting the tibial tuberosity and the midpoint of the patella.The participants were lying in a supine position with their hips and knees in a neutral position and extended, their feet in a neutral position, and their quadriceps femoris muscles contracted isometrically. A manual goniometer was used. Its axis was positioned over the center of the right patella, with the distal arm over the center of the tibial tuberosity and the proximal arm over the anterior-superior iliac spine.The reliability of goniometry-based Q angle is ICC= 0.88 (Weiss et al., 2013).

Waldron Test

During the Waldron test, the examiner evaluates the patellofemoral joint by palpating the patella while the patient undergoes slow, deep knee bends. Throughout this range of motion (ROM), the examiner focuses on various aspects. The examiner checks for the presence of crepitus, which refers to a crackling or grating sensation felt or heard during movement. Crepitus is deemed significant only if it accompanies pain. I f crepitus is detected, the examiner determines where it occurs within the ROM, whether it's at the beginning, middle, or end of the movement.The examiner assesses the patient's pain level during the movement. Pain may arise in conjunction with crepitus or independently. The examiner looks for any catching sensation or poor tracking of the patella as the knee moves through the ROM. This may indicate issues with patellar alignment or instability. If pain and crepitus coincide during the movement, the test is considered positive, suggesting potential pathology or dysfunction within the patellofemoral joint.Reliability is ICC =0.81 (Ferrari et al.,2014).

Eccentric Step-down Test

The test aims to assess the presence of pain or dysfunction during a controlled eccentric (lengthening) contraction of the lower limb muscles, particularly the quadriceps, hamstrings, and gluteal muscles, while stepping down from a her hands on her hips for stability.The participant is instructed to slowly and steadily lower one foot

down from the stool to the ground, controlling the movement with the muscles of the lower limb.The therapist closely observes the participant's movement quality, particularly focusing on the knee joint for any signs of instability, excessive movement, or pain.The test is considered positive if the participant experiences pain during the test, indicating potential dysfunction or pathology in the lower extremity musculature or joint structures.The test should be performed under the supervision of a qualified healthcare professional.Participants with known lower extremity injuries or conditions should be carefully evaluated before performing the test to ensure safety and appropriate modifications as needed.Test-retest reliability was ICC = 0.94 (Loudon et al., 2002).

Statistical Analysis

Data collected was registered in an excel sheet and the statistical analysis was conducted using SPSS 26.0 for Windows (SPSS Inc., Chicago, IL, USA). For the purpose of describing the characteristics of the research sample, descriptive statistics were used. Participants descriptive data are presented as mean, percentage, standard deviation, p value calculation of pain assessment and range of motion. Also, the descriptive statistics was used as bar diagrams, tables and percentages. The threshold for statistical significance was established at $p < 0.05$.

RESULTS

This cross-sectional study was carried out among 100 participants.

Table1. Demographic variables

Variables	No. of individuals (%)
Age (Years)	
45-50	35 (35%)
51-55	65 (65%)
Body mass index (BMI)	
Obesity Grade 1	70 (70%)
Obesity Grade 2	20 (20%)
Obesity Grade 3	10(10%)
Comorbid conditions	
Hypertension	32 (32%)
Diabetes	43 (43%)
No any comorbidities	25 (25%)
Completed months of menopause	
Less than 6 months	30 (30%)
More than 6 months	70 (70%)

Interpretation

Table1 interprets that among the 100 participants, 35 % of women aged between 45-50 years, and 65% of womenaged between 51-55 years. Participants were categorized according to grades of obesity. 71 % of women had grade 1 obesity, 20 % of women had grade 2 obesity and 10 % of women had grade 3obesity. On the other hand, comorbidities were additionally taken into account. Among100 participants, 32% had hypertension, 43% women had diabetesand25 % women had noco-morbidities. 30 % of women had completed less than 6 months of menopause. 70% of women had completed their menopause for more than 6 months.

Pain assessment

Table 2. Pain according to numerical pain rating scale

	At rest	On activity
Mean	2.25	3.28
Standard deviation	1.914	2.606
P value	<0.0001	<0.0001

Interpretation

Hundredwomen were assessed, and 63% of women had pain. Among those 63% of women 49 % had pain in the retro patellar region and the remaining 14 % had anterior knee pain. The pain assessment was carried out by usinga Numerical Pain Rating Scale at rest and during activity. The mean of pain at rest was 2.25±1.914 and during activity was 3.28±2.606 which shows a pvalue (<0.0001) on rest and during activity. These findings indicate significant mild intensity of pain

at p<0.05 experienced by women. Participants reported pain during activities like climbing or descending stairs, stepping up and down, prolonged sitting, squattingand getting up from a chair.

Range of motion

Table 3. Range of Motion

	Mean	Standard Deviation	p value
Hip joint			
Flexion	116.18	10.780	0.000303
Extension	20.8	2.913	<0.0001
Abduction	41.54	5.327	0.195112
Adduction	20.35	3.849	<0.0001
Medial Rotation	31.97	2.204	0.00014
Lateral Rotation	32.71	2.564	0.003356
Knee joint			
Flexion	129.74	12.707	0.039237
Extension	8.32	3.133	<0.0001
Ankle joint			
Dorsiflexion	11.875	1.893	0.0033
Plantarflexion	42.26	4.019	<0.0001
Inversion	25.62	3.601	<0.0001
Eversion	12.42	1.793	<0.0001

Interpretation

The average values for the hip, knee and ankle range of motion are shown in the Table No. 3. A goniometer was used to assess the range of motion of the hip, knee and ankle joint. According to this study, Range of motion of the hip, knee and ankle joint were somewhat reduced when compared with the range of motion of joints of the normal individuals of thesame age group. It was observed that, obesityand the presence of pain significantly reduced the range of motion of joints.

Quadricep angle

Table 4. Quadricep angle

	No.of individuals (%)
Quadriceps angle $>18^0$	35 (35%)
Quadriceps angle $<18^0$	65 (65%)

Interpretation

According to research, it was observed that 35% of women have quadriceps angles of more than 18 degrees and the remaining 65% have quadriceps angles of less than 18 degrees. Q angle of more than 18 degrees is considered an indicator of Patellofemoral Joint Dysfunction.

Crepitus

Research revealed that 63% of women had shown positive findings for crepitus during activities like squatting, stair climbing and walking and 37% had shown negative findings for crepitus.

Waldron Test

After analyzing thedataitwas revealed that 52% ofwomentested were positive and 48% showed negative results (Figure 1).

Eccentric step-down Test

After analyzing the datait is revealed that 60% of women are showing positive findings and the remaining 40% showing negative findings (Figure).

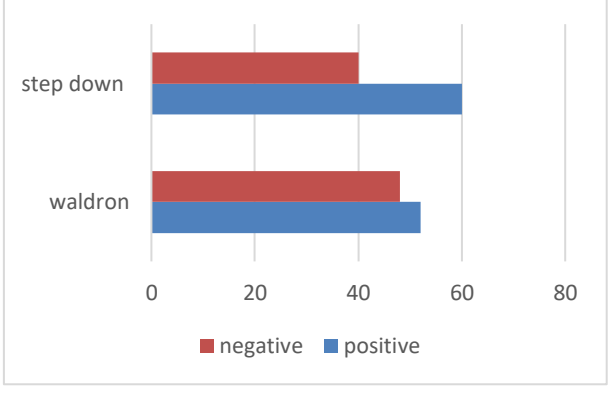

Figure1. Eccentric step-down Test and Waldron test

DISCUSSION

The purpose of this study is to estimate Patellofemoral Joint Dysfunction in obese postmenopausal women. In this study, 100 obese postmenopausal women were approached. After the selection of participants as per the criteria of the study, they were informed about thestudyand written consent was taken. Our investigations examined Patellofemoral Joint Dysfunction usingaNumericalPain Rating Scale for pain assessment, Range of motion of hip, knee, ankle joint, Quadriceps angle assessment, Waldron Test, and Eccentric Step-down Test. The tests have proven reliability and validity.

According toGao et al., 2013, 743 women between the ages of 35 and 64 were involved in this study, and 31.0% reported having knee discomfort regularly. In comparison to premenopausal women, postmenopausal women had a noticeably greater prevalence of musculoskeletal symptoms as per this study. Early menopause was the time when the prevalence of musculoskeletal problems peaked. Due to postmenopausal changes, body fat mass (kg) increases in women by 0.4 kg/year until the age of 50, at which point it increases more quickly until the age of 59, and then it slightly decreases after that. (Sahasrabuddhe et al., 2021) Along with increasing age the prevalence of joint stiffness and knee discomfort dramatically increased. Higher body mass index were linked to higher rates of joint stiffness and knee discomfort. The conclusion was that while musculoskeletal problems are known to rise with menopause, age and body mass index should also be taken into account.

Patellofemoral Joint Dysfunction suggests that the joint is afflicted by some sort of pathology. This illness could be caused by biomechanical reasons or physiological ones, including obesity or menopause related estrogen hormone insufficiency. Increased Patellofemoral Joint stress and subsequent articular cartilage wear and tear are linked with obesity and menopause, according to a widely accepted theory, that the etiology of Patellofemoral Joint Dysfunction results in Patellofemoral Joint pain. Commonly, people with Patellofemoral Joint problems experience pain during activities of daily living.

Several other studies have shown that Patellofemoral Joint Dysfunction is associated with pain in the retropatellar region. It is commonly observed that individuals with patellofemoral problems experience pain when climbing or descending stairs, when stepping up and down and with prolonged sitting when squatting and when getting up from a chair. According to Smith Be et. al., (2018), Patellofemoral pain (PFP) is one of the most common types of knee pain , with a prevalence reported to range from 15% to 45% . Knee pain is the second most common condition. It is characterized as non-traumatic and manifests as a diffused anterior knee discomfort during joint-loading movements including running, crouching and climbing and descending stairs. Crossley et al., (2004), mentioned that Numerical Pain Rating Scale assessment is reliable and valid and responsive in the assessment of Patellofemoral Joint.

Dysfunction.In this study, we asked participants aboutpain, the location of pain, and activities that aggravate the pain. In this study it was observed that 63% of women had pain. Among those 49 % had pain in the retro patellar region and the remaining 14 % had anterior knee pain. Participants reported pain during activities like climbing or descending stairs, stepping up and down, prolonged sitting, squattingand getting up from a chair. Ersoz & Ergun (2003), concluded that hip range of motion is observed to be reduced by an increase in body mass index. It was found that hip rotation was higher in females than in males. It was found that,33 out of 40 knees evaluated (82.5%) in a sample of individuals with primary knee OA aged 44 to 76 reported extension limits ranging from 1 degree to 14 degrees. The results showed that, in contrast to the findings, the passive knee flexion range of motion was smaller in female subjects than in male subjects of the same age. On average, women's knee flexion was only 2 degrees less than men's.The women's lower knee flexion may have resulted from their higher BMI than the men's. According to Lichtenstein et al., (2000), among 647 community participants, it was discovered that those with higher BMIs had less range of motion in their knees than those with lower BMIs. Compared to their non-obese counterparts, subjects who were severely obese had an average loss of 13 degrees of knee flexion range of motion. The researchers found that for every unit increase in BMI, there was a loss of knee range of motion of at least 1 degree.

Nunes et al., (2013) reported that the patellar tilt and squatting test showed evidence of supporting a diagnosis of Patellofemoral Joint Dysfunction. Nunes et al., (2013) concluded that clinical tests have more diagnostic accuracy in evaluating Patello femoral Joint Dysfunction. In

this study we assessed individuals for special tests, Our findings showed 52% positive results for the Waldron Test and 60 % positive results for the Eccentric Step-down Test.

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Dysfunction of the arch can cause the gait deformity, postural imbalance and other muscular imbalance (Sawant & Shinde, 2021). Ekim et al., (2017), concluded that a high Q angle was related with cartilage thickness which may further causePatellofemoral Joint Dysfunction. He used ultrasonography to measure Q angle. It was observed that high Q angle is a predictor for patellofemoral problems. The innate propensity of the patella to track laterally during dynamic motions is known as the law of valgus. The quadricep muscle linked to the femur is the cause of this valgus angulation. When compared to a smaller Q angle, a greater Q angle may result in a larger lateral vector and possibly a stronger inclination to lateral tracking. In our study, it was observed that 35 % of individuals had a Q angle of more than 18degree showing significant Patellofemoral Joint Dysfunction. 65% of individuals have a Q angle of less than 18degree. Grelsamer et al., (2005), concluded that a Q angle greater than 18 degrees is considered as Patellofemoral Joint Dysfunction.

Based on the findings, we can say that there is significant Patellofemoral Joint Dysfunction in obese postmenopausal women. We recommend that Patellofemoral Joint Dysfunction should be taken into account when treating knee joint related problems and an appropriate treatment program should be planned. The presence of pain and crepitus causes activity limitations which results in a decreased range of motion. An increase in Q angle may also cause significant impairments. All of these factors may affect the quality of life.

Activities of daily living may become painful. Sitting cross-leg, climbing ascending and descending stairs, squatting causes severe pain. With the help of assessment, range of motion assessment we can plan treatment. We can improve the quality of life of women so that they can perform their daily activities with more ease.

Limitations of this study were a smaller sample size and a smaller geographical area. In this study postmenopausal women were selected, so further attempts can select premenopausal women and future research should use larger samples to be better generalizability.

Clinical Implications

It provides an organised approach for medical professionals to identify and treat knee-related problems in this population, enhancing patient outcomes. The results may help prevent the advancement of joint dysfunction by providing targeted rehabilitation programmes to address the biomechanical issues faced by obese postmenopausal women. Through better care delivery and a contribution to the field of musculoskeletal health research, the study promotes functional independence and an enhanced quality of life.

Suggestions

Further studies can be conducted to determine patellofemoral dysfunction in postmenopausal women from other regions. Additional investigations could use more profound outcomes, such as X-rays (Knee Skyline Laurin View), to rule out patellar position for more accurate results.

Conclusion

According to the findings of this study, there was a significant Patellofemoral Joint Dysfunction in obese postmenopausal women. Along with retropatellar pain and crepitus, some participants reported anterior side of the knee pain. Significantly less lower limb range of motion was observed. Pain and high body mass index have been shown to limit the joint range of motionand an increased quadriceps angleindicates Patellofemoral Joint Dysfunction.The Eccentric Step-down Test and the Waldron Test both yielded positive results. The therapist must incorporate the research findings into the treatment plan to improve the patient's quality of life.

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Conflict of İnterest

Authors declare no conflict of interest.

Ethics Statement

This research followed ethical standards and received approval from the Institutional Ethical Committee of Krishna Vishwa Vidyapeeth, KIMSDU dated 19/05/2023 and numbered 616/2022-2023.

Author Contributions

Study Design, PJ and SD; Data Collection, AJ; Statistical Analysis, SD; Data Interpretation, AJ and SD; Manuscript Preparation, PJ and SD; Literature Search, PJ, and AJ. All authors have read and agreed to the published version of the manuscript.

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RESEARCH ARTICLE

Implementation of Manipulative Basic Movement Learning Model Development for Students aged 5-6 years

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Abstract

This research aims to know application of learning models motion base manipulative of participants educate aged 5-6 years . Loading experimental method pre test and post test as well as skills test results motion base manipulative . Population from study This participant educate 5-6 years old totaling 120 students . Experiment 12 meetings were held . Pretest and posttest were carried out with instrument motion base throwing , catching , dribbling , kicking and bouncing the ball. Based on the results of the data normality test stated that the data was not so that data analysis with using non- parametric statistics . Test results with using Wilcoxon states there is difference between group experiment and control with sig. 0.00 . With thereby can concluded that application of learning models with a motion model base manipulative effective For increase results ability motor rough child 5-6 years old .

Keywords
Learning Models, Basic Manipulative Movements, Early Childhood

INTRODUCTION

There are three stages of movement, namely "Cognitive, Associative and Autonomous." Cognitive stage is the stage where every movement is the result of previous thoughts and experiences. The associative stage is the stage where all movements are coordinated so that they become a complete movement. Meanwhile, autonomous movements are movements that are formed and produced according to external stimuli. According to Fitts and Posner in (Tarreh, 2020). Students in the automatic stage of motor skill learning do not have to concentrate on movement. These students can focus their energy on other areas, such as offensive and defensive situations in sports, targets in activities such as golf and archery, or the aesthetic feeling of movement in dance (Erazo-Damian, 2018).

Basic movement skills are basic movement patterns that begin to develop at the same time that a child is able to walk independently and move freely through his environment. Fundamental movement skills (FMS) are basic skills used in everyday life, and thus mastery of these skills among children and adolescents is an important

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contributor to future participation in sports and physical activity (McGrane, 2017). Fundamental movement skills are gross motor movements that are the basis for the development of more complex and specialized skills and include skills related to stability (e.g., stopping, turning, pushing), locomotion (e.g., jumping, running), and object control. (e.g., catching, kicking) (Gursel, 2014).

Achieving the advanced stage is greatly influenced by opportunities for practice, encouragement, and instruction in an environment that encourages learning (Goodway, 2019). For normal and special needs children, the fundamental stage is about learning all the basic movement skills. It is about learning to run and jump and leap and catch and throw and kick and it is also about learning to use a prosthetic arm or leg, or to become mobile using a wheelchair or walker. It is about learning all the skills that can be used in sports and physical activities later in life (Tóth-Király, 2020). These basic movement skills help participants engage confidently in a variety of sports (Byl, 2014). Basic movement skills are one of the important things in a person's movement development phase (Pangkey, 2020).

With good basic movement skills, a person can perform various sports skills. Foundational skills, sometimes called basic movement or functional skills, are the skills a child needs to function effectively in the environment (Stanton, 2016). Basic skills are basic human movements that are usually identified by a single verb, such as walking, turning, running, jumping, or stretching. Basic movement skills are "a set of specific skills that involve different parts of the body such as the legs, feet, body, head, arms and hands" (Kezić, 2018). Basic movement skills form the building blocks of everyday activities such as running for the bus, jumping over puddles, and stretching to stop a cup from tipping over (Wang, 2013). The unification method is a method and training to introduce and understand the basic movements of Running ABC which are good, efficient, and harmonious. Unification analysis can describe basic movement errors that are often made during training (Hernawan, 2020). Children's motor repertoires expand rapidly during the second year of life (Eime, 2013).

Basic movement skills support overall development of children, especially their force to and from objects to achieve certain results (Jenkins, 2022). Manipulative skills are a person's coordination and physical dexterity" (Cresham, 2021). The observable movements can be grouped into three functional categories according to the purpose and the entire phase of motor development: stability movement tasks, locomotor movement tasks, and manipulative movements, or a combination of the three Motor development in young children (Goodway, 2013). In brief, if movement functions as a trigger for the process of motor development, then one way to study this process is through the sequential development of motor skills across the life span. There are three fundamental phases that must be passed, namely the proficient stage, emerging elementary stages, and initial stage. Although children become mature and learn at different rates, almost all children learn their fundamental movement skills in the same order and through the same phases (Pommier, 2020). Stability is the ability to maintain body position against the force of gravity, which can include other circumstances that increase the difficulty of the task (Ozmun, 2012). Maintaining stability is essential for not only most sports-related motor skills, but also many functional skills (Foster, 2019). Nonlocomotor skills are performed without significant movement from one place to another (Aaron, 2022).

Manipulative skills are a person's skills in manipulating objects. "Manipulative skills (also referred to as object control skills) generally involve a combination of at least two movements and are performed in conjunction with other types of movement" Constraints Model for Improving Motor Skills in Children with CHARGE Syndrome (Foster, 2019). Additionally, manipulative skills involve the use of some types of tool, often with the hands but also with the feet or other parts of the body. Manipulative activities develop hand-eye and foot-eye coordination and dexterity (Pangrazi, 2019). By using equipment such as balloons, hoops, magic wands, bean bags, balls, tug-of-war ropes, Lummi sticks, Frisbees, and spoons, students can develop manipulative skills in a variety of situations (Li, 2013). Object control skills require the children to control objects using body parts or using tools (Bucher-Koenen, 2018). Manipulative skills involve moving and controlling objects. The body is used to apply force to an object and to absorb force when receiving or controlling an object. Manipulative skills allow children to give or receive ability to manipulate objects around them to achieve certain goals (Karisman, 2021). Manipulative skills

involve the use of some types of tool, often with the hands but also with the feet or other parts of the body (Stanton NA, 2019).

Quality physical education offers a variety of physical and fitness activities that are developmentally appropriate and enjoyable for students; use meaningful and appropriate teaching practices to provide students with maximum learning experiences; and ensure students to spend 50% of class time in MVPA (Heidorn, 2013). Students are people who have basic potential, namely cognitive, affective and psychomotor, who try to develop their own potential through the learning process in educational pathways, both formal and non-formal education, at certain levels of education and types of education (Suwartini, 2017). Movements can be grouped into three functional categories according to their purpose namely: stabilizing movement tasks, locomotor movement tasks, and manipulative movement tasks, or a combination of the three (Darmawan, 2018). The age period of 2-7 years is a fundamental movement phase (basic movement stage) and in the age period of 7-10 years, 11-13 years, 14 years is the specialized movement phase (special movement stage). The process of forming movements does not occur automatically, but is an accumulation of learning and practice processes, namely by understanding movements and carrying out movements repeatedly accompanied by awareness of whether the movements being carried out are correct or not. Therefore, the growth and development of students can have good basic movement skills with the presence of professional teachers. The potential of students generally consists of three categories, namely cognitive, affective and psychomotor in assessing their learning of movement skills, especially manipulative basic movements which have been programmed through RPPH indicators and visitation assessment instruments in schools.

MATERIALS AND METHODS

Metodh

Study This use method loading experiments *pre test* and *post test* as well as skills test results Study motion base manipulative.

Participants

Population from study This is all over participant educate 5-6 years old. Treatment given in the form of a learning model motion base manipulative through development of throwing, catching, bouncing, hitting and kicking models (Asmawati, 2015). With amount sample involving 120 of participant divided education into 2 groups, groups experiments and groups control at AHA Asahan Kindergarten North Sumatra Province, with using 22 existing models worthy used For 5-6 years old.

This research was approved and supervised by the research committee department, Institute for Research and Community Service, Muhammad Arsyad Al Banjari Islamic University of Kalimantan Banjarmasin, Indonesia (Reg No 38/UNISKA-LP2M/II/2024. Participant provided informed consent, with the volunteer form covering research details, risks, benefits, confidentiality, and participant rights. The research strictly adhered to the ethical principles of the Declaration of Helsinki, prioritizing participant's rights and well-being in design, procedures, and confidentiality measures.

Treatment

Treatment held for 12 meetings. steps which is conducted is as following : (1) determine group subject research : (2) carry out *pre-test* , (3) do treatment learning motor rough with a motion model base manipulative , (4) carry out *post-test* (5) look for average score results *pretest* and *posttest* , then compare with group control , (6) difference these two averages through method statistics observation repeat For know is there is significant influence from use of this model in results Study motor rough with a motion model base manipulative .

Instrument Study

Instrument study is sheet consists of observations from motion throwing, catching, kicking, hitting, dribbling, bouncing the ball with grille as following:

Validity instrument with correlation between score item with factor score. The instrument was tested Then results calculation correlation as following.

Table 1. Validity instrument

	Scale Mean if Item Deleted	Critical limit n 30	Information
Throw	,561 **	0.3494	valid
Catch	,807 **	0.3494	valid
Herding	,561 **	0.3494	valid
Kick	,716 **	0.3494	valid
Reflect	766 **	0.3494	valid

Based on table 1 it is stated instrument declared valid with results correlation with sample 30 with mark critical 0.3494, five sub -instruments own value above mark critical. Likewise with results calculation reliability. The calculation results reliability show a Cronbach's Alpha result of 0.716 was stated reliable.

Table 2a. Instrument reliability

Reliability Statistics	
Cronbach's Alpha	N of Items
,716	5

Table 2b. Advanced reliability instrument

Item-Total Statistics				
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Throw	56.4333	46,392	,309	,732
Catch	56.5667	38,185	,665	,591
Herding	59.8667	48,464	,366	,707
Kick	57,1000	40,300	,510	,654
Reflect	57.2333	36,392	,552	,635

Table 3. Grid lattice test instrument

Sub Indicator	Stages of Movement
1. Throw "direction lower " 1 leg position 2 body positions 3 positions view	1. Upright leg position Straight , one leg is in front . 2. Bending body position body and leaning toward front . 3. Arm position moment throw swing and hold the ball. 4. Views eye forward toward target .
2. Throws a "strong" direction front 1 leg position 2 body positions 3 positions lengn 4 views	1. Leg position straight Straight , one leg is in front 2. Body position slightly tilted and upright **3.** Position one arm straight facing toward front , and Position arm 1 holding a small ball bend with direction 180 and ready swing his arm as well as do throw 4. View and head looked up to on
3. Throw direction bottom " circular "	1. Leg position straight straight both legs opened shoulder width 2. Body position facing to front 3. Position second arm bend and hand holding the ball right in front of the chest **4.** Position view toward front see friends who will chosen For throw the ball to her friend
4. Throw goal Alone	**1.** Leg position straight straight opened wide over the shoulder **2.** Bending body position **3.** Position second arm toward lower under your feet and ready holding the ball 4. Position view toward lower Ready do throw .
5. Throw while jump " direction on "	1. Position both feet parallel with a slight shoulder bend 60 2. Position second arm A little bend 60 and second hand yeah hold the ball in front of the chest. Position second arm changed on head moment do throw to the top . 3. Body position slightly bent 70 4. View to direction front
6. Throw the ball to " right " basket	**1.** Position both legs standing straight , left leg is at the front . Core movements Position right sole tiptoe next Both legs are slightly tilted at 90 degrees body direction . 2. Body position towards front with tilt position 90 3. Position hand right hold the ball and be ready swing and hand the left is silent 4. View toward front basket
7. Throwing a Basketball " Left"	1. Position both legs standing straight , right leg is at the front . Both legs are slightly tilted at 90 degrees body direction . Core movements Position left sole tiptoe .

	2. Position hand left hold the ball and be ready swing and hand right, just keep quiet . 3. Body position towards front with tilt position 90 4. View toward front basket
8. Throw " top " balloon	**1.** Position both legs standing straight 2. Straight body position 3. Position second arm hold balloon and is at the top head **4.** Position view toward on
9. Catching "2- handed " Sitting	1. Position both legs folded in a way cross-legged 2. position sitting and upright 3. Position second hand is in front of the chest and holding the ball 4. Position view see toward
10. Catch reflection " hand right"	**1** Position both legs opened wide shoulder -width apart and upright straight . **2** Upright body position straight 3, Position arm right holding the ball, Position hand right Ready is at in front of the chest, Position palm hand right open wide . Next palm hand right open wide Ready catch reflection from lower 4, Outlook toward lower .
11. Catch reflection ' hand left "	1. Position both legs opened wide shoulder -width apart and upright straight. 2. Upright body position straight, 3. Position arm left holding the ball, Position hand left Ready is at in front of the chest, Position palm hand right open width and palm hand left open wide Ready catch reflection from lower 4. View toward lower
12. Catch 2 hands and sit together	1. Position both legs folded in a way cross-legged **2.** position sitting and upright 3. Position second hand is in front of the chest with hand empty, Position second tap hand open wide 4, Position view see toward the ball arrives
13. Catch the ball bounced in the middle with second hand	1. Position both legs straight straight and open shoulder width 2. Upright body position straight 3. Position arm and second hand is at the front body. Position palm hand open wide and facing toward on Position palm hand right still open and palm hand is at toward on 4. View see toward the ball arrives
14. Capture reflection togetherness	1, Position both legs bend 80 degrees and open shoulder width 2, Upright body position straight stand 3., Position second hand is in front of the chest and palms hand open wide toward front 4. View see toward the ball arrives
15. Kicking the Gender Ball	**1.** Right foot position is at behind and left foot position bend 90. right leg swung , sole of the right foot part top and fingers the tip of the foot touches the ball and is ready For kick **2.** Body position tilted 90 degrees direction front **3.** Position arm left is at toward front and arms right behind the right leg **4.** View see the ball in front
16. Kicking Reflection direction wall / walls	1. Position both legs straight and open shoulder width apart , Perkenaan sole of the front foot and toe with the ball 2. Position second arm beside the body 3. Upright body position straight 4. Outlook facing direction of the ball and the wall .
17. Hitting Balloon on	**1.** Standing leg position straight and one leg in front and 1 behind **2.** Standing body position tilted 90 **3.** Position second hand grasp tool bat directed on head **4.** Position view toward on
	1. Standing leg position straight and one leg in front and 1 behind **2.** Side body position stand straight and chest out to front

18. Hitting Balloon with hand right	**3.** Position 1 hand (left) bent hold balloons in front face and Position 1 hand the other (right) is open chest width ready swing **4.** View is at toward front holding balloon
19. Hitting like Golf	1. Leg position slightly bend one leg in front 2. Position second arm is at the front stomach hold tool hitter and second arm swing from direction side 3. Body position bent 70 degrees 4. View leads to in front of the ball that will hit
20. Hitting balloon with hand right sitting position	1. Position both legs folded in a way cross-legged 2. position sitting and upright 3. Position hand left holding the ball and hands right is at beside face For preparation hit the ball 4. Position view see toward front
21. Bouncing the ball to middle	1. Position both legs straight Straight , one leg is in front 2. Upright body position straight 3. Position one arm is on the side Ears and Position hand other beside the body and towards lower relax then move the hand to the side ear Ready swung toward back 180 4. View toward front
22. Bouncing the ball while walk	1. Position both legs straight Straight , one leg is in front . 2. Body position tilted to front 3. Position one arm is next to the body as a control for Move and Position hand other holding the ball and bouncing the ball while dribbling the ball with walk . 4. View toward front .

Data Analysis

Test and post test data furthermore analyzed with use SPSS assistance in the form of descriptive statistics, normality tests, and non- parametric statistical tests.

RESULTS

As for the results evaluation from effectiveness of the jumping model motion base manipulative For child 5-6 years old is as following:

Table 4. Test results skills motor rough manipulative

		Pretestexperiment	Posttestexperiment	Pretestcontrol	Posttest Control
N	Valid	60	60	60	60
	Missing	60	60	60	60
Mean		60.18	76.48	61.26	71.10
Median		61.00	75.00	63.00	71.00
Mode		63.00	75.00	63.00	70.00
Std. Deviation		5,016	4.15990	3.66	4.35
Minimum		50.00	70.00	55.00	60.00
Maximum		69.00	87.00	65.00	78.00

This result show that the mean value is good control and experimental groups in the post test section The same The same experience enhancement compared to with pre-test. Pre test scores group experimental 60.18 while post test 76.48 as well as pre test control group 61.25 and post test 71.10. happen the difference is 16.30 each for group experiment and 9.84. Viewed from difference This can in the article group experiment experience more improvement tall. Viewed from standard deviation group experiment experience repair data tightness, meanwhile control group instead experience allowance, based on matter This beside happen more improvement tall it turns out enhancement This range distance between the data also experienced distance is not Far more strict compared to with control group.

Table 5. Normality test results

Tests of Normality						
	Kolmogorov-Smirnov [a]			Shapiro-Wilk		
	Statistics	df	Sig.	Statistics	df	Sig.
Pretestexperiment	.113	60	,056	,966	60	,096
Posttestexperiment	,156	60	,001	,945	60	,009
Pretestcontrol	,382	60	,000	,734	60	,000
Posttest Control	.134	60	,009	,955	60	.028
a. Lilliefors Significance Correction						

Based on the results of the data normality test it turns out only group pre-test experiments were declared normal, the other groups had sig values. more small of 0.05, so analysis next using non-parametric statistics . As for the results non-parameteric analysis as in table 6.

Table 6. results Wilcoxon analysis

Test Statistics [a]	Score
Mann-Whitney U	714,000
Wilcoxon W	2544,000
Z	-5,719
Asymp . Sig. (2-tailed)	,000
a. Grouping Variable: ex	

Based on non- parameteric test results it turns out the calculated sig is 0.000 < 0.05 so can stated there is difference between results control group and group experiment stated median control group 63 with mean 71 and posttest group experiment media value 61 and average 75.

DISCUSSION

Research purposes This For know results implement learning motion to enhancement manipulative abilities consisting from motion throwing, catching, leading, kicking and bouncing. Research result show exists enhancement Good For group experiment or so control group. Reviewed from achievements group mean value experiment experience more improvement tall compared to with control group. Non- parametric test show that happen difference between group experiment and control with median test. Important point from study This is happen enhancement Skills manipulation being tested from treatment given. However treatment in Movement Education is very important thing. Observation to child 4-5 years old in place custody child shows, apparently inside activities room dominate up to 70%, so matter This cause lack stimulation child For activity physical (S. Iivonen et al., 2016). In better condition positive proof study children involved in sport show enhancement locomotor, manipulator and TGM test results. Mastery to a number of Skills like ability For running, playing objects, self control and jumping is very important thing at the age of 1-3 years (Akbar et al., 2021). Very different the incident If child get treatment and environment Study good move.

Why mastery Skills motion This become important? There is proof supporting research matter This other evidence shows between movement, language and activity physical own significant relationship in the process of development and learning child 4-5 years old (Vargas-Vitoria et al., 2023). Mastery balancing yourself above bicycle it turns out own strong relationship to locomotor, balance and object control (Kavanagh et al., 2020). Skills motion base give influence to Study rhythmic gymnastics movements, especially the learning phase coordination hand, in phase Study more high on coordination hands, strength and precision motion (Kezić et al., 2018b). There is significant correlation between Skills motion base specifically balance dynamic and static children 5-6 years old to performance academic (de Waal, 2019). Study to child 4-4.5 years old state that ability motion base own connection development ability cognition (Martzog et al., 2019). Children who are overweight have a negative correlation with Skills motion locomotor including ball control, kid daughter more good at movement locomotor compared to son but

child son more Good in possession of the ball (Song et al., 2023) furthermore there is close relationship between Skills motor rudeness and activity physical to metabolism, neuromuscular ability paa child ages 5-8 years (Laukkanen et al., 2014). In children age ability locomotor and motor fine correlated with literacy movement in the environment home and possession vocabulary (Suggate et al., 2017). A very crucial message from results study as example, about mastery balance and movement control, p This will Keep going continues arrived at class One school base (Bellows et al., 2017). Text there is a transfer of learning when the child has control A skills, skills beginning This can made child as initial capital as a process for get new movement.

Mastery Skills motion This Good sons and daughters will experience differences , several study show son only superior in ability throw the ball over head and kicking , while That ability gullap , leap, run , hop, spar long jump, skip and women's slide more superior (Nikolić et al., 2016) Ability locomotor and object control between sons and daughters 4-4.5 years old based on observation for 3 days at school and two days at home , apparently There is significant relationship between age , type gender , and BMI against activity physical (KS Iivonen et al., 2013) . Children aged 3-5 years ability women's vertical jump more superior, next between activity physical and skill motion base No There is close correlation (Duff et al., 2019). Other research shows son 5-7 years old more excel at skills locomotor, meanwhile daughter more excel at skills manipulation (Friskawati, 2023).

Skills motion base experience enhancement along with increase age, conclusion This based on measurement child ages 3-7 years with 1,029 samples (Lin & Yang, 2020). Basic movements correlated with age, type gender, BMI and activity (Chen et al., 2021), based on p This It is recommended that children accept activity motion fun dynamic between 30-60 minutes furthermore stated there is connection between activity levels with mastery calories per hour, ability motor and activity physical, as well ability control object (Ali et al., 2021). At least there is three factors of outside the child who gave it donation to learning and results Study children, environment, family, and education. Environmental factors prove that condition social ecology child it turns out correlated to ability motion base (Zeng et al., 2019). Desire child For move influenced by one among them is environment around child (Nazarpouri et al., 2023), increasingly child live in the neighborhood active so will increase motivation For move.

From family factors influenced by patterns parenting Parental education, activities carried out by father, transportation to school, sports parents, negative influence is influenced by interaction watching TV and reading book (Cools et al., 2011). Enhancement mastery movement in children aged 2-4 years influenced by chance For do activity physicality and movement good basis with guidance good by the teacher or parents in a way sustainable (Roscoe et al., 2017), engagement child in kindergarten activities physical including patterns foster, environment school, facility playing outside class (Coe, 2020). Proven son more tall score Skills control object compared to daughter, skills motor This related with activity weekend done especially activity with intensity moderate (Foweather et al., 2015), be message from study This are parents need For invite child For do recreation form activity physical give provisions For mastery movement skills and provisions For life active later day.

Furthermore From the education factor it is very giving proof that creation chance for child For do practice, engage and design with quality learning give great guarantee For development motion child. Study motor skills in children No only just about body, muscles and joints, more Far Again matter This about make synergy, balance, symemmtery, and skill Skills during Study form motion (Akbar & Awalludin, 2021). Teaching motor rough 4-5 years old in Longitudinal study in Singapore, in class show involvement lowly students, in fact student more high outside class in Study motor rough (Bautista et al., 2020). Exercise program intervention for 1 year own influence positive to level Skills motor child (Plazibat et al., 2021)

Skills education intervention motion base child 5-6 years old influenced by treatment motion elementary, locomotor and manipulation at school (Boz & Aytar, 2012). In children 4-4.5 years old the more child own allocation high movement will give matter positive to mark motor (Mota et al., 2020), a study student given do it with give fruit and activity motion base for 10 months against 10 parks child child, the result significant lower number obesity and increasing Skills motion (Zask et al., 2012) . Still around child 4-5 years old given treat activity physical it turns out happen enhancement Skills motor rough compared to with test the beginning

and end of the program with average enhancement up to 45.7% (Kordi et al., 2012).

For ensure development Skills motion basics are very important For held Physical education class in the park child child (da Silva et al., 2024) , for effectiveness of the learning process class more small it turns out more effective compared with class big in learning motion base (Cheung & Zhang, 2020) , as example small allocated 5 minutes quality per day and activities activity physically on weekends significant increase competence motor and movement control abilities (Roscoe et al., 2021).

Research and study results review study This show proof that, mastery movement is very important. Ability motion will experience development along with increase age, happens difference achievements mastery between sons and daughters. Furthermore Skills motion Good locomotor nor manipulation (throwing, catching, kicking, bouncing the ball, etc herding) will increase If child given chance For do in environment (family or education). Guarantee educational environment quality move and give child chance For move in a positive setting so that achievements targeted and designed. What a message crucial from results research and studies This is mastery motion child will continues at the next age and level of education. So that attention every level become important thing.

Conclusion

From the results application development learning model motion base manipulative is one of effort help participant educate 5-6 years old to be deep follow learning motor rough can active, creative, effective, encouraging and fun. Learning model motion base manipulative own principles that require teachers to evaluate need Study child 5-6 years old, so child in do learning besides fun and improve multilateral quality of the movement, Experimental results This prove that designed intervention give influence positive to enhancement Skills motion manipulation.

Conflict of Interest

The author declares that this article has no conflict of interest.

Ethics Committee

This research was approved and supervised by the research committee department, Institute for Research and Community Service, Muhammad Arsyad Al Banjari Islamic University of Kalimantan Banjarmasin, Indonesia (Reg No 38/UNISKA-LP2M/II/2024

Author Contributions

Study Design, AN, PE, JM; Data Collection, JM, SYTJ, BS, IEP; Statistical Analysis, SMHD, DD, SEFN, AM; Data Interpretation, PE, JM, SYTJ; Manuscript Preperation, PE, JM; Literature Search, AN, PE, JM, SYTJ, BS, IEP, SMHD, DD, SEFN, AM. All authors have read and agreed to the published version of the manuscript.

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RESEARCH ARTICLE

A Comparative Study on Participation Motives and Psychological Well-being of Female University Student-Athletes in Kenya and Türkiye

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Abstract

In this study, it was aimed to examine the motivation to participate, psychological well-being, harmony in life, and contentment with life assessment of female university student athletes in Kenya and Türkiye. The study was designed with the descriptive and relational survey model as a quantitative research method. The research group consisted of 379 students representing female university athletes in Türkiye (224) and Kenya (155). Motivation to Participate in Sport Scale (Gill et al., 1983), Psychological Well-being Scale (Diener et al., 2010), Harmony in Life Scale (Kjell et al., 2016) and Contentment with Life Assessment Scale (Lavallee et al., 2007) were used as data collection tools. As a result of the findings of the study, there was a significant difference between individual athletes and team athletes studying in Türkiye in motivation to participate in sports and this difference was in favor of team athletes ($p<.05$). As a result, female athlete university students' motives for participation in sports and adaptation in life were in favor of Türkiye, but their psychological well-being levels were against Türkiye. Although the psychological well-being levels of female athlete university students are in favor of Kenya, their motives for sports participation and harmony in life are against Kenya. In this case, it shows that there are issues that both countries should pay attention to in order for female university students to be better and more successful.

Keywords
Sports, Psychological Well-Being, Athlete, Kenya, Türkiye

INTRODUCTION

It is an indisputable fact that there is a relationship between healthy life and sports participation in community life. As a result of this relationship, it has been reported that the health benefits of sports participation extend to physical, mental and social factors (Akpınar & Güler, 2023; Eime et al., 2013). Therefore, maintaining a high level of participation motivation is recognized as one of the most important characteristics that athletes need to develop (Manalo, 2023). Considering the purposes of participation in sporting activities, it has been reported that individuals participate in sports for competitive or recreational purposes over a long period of time (Cheung et al., 2012).

In the literature, the factors that are thought to affect the motivation of athletes to participate in sports are stated as being in shape, relaxing, developing skills, success/status, belonging to a team, having fun, making friends, and competing (Gill et al., 1983; Zaharidis et al., 2006). On the other hand, Bandura (1997) stated that student athletes are interested in sporting activities for fun, enjoyment, developing skills, learning, being with

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friends, success, winning and health. Similarly, it has been stated in the literature that intrinsic motivation of female athletes increases through sports participation (Gaston-Gayles, 2005; Mouratadis et al., 2008; Waldron & Dieser, 2010).

Female university students involved in sports have to cope with a number of stressors in their daily lives such as education, school, homework, and gender stereotypes (Gillet et al., 2012). This situation can psychologically affect women's general health status. If young adults are psychologically positively affected by the activities they do in their daily lives, it may also change the overall social life of these participants.

Psychological well-being is a micro-level construct and provides information about how a person evaluates himself/herself and the quality of his/her life (Ryff et al., 1999). Ryff (1989) stated that psychological well-being includes self-acceptance, positive relationships with others, autonomy, environmental control, life purpose, and personal development. According to the psychological well-being perspective, human well-being is characterized as living well and doing good things rather than feeling good (Forgeard et al., 2011). Harmony involves balance and flexibility in harmonizing different aspects in the world. Thus, "harmony is inherently relational. It is through mutual support and interdependence that everything flourishes" (Li, 2008). From a psychological well-being perspective, it is argued here that the concept of adaptation promotes a holistic worldview that includes a balanced and flexible approach to personal well-being that takes into account social and environmental contexts. Adaptation can be explained as the individual's ability to achieve and maintain a balance between the self and the environment in terms of the relationship between the self and the environment by using the existing abilities (Kalyencioğlu & Kutlu, 2010). Harmony is basically related to well-being, and there are slight differences in the assessment of well-being (Satici & Gocet-Tekin, 2017). It can be said that individuals who are in harmony with life can also feel psychologically well. In this context, it is thought that individuals' psychological well-being may have an impact in different areas.

Life satisfaction means the degree of positivity that an individual reaches as a result of evaluating his/her own quality of life in its entirety. Life satisfaction, which can also be expressed as life contentment, and includes satisfaction and pleasure, expresses how much the individual enjoys his/her life (Veenhoven, 1996: 17). It has been observed that factors such as having a meaningful life, enjoying life, and having a lot of effort in life are related to life satisfaction (Peterson et al., 2005). Among the determinants of life satisfaction, many variables such as age, stress level, physical health status, lifestyle, and personality traits play a role (Chow, 2005). It is also stated that factors such as social interaction, sexual activity, achievement, physical activity, engagement with nature, reading or listening to music, nutrition and beverage consumption have a positive effect on life satisfaction (Dockery, 2003: 4).

The significance of this study is that it is an important step in assessing the impact of cultural adaptation and cultural differences on athletes' overall well-being. By examining the effects of sport on motivations to participate and psychological well-being among female student-athletes, it can help us understand the impact of sport on women in more depth. By assessing the role of sport in college student-athletes' life satisfaction and harmony in life, it can help us develop potential strategies to improve the quality of college life.

The primary aim of this study is to examine the motives for participation (reasons for participating in sport) of female university student athletes in Kenya and Türkiye. Participation in formal/structured sports in higher education institutions is a relatively challenging opportunity for female athletes. A secondary aim was to examine the psychological well-being, life harmony and contentment with life assessment of female university athletes in Türkiye and Kenya. The results obtained are intended to serve as a basis for more in-depth studies.

MATERIALS AND METHODS

Research Model

In this study, "descriptive and relational survey model", one of the quantitative research methods that refers to the study of numbers obtained through measurements and suitable for analysis, was used. Relational survey is a research model that aims to determine the existence and degree of co-variance between two or more variables (Karasar, 2010).

Study Group

A total of 379 female university students representing individual and team sports in Kenya and Türkiye were included in the study. Of these participants, 224 were from Türkiye and 155 were from Kenya.

Ethics Statement

Regarding the ethical appropriateness of the study, consent was obtained at the meeting of Manisa Celal Bayar University Social and Human Sciences Ethics Commission dated 04.07.2023 and numbered 2023/07 and also by Kenyatta University Center for Research Ethics and Safety on 27.06.2023.

Data Collection Tools

Personal information form, Motivation to Participate in Sports, Psychological Well-being, Harmony in Life and Contentment with Life Assessment Scales were used as data collection tools.

Personal Information Form

Participants were asked to fill in a 6-item personal information form about personal characteristics (age, type of sport branch, years of doing competitive sport, etc.).

Sport Participation Motivation Scale

It is an inventory consisting of 30 items used to explain the individual's reasons for participating in sports. The original scale developed by Gill et al. (1983) is a Likert-type 3-point response and rating scale in which the participant gives "Very Important", "Somewhat Important" and "Not Important at All" responses to reveal how effective the reason is in participating in sports and exercise. Since the items in the inventory are evaluated between 1 (Very Important) and 3 (Not at all Important), the lower values obtained reveal that the item is more important.

Psychological Well-being Scale

The scale developed by Diener et al. (2010) to determine an individual's psychological well-being is an 8-item, 7-point Likert-type scale. The scale is calculated over the total score.

Harmony in Life Scale

The measurement tool was developed by Kjell et al. (2016) and validity and reliability studies were conducted. The scale is a 5-point scale. It consists of 5 items and is calculated on a total score.

Contentment with Life Assessment Scale

Contentment with Life Scale developed by Lavallee et al. (2007) consists of 5 items. This one-dimensional scale has a 7-point Likert-type rating ("1" Strongly disagree - "7" Strongly agree).

Scale Reliabilities of the Stud

Table 1. Cronbach Alpha (a) values of the scale

Scales	Current Research
Sport Participation Motivation	.83
Psychological Well-Being	.89
Harmony in Life	.85
Contentment With Life Assessment	.77

It is stated that test scores are reliable if the reliability coefficient is 0.70 and higher (Bandalos, 2018; Büyüköztürk, 2012: 171). In the reliability analysis conducted in this study, it was seen that all scales had values of 0.70 and higher.

Data Analysis

A statistical program was used in the statistical analysis of the data obtained. Arithmetic mean, standard deviation, frequency, minimum and maximum values were used in statistical representations of the data. In the normality testing of the data, kurtosis and skewness values of ±1.5 were taken into consideration (Tabachnick & Fidell, 2013). Independent Samples T-test and One-Way Anova were used in the analysis of normally distributed data; Kruskal Wallis H-test and Mann Whitney U-test were used in the analysis of non-normally distributed data. Among the scales used in our research, parametric tests were performed because the kurtosis-skewness values of Sport Participation Motivation, Harmony in Life and Contentment with Life Assessment were between ±1,5. Since the Psychological Well-being scale was not between ±1,5, nonparametric tests were applied.

RESULTS

In this section of the study, statistical analysis results and interpretations of the data obtained are given.

Table 2. Descriptive statistics- percentage frequency-mean prevalence

		N	%	Min.	Max.	Mean
Country of Participant	Türkiye	224	59.1			
	Kenya	155	40.9			
Sports Branches Type	Individual Sports	179	47.2			
	Team Sports	200	52.8			
General Education Level	Licence	352	92.9			
	Postgraduate	27	7.1			
Year of Competitive Sport	1-5 years	192	50.7			
	6-10 years	139	36.7			
	11 years and over	48	12.7			
Person Directing Sports	Myself	64	16.9			
	My family	79	20.8			
	My Friend	64	16.9			
	Teacher	138	36.4			
	My coach	34	9			
Age				18	43	21.61

When Table 2 is examined, 59.1% of the university students participating in the study were female university students studying in Türkiye, while 40.9% were female university students studying in Kenya. It is seen that Turkish participants have a higher rate. When we look at the age distribution, it can be said that there is a distribution in the minimum 18 and maximum 43 age range. According to the type of sports branch, 47.2% of the participants are female university students who play individual sports, while 52.8% are female university students who play team sports, and it is observed that the proportion of participants who play team sports is slightly higher. According to the general education level, it is observed that 92.9% of the participants are female university students with undergraduate education, while 7.1% are female university students with postgraduate education, and the proportion of participants with undergraduate education is very high. When we have a look according to the years of doing competitive sports, 50.7% of the participants with 1-5 years of competitive sports are observed more. According to the person who introduced them to sports, 36.4% of them are female university students who were guided by the teacher, and this rate is higher than the other options. Considering the age distribution, it can be said that there is a distribution in the range of minimum 18 and maximum 43 years.

Table 3. Independent sample T-Test of sport participation motivation, harmony in life and contentment with life assessment scores according to participant country variable

Variables	**Country**	**N**	**X̄**	**S**	**sd**	**T**	**p**
Sport Participation Motivation	Türkiye	224	1.21	0.18	277.927	4.427	**0.00****
	Kenya	155	1.31	0.24			
Harmony in Life	Türkiye	224	27.99	5.04	299.261	1.896	**0.04***
	Kenya	155	26.89	5.83			
Contentment With Life Assessment	Türkiye	224	24.13	5.76	377	4.774	0.45
	Kenya	155	21.19	6.07			

***p<.05; **p<.001**

When Table 3 is examined, a significant difference was found in the motivation to participate in sports and adaptation in life of female university students studying in Türkiye and Kenya ($p<0.05$). These differences were found to be in favor of female university students studying in Türkiye. No significant difference was found in contentment with life assessment according to the participant country variable ($p>0.05$).

Table 4. Mann whitney U test of psychological well-being scores according to participant country variable

	Country	N	Mean Rank	Sum of Ranks	U	p
Psychological Well-Being	Türkiye	224	170.24	38133.00	12933	**0.00****
	Kenya	155	218.56	33877.00		

***p<.05; **p<.001**

When Table 4 is examined, a significant difference was found between the mean psychological well-being of female university students studying in Türkiye and Kenya (U=12933; p<.05). This difference was found to be in favor of female university students studying in Kenya.

Table 5. Independent sample T-Test of sport participation motivation, harmony in life and contentment with life assessment scores of participant country classification according to sport type variable

	Country	Sport Type	N	X̄	S	sd	T	p
Sport Participation Motivation	Türkiye	Individual Sports	128	1.23	0.20	215.238	1.413	**0.03***
		Team Sports	96	1.20	0.18			
	Kenya	Individual Sports	51	1.29	0.22	153	1.165	0.26
		Team Sports	104	1.33	0.25			
Harmony in Life	Türkiye	Individual Sports	128	28.07	4.38	169.578	0.260	**0.03***
		Team Sports	96	27.89	5.84			
	Kenya	Individual Sports	51	26.98	5.66	153	0.255	0.92
		Team Sports	104	26.73	6.22			
Contentment With Life Assessment	Türkiye	Individual Sports	128	24.27	5.63	222	0.394	0.81
		Team Sports	96	23.96	5.98			
	Kenya	Individual Sports	51	20.76	6.51	153	0.614	0.49
		Team Sports	104	21.40	5.87			

***p<.05; **p<.001**

When Table 5 is analyzed according to the sport type variable of the country grouping of the research participants, a significant difference was found in the motivation to participate in sports between individual athletes and team athletes studying in Türkiye (p<0.05). This difference is in favor of team athletes. According to the sport type variable of the participant country grouping, a significant difference was found in adaptation in life between individual athletes and team athletes studying in Türkiye (p<0.05). This difference is in favor of individual athletes. There was no significant difference in contentment with life assessment between individual athletes and team athletes studying in Türkiye according to the branch type variable of the participating country classification (p>0.05). When Table 5 is examined, no significant difference was found in motivation to participate in sports, adaptation in life and contentment with life assessment between individual athletes and team athletes studying in Kenya according to the sport type variable of the participant country grouping (p>0.05).

Table 6. Mann whitney U test of participant country classification of psychological well-being scores according to sport type variable

	Country	Sport Type	N	Mean Rank	Sum of Ranks	U	p
Psychological Well-Being	Türkiye	Individual Sports	128	110.19	14104.00	5848.000	0.53
		Team Sports	96	115.58	11096.00		
	Kenya	Individual Sports	51	73.78	3763.00	2437.000	0.41
		Team Sports	104	80.07	8327.00		

***p<.05; **p<.001**

When Table 6 is examined, when the country grouping is examined according to the sport type variable, there is no significant difference in psychological well-being between individual athletes and team athletes studying in Türkiye and Kenya (p>0.05).

Table 7. Descriptive statistics of motivation to participate in sport scores according to the branch type of participant country classification as a result of two-factor ANOVA for unrelated samples

	Türkiye		Kenya		Total	
	Mean	**Std. Dev.**	**Mean**	**Mean**	**Std. Dev.**	**Mean**
Individual Sports	1.23	0.20	1.29	0.22	1.25	0.20
Team Sports	1.20	0.18	1.33	0.25	1.27	0.23
Total	1.22	0.19	1.32	0.24	1.26	0.22

When Table 7 is examined, when the mean scores of the participants' motivation to participate in sports are analyzed according to the participant country variable, $\bar{X}$=1.22 for Türkiye and $\bar{X}$=1.32 for Kenya. There was a statistically significant difference between the mean scores of these 2 groups, F(1, 375)=17.620 p< 0.05. According to the results of Tukey test, there is a significant difference between Türkiye and Kenya and this difference is in favor of Türkiye. This difference has a small effect size.

When Table 7 is examined, when the mean scores of the participants' motivation to participate in sports are analyzed according to the sport type variable, $\bar{X}$=1.25 for individual athletes and $\bar{X}$=1.27 for team sports. There was no statistically significant difference between the mean scores of these 2 groups, F(1, 375)=3.27 p> 0.05.

Table 8. ANOVA results of sport participation motivation scores according to participant country and sport type

Source	**Sum of Square**	**df**	**Mean Square**	**F**	**p**	**Partial Eta Squared**
Participant Country	0.789	1	0.789	17.620	**0.00****	0.045
Sport Type	0.003	1	0.003	0.075	0.78	0.000
Participant Country * Sport Type	0.147	1	0.147	3.277	0.07	0.009
Error	16.790	375	0.045			
Total	617.652	379				

***p<.05; **p<.001**

It was seen that the joint effect of participant country and sport type on the mean scores of motive to participate in sport was not significant, F(1, 375)=3.277, p>0.05. In other words, the mean motivation to participate in different sport types does not change according to the participant's country.

Table 3. Descriptive statistics of contentment with life assessment scores of participant country classification by sport type as a result of two-factor ANOVA for unrelated samples

	Türkiye		Kenya		Total	
	Mean	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Individual Sports	24.26	5.62	20.76	6.51	23.26	6.08
Team Sports	23.95	5.97	21.40	5.86	22.63	6.04
Total	24.13	5.76	21.19	6.07	22.93	6.06

According to Table 9, when the contentment with life assessment mean scores of the participants are analyzed according to the participant country variable, $\bar{X}$=24.13 for Türkiye and $\bar{X}$=21.19 for Kenya. A statistically significant difference was found between the contentment with life assessment mean scores of these 2 groups, F(1, 375)=22.145 p< 0.05. According to the results of the Tukey test, there is a significant difference between Türkiye

and Kenya and this difference is in favor of Türkiye. This difference has a small effect size.

According to Table 9, when the contentment with life assessment mean scores of the participants are analyzed according to the sport type variable, $\bar{X}$=23.26 for individual athletes and $\bar{X}$=22.23 for team sports. There was a statistically significant difference between the contentment with life assessment mean scores of these 2 groups, F(1,375) = 0.067 p> 0.0.

Table 10. ANOVA results of contentment with life assessment scores according to participant country and sport type

Source	Sum of Square	df	Mean Square	F	p	Partial Eta Squared
Participant Country	772.731	1	772.731	22.145	**0.00****	0.056
Sport Type	2.321	1	2.321	0.067	0.79	0.000
Participant Country * Sport Type	18.876	1	18.876	0.541	0.46	0.001
Error	13085.017	375	34.893			
Total	213193.000	379				

***p<.05; **p<.001**

It was observed that the joint effect of participant country and sport type on the mean scores of contentment with life assessment was not significant, F (1,375)=0.541 p>0.05. In other words, the mean contentment with life assessment of the participants in different sport types does not change according to the participant's country.

Table 4. Descriptive statistics of psychological well-being scores of participant country classification by sport type as a result of two-factor ANOVA for unrelated samples

	Türkiye		Kenya		Total	
	Mean	Std. Dev.	Mean	Mean	Std. Dev.	Mean
Individual Sports	5.71	0.89	5.97	1.00	5.79	0.93
Team Sports	5.63	1.21	6.04	0.97	5.84	1.11
Total	5.68	1.04	6.02	0.98	5.82	1.02

According to Table 11, when the mean psychological well-being scores of the participants are analyzed according to the participant country variable, $\bar{X}$=5.68 for Türkiye and $\bar{X}$=6.02 for Kenya. There was a statistically significant difference between the mean scores of psychological well-being of these 2 groups, F(1, 375)=9,358 p< 0.05. According to the result of the Tukey test, there is a significant difference between Türkiye and Kenya and this difference is in favor of Kenya. This difference has a small effect size.

According to Table 11, when the mean psychological well-being scores of the participants are analyzed according to the type of sport variable, $\bar{X}$=5.79 for individual athletes and $\bar{X}$=5.84 for team sports.

There was a statistically significant difference between the mean scores of psychological well-being of these 2 groups, F(1, 375)=0.003 p> 0.05.

The joint effect of participant country and sport type on the mean scores of psychological well-being was not significant, F(1, 375)=0.514 p>0.05. In other words, the mean psychological well-being of the participants in different sport types does not change according to the participant's country.

Table 5. ANOVA results of psychological well-being scores according to participant country and sport type

Source	Sum of Square	df	Mean Square	F	p	Partial Eta Squared
Participant Country	9.620	1	9.620	9.358	**0.00****	0.024
Sport Type	0.004	1	0.004	0.003	0.95	0.000
Participant Country * Sport Type	0.528	1	0.528	0.514	0.47	0.001
Error	385.482	375	1.028			
Total	13216.750	379				

***p<.05; **p<.001**

DISCUSSION

Participation in sportive activities is one of the most important issues for the formation of healthy futures. Healthy generations are also an effective factor in prolonging life expectancy. Participation in sporting activities is important not only for individuals to achieve competitive gains but also for recreational gains. The gains that young adults, especially those studying at universities, achieve through sporting activities will also have a special importance in the maturation of sports policies of countries. In this study, it was aimed to examine the motivation to participate, psychological well-being, harmony in life and contentment with life assessment of female university student athletes in Kenya and Türkiye. Participation of female athletes in sports is important for the social health of countries and their success in the sports community. Especially female athletes who are successful in sports at university age are important for the continuity of sports in their countries. **Bulgu et al., (2007)** reported that participation in sports and physical activity has enriching and empowering aspects that contribute to women's realization of their body potential and themselves, self-knowledge and independence in their lives. With the current research, it is thought that psychological well-being, harmony in life, and contentment with life assessment, which are thought to support the motivation of female university student athletes to participate in sports as well as their motivation to participate in sports, should be taken into consideration.

When we examined Table 3, we found significant differences in the motivation to participate in sports and adaptation in life of female university students studying in Türkiye and Kenya. These differences were found to be in favor of female university students studying in Türkiye. The reason for this difference can be said to be due to the importance that Turkish culture attaches to female athletes. It may be due to the fact that it has a system structure that encourages and rewards female university student athletes against sports and that athletes experience conflict during sports participation. In this context, the motivation of female university students studying in Kenya to participate in sports and the development of harmony in life can contribute from different dimensions. In a study conducted on female athletes in Kenya, it was reported that women are underrepresented as participants in competitive and recreational sports and in sports-related academic fields (**Njororai et al., 2003**). Similarly, other studies conducted on the same population indicate that the number of female participants is low and there is gender inequality in sports (**Munayi, 2003; Mwisukha & Rintaugu, 2013**). These findings suggest that female participants may have different motives for participation and contentment with life assessment as a result of not participating less in sporting activities.

When Table 4 is analyzed, a significant difference was found between the mean psychological well-being of female university students studying in Türkiye and Kenya. This difference was found to be in favor of female university students studying in Kenya. It can be said that the reason for this difference is that female university students studying in Kenya are better at managing the existential struggles they face in their lives due to cultural differences. In the literature, it is stated that Kenyan young adult female athletes are affected by cultural factors in social life (**Ananura, 2005; Mwisukha & Rintaugu, 2013**). It can be said that cultural pressure may be different for the athletes of the two countries. On the other hand, in a previous study examining the participation motives of Kenyan young adults, it

was stated that the effects of psychological factors on women's participation and performance in sports should be investigated (**Mwisukha & Rintaugu, 2013**). In a study conducted in Türkiye, while it was stated that the conditions for participation in sports are equal; it was emphasized that it has a significant effect on cognitive and psycho-social development through active participation in the right ways (**Yaprak & Amman, 2009**). This situation indicates that individuals' moods can be improved by both improving the conditions of participation and increasing active participation.

When Table 5 is examined, when the country grouping of the research participants is considered according to the branch type variable, a significant difference was found in the motivation to participate in sports between individual athletes and team athletes studying in Türkiye. This difference is in favor of team athletes. In a study examining the motivation to participate in sports in three different countries in the literature, a significant difference was found between team athletes and individual athletes (**Andersen et al., 2018; Edwards et al., 2004; Kondric et al., 2013**). In addition, a significant difference was found in a study conducted between individual athletes and team athletes (**Moradi et al., 2020**). The fact that young adult female athletes act especially with the awareness of being a team may also lead to the formation of a social environment and ensure effective communication. In another study, no difference was found in motivation to participate in sports in team and individual sports (**Jakobsen, 2014**). It can be said that the most important factor that motivates female team athletes studying in Türkiye to participate in sports may be that they have teammates in the team, that is, a social environment can be formed more easily, and they are in a group with the same goal. When Table 5 is examined, a significant difference was found in adaptation in life between individual athletes and team athletes studying in Türkiye. This difference is in favor of individual athletes. It can be said that this difference may be due to the fact that female individual athletes studying in Türkiye struggle on their own against the difficulties they face in competitions and in life. A literature review on the participation and achievements of Kenyan women athletes in sports attributes this to the constitutional amendment in 2010. One of the key requirements of this constitutional amendment process included measures to eliminate gender inequality in all public positions. Since then, all sports federations/associations have made efforts to increase female representation in sport.

When Table 6 is examined, when the country grouping is examined according to the branch type variable, there is no significant difference in psychological well-being between individual athletes and team athletes studying in Türkiye and Kenya ($p>0.05$). In the study conducted by **Uluç (2022)**, it was found that there was no significant difference in the psychological well-being of team and individual athletes. In addition, there are studies that did not find a significant difference in psychological well-being according to the type of sport variable (**Arslandoğan et al., 2020; Demir et al., 2018**). It can be stated that this situation does not show a significant difference with the idea that it may cause an improvement in the general mood of individuals participating in sports.

Table 8, Table 10 and Table 12 show that the joint effect of participant country and sport type on the mean scores of motivation to participate in sport, harmony in life, and psychological well-being, respectively, is not significant.

Conclusion

Today, it is a well-known fact that sport and physical activity is one of the important activities in social life. The importance of sport in different cultures manifests itself as a platform where humanity meets in a common language. Beyond promoting a healthy lifestyle, sport brings communities together and strengthens social bonds. Sport is also used as an educational tool in many cultures with different emphases such as protecting physical health in the West, balancing energy flow in Asia and strengthening ties within the community in Africa. Sport, combined with elements such as character development, self-discipline and the reinforcement of national pride, creates a common meaning and value system across cultures. International events, platforms such as the Olympics and world championships, strengthen intercultural relations by bringing people together not only through competition, but also through mutual understanding and peace. Sport at university level plays an important role for female athletes, both in terms of individual development and social impact. This process allows young women to strengthen their leadership skills, gain self-confidence and experience working in a team spirit. Sport not only improves their physical health, but

also increases their problem-solving abilities, opening them to broader perspectives on their lives. Furthermore, sports activities at university level allow female athletes to inspire their communities and play an important role in the fight for gender equality. Therefore, sport for women studying at university allows them to show themselves at their best.

A significant difference was found in favour of Türkiye in the motivation of female athlete university students to participate in sports and adaptation in life. It shows that Kenya should take measures to encourage female athlete university students' motivation towards sports and adaptation to life. The psychological well-being levels of female athlete university students showed a significant difference in favour of Kenya. It shows that Türkiye should take measures to support the psychological well-being of female athlete university students. There was a significant difference in the motivation to participate in sports between individual athletes and team athletes studying in Türkiye and this difference was in favour of team athletes. It is necessary to create a system that encourages and rewards female university students to participate in individual sports in Türkiye. This study will contribute to a better understanding of the role of sport in women's lives by revealing the similarities and differences between the motivation to participate in sport, psychological health, contentment with life assessment and life harmony of female university student-athletes in Kenya and Türkiye. By providing comprehensive guidance for sport management, educators and policy makers, this information can form an important basis for supporting female athletes and making sport more inclusive.

Implications

This study may be an important step to increase women's participation in sports and improve their quality of life. It can support measures and policy recommendations that can be taken to increase the participation of female university student athletes in healthy lifestyles. It can make an important contribution to understanding the social and emotional needs of female athletes and providing them with better support. However, the physiological and psychological needs of women as well as their social expectations should be taken into consideration. The results of the study can have various effects both in the academic field and in applied studies. Despite the valuable results obtained, this study also has some limitations. The research data were obtained from a limited sample of female athletes in Kenya and Türkiye. Considering different variables in larger samples may reveal important results.

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Conflict of Interest

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethics Statement

This study is approved by the Manisa Celal Bayar University (MCBU) Social Sciences and Humanities Scientific Publications Ethics Committee (Approvel Nummer and Subject: 569950 and 12.06.2023 2023/07).

Author Contributions

Study Design, ŞB, HG, NM, Data Collection, DN, FG, CAA, JR, ŞB, HG, KY; Statistical Analysis, ŞB and KY; Data Interpretation, ŞB and KY; Manuscript Preparation, KY, DN, FG, CAA, JR, ŞB, HG; Literature Search, KY, CAA, ŞB, HG. All authors have read and agreed to the published version of the manuscript.

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RESEARCH ARTICLE

Effects of Aerobic Exercise and Yoga on Blood Pressure in Women Between the Ages of 30 and 40 Years

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Abstract

High blood pressure or hypertension is a major risk factor for cardiovascular disease. This study aims to prove the effectiveness of aerobic exercise and yoga in lowering blood pressure in mothers. The study was conducted using experimental methods and involved 28 participants selected by purposive sampling from Nogosari village, Boyolali regency, Indonesia, during 12 sessions. Blood pressure data were collected from participants with hypertension before and after aerobic exercise and yoga. Measurements were taken on participants for 12 sessions in one month using a blood pressure monitor. The device used in this study was a sphygmomanometer ambulatory blood pressure monitoring (ABPM). Statistical tests were performed using independent samples t-tests with a significance level of $p < 0.05$. The results of the homogeneity test showed that the systolic and diastolic variance in the control and experimental groups had the same variance with a significance level of $p < 0.05$. The results of both mean difference tests showed that there were significant differences in systolic and diastolic blood pressure between the aerobic and yoga groups. This can be seen from the value of P-value Independent Samples t-test < 0.05. The results showed that low-impact aerobic exercise and yoga had a significant effect on blood pressure in women aged 30-40 years. Based on these data, it can be concluded that there is a significant decrease in systolic and diastolic blood pressure from the category of moderate hypertension to normal-high in women aged 30-40 years after doing aerobic exercise and yoga.

Keywords
Aerobic Exercise, Yoga, Blood Pressure, Women Aged 30-40 Years

INTRODUCTION

The older a person gets, the more the human body's immune system deteriorates (Spencer et al., 2017; Warreman et al., 2023). This physical decline will cause changes in a person according to their age. With increasing age, there are also various diseases that will easily attack the body due to the changes in the body, including infectious diseases, diseases due to the influence of wrong lifestyle, degenerative diseases and also infectious diseases (Abdel-aziem, 2024). The emergence of diseases in the body results in the deterioration of organ function from a normal state to worse, commonly referred to as degenerative diseases (Mendez Colmenares et al., 2021). Degenerative causes several types of diseases including kidney, heart, diabetes mellitus, stroke, blood pressure disorders, gout and others (Liguori et al., 2018; Nandi et al., 2019; Sharaf El Din et al., 2017 ;Thind et al., 2017

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). In addition to maintaining an adequate diet and rest, it is also necessary to engage in regular sports activities such as gymnastics. Therefore, awareness is needed to maintain the physical and mental changes of life in old age.

Cardiovascular disease, including hypertension, is a leading cause of death worldwide and often occurs in young adult women (Doewes et al., 2023; Franklin & Quindry, 2022). This highlights the importance of treating high blood pressure to prevent the risk of serious conditions such as stroke and heart disease. Aerobic exercise and yoga are two forms of exercise that have been shown to be beneficial in managing blood pressure and improving cardiovascular health in general (Alfiansyah, 2022; Arfanda, 2023; Shohani et al., 2020). Aerobic exercise, which involves rhythmic movement and most of the large muscles of the body, can improve blood circulation and heart strength (Espí-López et al., 2016; Thomas et al., 2023). Meanwhile, yoga offers a more holistic approach that focuses on breathing, posture and relaxation, which can help reduce stress and lower blood pressure (Peng & Xie, 2021; Shiraishi & Bezerra, 2016). Although the benefits of these two types of exercise have been recognised, more research is needed to understand the differences in effectiveness and relative benefits of each in the context of young adult women.

Aerobic exercise and yoga can help reduce blood pressure. The body's balance is affected by increases and decreases in blood pressure (Muñoz-Vera et al., 2017; Nobari et al., 2023).The flow of blood throughout the body is influenced by blood pressure, which gives it a boost. A person's blood pressure is not always good or stable. Unstable changes in blood pressure affect a person's health, especially someone who does not exercise (Gröpel et al., 2016; Schütz et al., 2023). Even the symptoms resulting from blood pressure instability are often overlooked and can lead to very dangerous diseases from blood pressure instability (Asiah et al., 2023; Thind et al., 2017).

There are two types of blood pressure disorders, including hypotension (low blood pressure) and hypertension (high blood pressure). Hypertension is an increase above the normal value described by systole and diastole (Lawrence et al., 2023; Lobene et al., 2022). While low blood pressure or hypotension is a decrease in systole up to 20-30% compared to normal, current systolic measurements show <100 mmHg (Pheiffer et al., 2023). Older people often complain of health problems, one of which is high blood pressure or hypertension. Hypertension is an increase in blood pressure >140/90 mmHg.

Uncontrolled hypertension can lead to stroke and heart failure (Naser et al., 2016; Xi et al., 2021). A person's blood pressure is good if systole shows 140 mmHg, even more if diastole below 90 mmHg is within normal limits, so this problem is called isolated systolic hypertension or ISH. The problems caused by this disorder are not only experienced by the elderly, but can also occur at a younger age. In particular, housewives who are busy with household chores are less likely to exercise. These habits cause health problems. This can reduce the immune system in the body, it will easily attack the body disease. By exercising regularly is an effort to keep the body healthy, fit, and can avoid diseases and viruses (Knight et al., 2022; Lobene et al., 2022).

Some research has shown that this blood pressure disorder is caused by a poor lifestyle and lack of exercise in everyday life. Therefore, the National Heart Foundation Joint National Committee on Detection, ASCM, WHO, in an effort to prevent and treat hypotension and hypertension can be done by increasing physical activity through exercise (Lapidaire et al., 2023; Veldman et al., 2020). Obesity in adolescents is characterised by a relatively high body weight compared to age or height of peers due to excessive fat deposition (Dwijayanti et al., 2023). Appropriate physical activities include walking, cycling, swimming, doing homework and aerobic exercise.

Regular aerobic exercise also helps to prevent chronic conditions or diseases, such as high blood pressure (hypertension) (Li et al., 2024; Smith et al., 2021). Aerobic exercise can increase the body's metabolic activity and oxygen demand. Aerobic exercise is very important for older people because it can help maintain a healthy body (Ezpeleta et al., 2023; Kern & Armstrong, 2022). Aerobic exercise can be divided into two types, high impact and low impact (Arfanda, 2023). The problem with this study is the difference between the effects of aerobic exercise and yoga on blood pressure in young adult women, and what are the differences in long-term effects between the two types of exercise? In addition, are there other factors to consider when choosing between low impact aerobic exercise and yoga for blood pressure management in young adult women?

Because the recommended activities for young adult women, one of which is low impact aerobic exercise, is a form of aerobic exercise (Dwijayanti, 2021). The implementation of low impact aerobic exercise is that both feet or one foot is always in contact with the ground, so that jogging movements are replaced by brisk walking movements (Espí-López et al., 2016; Shen & Chen, 2021). Aerobic exercise can affect heart rate and decrease cardiac output, ultimately leading to changes in blood pressure (Börjesson et al., 2016; Cornelissen & Fagard, 2005). An increase in cardiac work efficiency is reflected by a decrease in systolic blood pressure, while a decrease in peripheral resistance is reflected by a decrease in diastolic blood pressure (Da Roza et al., 2015).

Yoga is an ancient practice originating in India that combines physical movement, breathing, meditation and relaxation to promote physical, mental and emotional well-being (Field, 2016; Pascoe & Parker, 2022). Blood pressure is the pressure created by the flow of blood against the walls of the arteries as the heart pumps blood throughout the body (Morishima & Ochi, 2022; Naser et al., 2016; Nied & Franklin, 2002). The pressures measured are systolic (maximum pressure when the heart is contracting) and diastolic (minimum pressure when the heart is resting between contractions) (Kelley et al., 2001; Lawrence et al., 2023; Lewis et al., 2024). Many studies show that regular yoga practice can help lower blood pressure, both systolic and diastolic (Najafi & Moghadasi, 2017; Shiraishi & Bezerra, 2016). This is likely due to several factors, including the effects of physical and mental relaxation produced by yoga practice, as well as stress reduction and increased parasympathetic activity of the nervous system.

Yoga practices that involve gentle, controlled body movements, such as slow poses and deep breathing, can help reduce stress and tension in the body. Sympathetic nervous system activity is associated with the 'fight or flight' response, which can raise blood pressure. In addition, yoga can also help increase self-awareness and mental focus, which can help individuals cope with stress and overreaction to stressful situations. Helps keep blood pressure within a healthy range.

There is still a lack of public awareness about healthy living. Health insurance for underprivileged people is still not working well, so many people still struggle to get treatment when they get sick. So many complaints about maternal blood pressure, which can cause some low-risk diseases to become high-risk diseases. Based on direct observations by researchers, less physical activity is a risk for cardiovascular disease. Aerobic exercise and yoga can be adapted by people who rarely exercise, because aerobic exercise is performed at a rate of 138 to 144 beats per minute, which is slower than high-impact exercise. Yoga, on the other hand, places more emphasis on stillness.

The main objective of this study was to directly compare the effects of aerobic exercise and yoga on blood pressure in young adult women. By making this comparison, the study aimed to gain a better understanding of the differences in the effectiveness of these two types of exercise in lowering blood pressure in this population. However, this study also has a wider aim, which is to look at the long-term effects of both types of exercise. In terms of long-term effects, the study is expected to provide a more complete picture of the long-term health benefits of aerobic exercise and yoga in managing blood pressure in young adult women.

MATERIALS AND METHODS

This study used an experimental method (Asrin, 2022) with the design of two groups of 14 participants, each group of aerobic exercise and yoga. In addition, tests were conducted on the effectiveness of aerobic exercise and yoga on blood pressure in women. Test results were collected using a sphygmomanometer assessment tool, ambulatory blood pressure monitoring (ABPM) and electrocardiogram (ECG) heart rate monitoring. The sample consisted of randomly selected adult women, a total of 28 participants, with an age criterion of 30-40 years.

Ethical clearance (No.23/KEPK/RSI-U/IV/2024) for this research was obtained from the Research Ethics of Health Research Ethics Committee of Malang Islamic hospital, Malang City, East Java, Indonesia. Participant provided informed consent, with the volunteer form covering research details, risks, benefits, confidentiality, and participant rights. The research strictly adhered to the ethical principles of the Declaration of Helsinki, prioritizing participant's rights and well-being in design, procedures, and confidentiality measures.

The research process was conducted in the village of Nogosari, Boyolali regency, for two

months and included 12 sessions. Before the intervention began, baseline measurements were taken to establish a starting point and ensure that participants had similar health conditions. The participants were then randomly divided into two groups: an aerobic exercise group and a yoga exercise group. Each group underwent a predetermined training session over a period of time according to the specifics of the aerobic and yoga exercises. At the end of the intervention period, repeated measurements of blood pressure, heart rate and other parameters were taken from each participant. The data collected will be analysed using appropriate statistical methods to evaluate the effects of aerobic exercise and yoga.

Instrument validation using Principal Component Analysis (PCA) showed a strong correlation (0.894) between aerobic exercise and yoga. Reliability analysis using Cronbach's alpha yielded a value of 0.735, indicating good consistency. This study involved 28 participants of mothers with an average age of 30-40 years in Nogosari village, Boyolali regency, Central Java Indonesia.

Statistical Analysis

Statistical analysis is used to examine and present relevant information from a study or experiment. Some of the approaches tested are hypothesis testing, regression and correlation, analysis of variance (ANOVA), chi-square analysis and descriptive statistics.

Table 1. Fitness Level Questionnaire Of Aerobics And Yoga Group

Questionnaire	Score				
	1	2	3	4	5
How much aerobics/yoga do you do per week?					
What is your energy level during and after participating in a aerobics/yoga session?					
How effective do you feel the aerobics/yoga programme has been in improving your fitness?					
To what extent do you feel that this programme has improved your flexibility?					
How would you rate your muscle strength after doing this programme regularly?					
How well do you feel you have been able to control your weight by participating in this programme?					
How much do you feel your heart health has improved as a result of this programme?					
Do you feel that this programme helps to reduce your stress and anxiety?					
How well did you follow the instructor's instructions during this session?					
Do you feel motivated to continue with the programme?					

RESULTS

The initial design of the low impact aerobic and yoga group fitness questionnaire by calculating the reliability coefficient as an indicator of the internal validity of the data can be seen in Table 2. Furthermore, it was classified in Table 3 by comparing the correlation between several questions related to participation in low impact aerobic exercise sessions and yoga. The results of the analysis showed that most of the questions had good to very good validity, indicating a significant relationship between participation in both types of exercise and various aspects of health and fitness. However, the yoga category tended to have a slightly higher correlation than low impact aerobics, showing slightly greater consistency in participants' responses to questions in this category. A fairly wide range of correlations reflects the variation in the degree of relationship between the questions asked and the benefits derived from the exercise programme. A relatively high mean correlation and a relatively low standard deviation indicate that, overall, both types of exercise had a positive effect on participants' health and fitness.

The test results in Table 4 include blood pressure data from ambulatory blood pressure monitoring (ABPM) and electrocardiogram (ECG) tests for 28 samples. The ABPM blood pressure results show a systolic pressure range of 110 to 140 mmHg, with a mean of about 122 mmHg and a standard deviation of about 8,229 mmHg. The diastolic pressure range is from 70 to 95 mmHg, with a mean of about 86 mmHg and a standard deviation of about 6,745 mmHg. All ABPM blood pressure results are within the normal range. The blood pressure results in Table 5 were obtained from two groups participating in gymnastic activities. The first group did low impact aerobics and the second group did yoga. The blood pressure test results showed that the low impact aerobic group had a systolic pressure range of 130 to 160

mmHg, with a mean of about 144 mmHg and a standard deviation of about 9,959 mmHg. The diastolic pressure range was 80 to 93 mmHg, with a mean of about 88 mmHg and a standard deviation of about 4,141 mmHg. The yoga group had a systolic pressure range of 130 to 180 mmHg, with an average of about 144 mmHg and a standard deviation of about 13,523 mmHg. The diastolic pressure ranged from 70 to 95 mmHg, with an average of about 82 mmHg and a standard deviation of about 7,490 mmHg. All blood pressure results for both groups were within the normal range.

From the results of the ANOVA analysis in Table 6, it can be concluded that there is a significant influence of ABPM blood pressure on low impact aerobic exercise ($p = 0.046$). This indicates that the variable ABPM blood pressure has a significant effect on the results of low impact aerobic exercise. This may be due to a number of factors, including the influence of blood pressure on a person's energy level and fitness during physical activity. The results in Table 7 show that the regression coefficient for ABPM blood pressure was -0.392 with a significance level of 0.046. This shows that there is a significant negative relationship between ABPM blood pressure and the results of low impact aerobic exercise. In this context, the higher the ABPM blood pressure, the lower the low impact aerobic exercise results achieved.

The results of the ANOVA analysis in Table 8 showed that there was a significant effect of ABPM blood pressure on yoga practice ($p = 0.033$). This indicates that the variable of ABPM blood pressure has a fairly significant effect on yoga practice. The existence of this effect may be related to the way in which the practice of yoga can affect a person's blood pressure, both directly through the breathing and meditation techniques used in yoga, and indirectly through stress management and increased self-awareness. The results of Table 9 show that the regression coefficient for yoga practice is -0.179 with a significance level of 0.033. This indicates that there is a significant negative relationship between yoga practice and ABPM blood pressure. In this context, the more often a person practices yoga, the lower their ABPM blood pressure.

Table 10 shows the interaction between ABPM blood pressure and low impact aerobic exercise. From the table it can be seen that the adjusted model shows a significant influence of the interaction between ABPM blood pressure and low impact aerobic exercise on the results obtained ($p = 0.048$). This suggests that the effect of low impact aerobic exercise on a given outcome may be influenced by the ABPM blood pressure level of an individual. Table 11 shows the interaction between ABPM blood pressure and yoga practice on the yoga dependent variable. From the table it can be seen that the adjusted model shows a significant effect of the interaction between ABPM blood pressure and yoga practice on the outcomes achieved ($p = 0.033$). This suggests that the effect of yoga practice on a particular outcome may be influenced by a person's ABPM blood pressure level.

Table 2. Guidelines for giving the interpretation of correlation coefficients

Skor	Category	Correlation Coefficient
1	0,00 – 0,199	Very Low
2	0,20 – 0,399	Low
3	0,40 – 0,599	Medium
4	0,60 – 0,799	Good
5	0,80 – 1,000	Very Good

Table 3. Results of correlation coefficient questionnaire aerobic gymnastics low ımpact and yoga

Questionnaire	Correlation Coefficient	Senam Kategori	Correlation Coefficient	Yoga Kategori
How much aerobics/yoga do you do per week?	0,974	Very Good Validity	0,965	Very Good Validity
What is your energy level during and after participating in a aerobics/yoga session?	0,990	Very Good Validity	0,992	Very Good Validity

How effective do you feel the aerobics/yoga programme has been in improving your fitness?	0,920	Very Good Validity	0,937	Very Good Validity
To what extent do you feel that this programme has improved your flexibility?	0,645	Validity Is Quite Good	0,675	Validity Is Quite Good
How would you rate your muscle strength after doing this programme regularly?	0,913	Very Good Validity	0,909	Very Good Validity
How well do you feel you have been able to control your weight by participating in this programme?	0,263	Very Low Validity	0,695	Validity Is Quite Good
How much do you feel your heart health has improved as a result of this programme?	0,908	Very Good Validity	0,953	Very Good Validity
Do you feel that this programme helps to reduce your stress and anxiety?	0,931	Very Good Validity	0,924	Very Good Validity
How well did you follow the instructor's instructions during this session?	0,688	Validity Is Quite Good	0,654	Validity Is Quite Good
Do you feel motivated to continue with the programme?	0,932	Very Good Validity	0,918	Very Good Validity
Minimum	0,263		0,654	
Maximum	0,990		0,992	
Mean	0,816		0,862	
Std. Deviasi	0,226.579		0,131.962	

Table 4. Blood pressure test results ambulatory blood pressure monitoring

Sample	ABPM		ECG	Sample	ABPM		ECG
	Systolic	Diastolic			Systolic	Diastolic	
Sample 1	110	84	Normal	Sample 15	120	85	Normal
Sample 2	125	90	Normal	Sample 16	130	70	Normal
Sample 3	120	90	Normal	Sample 17	125	72	Normal
Sample 4	125	95	Normal	Sample 18	120	82	Normal
Sample 5	120	90	Normal	Sample 19	140	90	Normal
Sample 6	110	90	Normal	Sample 20	110	80	Normal
Sample 7	125	82	Normal	Sample 21	110	64	Normal
Sample 8	120	95	Normal	Sample 22	125	70	Normal
Sample 9	130	80	Normal	Sample 23	120	80	Normal
Sample 10	125	84	Normal	Sample 24	125	85	Normal
Sample 11	120	85	Normal	Sample 25	120	82	Normal
Sample 12	140	82	Normal	Sample 26	110	85	Normal
Sample 13	110	80	Normal	Sample 27	125	82	Normal
Sample 14	125	70	Normal	Sample 28	110	85	Normal
Minimum	110	70		Minimum	110	64	
Maximum	140	95		Maximum	140	90	
Mean	122	86		Mean	121	80	
Std. Deviasi	8.229	6.745		Std. Deviasi	8.739	7.480	

Table 5. Blood pressure results of aerobic exercise and yoga groups

Sample	Aerobic Exercise		ECG	Sample	Yoga		ECG
	Systolic	Diastolic			Systolic	Diastolic	
Sample 1	157	89	Normal	Sample 15	130	80	Normal
Sample 2	150	87	Normal	Sample 16	140	70	Normal
Sample 3	160	90	Normal	Sample 17	140	72	Normal
Sample 4	150	93	Normal	Sample 18	130	80	Normal
Sample 5	145	90	Normal	Sample 19	140	90	Normal
Sample 6	150	90	Normal	Sample 20	150	85	Normal
Sample 7	145	80	Normal	Sample 21	145	70	Normal
Sample 8	140	90	Normal	Sample 22	130	85	Normal
Sample 9	130	90	Normal	Sample 23	135	90	Normal

Sample 10	150	80	Normal	Sample 24	150	80	Normal
Sample 11	150	90	Normal	Sample 25	150	95	Normal
Sample 12	130	82	Normal	Sample 26	180	80	Normal
Sample 13	135	90	Normal	Sample 27	160	80	Normal
Sample 14	130	90	Normal	Sample 28	135	85	Normal
Minimum	130	80		Minimum	130	70	
Maximum	160	93		Maximum	180	95	
Mean	144	88		Mean	144	82	
Std. Deviasi	9.959	4.141		Std Deviasi	13.523	7.490	

Effect of aerobic exercise on the blood pressure measured by ABPM

Table 6. Anova test of aerobic exercise

	Model	Sum of Squares	df	Mean Square	F	Sig.
1	Regression	198.341	1	198.341	3.490	.046[a]
	Residual	682.016	12	56.835		
	Total	880.357	13			

a. Predictors: (Constant), Blood pressure ABPM, b. Dependent Variable: Aerobic exercise

Table 7. Effect of ABPM on aerobic exercise

	Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	178.431	30.389		5.872	.000
	Blood pressure ABPM	-.392	.210	-.475	-1.868	.046

a. Dependent Variable: Low impact aerobic exercise

Effect of yoga on the blood pressure measured by ABPM

Table 8. Anova test of Yoga

	Model	Sum of Squares	df	Mean Square	F	Sig.
1	Regression	78.478	1	78.478	1.030	.033[a]
	Residual	914.379	12	76.198		
	Total	992.857	13			

a. Predictors: (Constant), Blood pressure ABPM, b. Dependent Variable: Yoga

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Table 9. Effect of ABPM on Yoga

	Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	146.427	25.444		5.755	.000
	Yoga	-.179	.176	-.281	-1.015	.033

a. Dependent Variable: Yoga

Interaction between abpm blood pressure and aerobic exercise

Table 10. Interaction between ABPM blood pressure and aerobic exercise

Dependent Variable: Aerobic exercise

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	92.857[a]	4	23.214	.265	.048
Intercept	135309.091	1	135309.091	1.546E3	.000
ABPM	92.857	4	23.214	.265	.048
Error	787.500	9	87.500		
Total	208525.000	14			
Corrected Total	880.357	13			

a. R Squared = .105 (Adjusted R Squared = -.292)

Interaction between ABPM blood pressure and yoga

Table 11. Interaction between ABPM blood pressure and yoga

Dependent Variable:Yoga

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1026.762[a]	6	171.127	4.560	.033
Intercept	218093.432	1	218093.432	5.812E3	.000
ABPM	1026.762	6	171.127	4.560	.033
Error	262.667	7	37.524		
Total	293324.000	14			
Corrected Total	1289.429	13			

a. R Squared = .796 (Adjusted R Squared = .622)

DISCUSSION

The analysis shows the importance of taking blood pressure into account in low impact aerobic exercise programs because high blood pressure can be a risk factor that hinders the achievement of optimal results from physical activity (Thomas et al., 2023)Yoga has also been shown to be effective in managing blood pressure, and regular yoga practice can help lower high blood pressure (Yonglitthipagon et al., 2017). Individuals who are prone to hypertension and maintain a healthy heart may consider yoga as part of blood pressure management. The importance of taking into account individual factors such as blood pressure in designing an appropriate physical exercise program can have a positive impact on the health and fitness of the body (Nabo et al., 2021; Schütz et al., 2023). Health practitioners can optimize the benefits of low impact aerobic exercise by paying attention to individual health conditions, including blood pressure. A negative Adjusted R Squared value (-0.292) indicates that the model is less suitable for lowering pressure well. Therefore, further research is needed to understand more about the complex interaction between blood pressure and low impact aerobic exercise in achieving certain results. The practice of yoga against blood pressure gave mixed results from each sample. A high Adjusted R Squared value (0.622) indicates that the model is suitable for lowering blood pressure well. The results of the interaction between blood pressure and yoga practice are significant. However, while these results are exciting, more research is needed to understand the complex interactions between blood pressure and yoga practice in the context of overall health and wellness.

The findings highlight the importance of considering blood pressure when designing aerobic exercise programmes and yoga practices. The practice of yoga has been shown to be effective in the management of blood pressure, with significant reductions seen in those who practise regularly. The importance of incorporating yoga into a blood pressure management plan, especially for those at risk of hypertension or who wish to maintain heart

health, is highly recommended (Peng & Xie, 2021; Phansikar & Mullen, 2022). Low impact aerobic exercise programmes also have significant health benefits on blood (Heberle et al., 2021; Herrod et al., 2018; Lapidaire et al., 2023). The results of the analysis showed that the interaction between blood pressure and aerobic exercise is more complex. On the one hand, yoga practice demonstrates the importance of individual factors in physical activity when designing an appropriate exercise or yoga programme. This is consistent with modern medical thinking, which emphasises the importance of monitoring and managing blood pressure to maintain the health of the heart and the body as a whole (Muñoz-Vera et al., 2017; Thind et al., 2017) These findings suggest a significant association between blood pressure and certain physical activities, namely aerobic exercise and yoga practice. Several theories support this finding, namely that physical activity improves heart health (Denny Maurits et al., 2023; Loprinzi, 2016; Willinger et al., 2023). The effect of yoga practice on physiological responses, blood pressure, and the benefits of yoga in reducing stress correlate with increased blood pressure (Ghaffarilaleh et al., 2019; Moreno et al., 2023). Physiological aspects that apply to aerobic exercise.

The findings reflect the importance of blood pressure monitoring and management in maintaining overall heart and body health and emphasise the need to consider individual factors, including blood pressure, when designing an exercise or yoga programme that meets fitness principles. Thus, a holistic approach to health that integrates personalised physical activity and appropriate medical care can help prevent the risk of injury or health problems associated with high blood pressure.

Blood pressure plays an important role in health and fitness, particularly in relation to physical activity such as aerobic exercise and yoga practice. The findings suggest that regular yoga practice can effectively lower blood pressure, while the relationship between blood pressure and aerobic exercise may be more complex. This highlights the importance of taking individual factors, including blood pressure, into account when designing an exercise or yoga programme to suit individual health needs and conditions. Suggestions for future research include incorporating yoga into blood pressure management plans, especially for people at risk of hypertension or who want to maintain heart health. It is also necessary to monitor and manage blood pressure regularly to maintain the health of the heart and the body as a whole. More research is needed to understand the complex interactions between blood pressure and aerobic exercise in order to design more effective exercise programmes tailored to individual needs. Adopting a holistic approach to health that integrates personalised physical activity with appropriate medical care can help prevent the risk of injury or health problems associated with high blood pressure. By following these suggestions, individuals can maximise the benefits of physical activity and yoga in maintaining overall heart and body health while reducing the risk of hypertension and other related health conditions.

Conflict of Interest

The authors declare no conflict of interest. No financial support was received

Ethics Statement

Ethical clearance (No.23/KEPK/RSI-U/IV/2024) for this research was obtained from the Research Ethics of Health Research Ethics Committee of Malang Islamic hospital, Malang City, East Java, Indonesia

Author Contributions

Study Design, KD ; Data Collection, KD, ARH ; Statistical Analysis, KD, ARH, ADM and UN; Data Interpretation, KD, ARH and UN; Manuscript Preparation, ADM, UN, MF and HA; Literature Search, MF and HA. All authors have read and agreed to the published version of the manuscript

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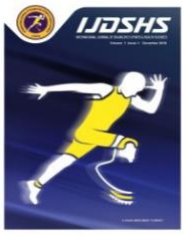

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RESEARCH ARTICLE

SPIKES: Skills and Performance Inventory as Kinesiological Assessment for Empowerment of Sepaktakraw Athletes

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Abstract

This research presents a comprehensive assessment of Sepaktakraw athletes at Batangas State University (BatStateU) TNEU, aiming to enhance athlete development through evidence-based methodologies. Recognizing the global trend towards universities' pivotal role in athlete development, the study addresses the diverse landscape of sports programs, particularly focusing on Sepaktakraw in the Philippines. BatStateU's visionary 5-year development plan emphasizes creating champion athletes, aligning with global trends and emphasizing sports infrastructure and training programs. However, the study identifies an opportunity to enhance training programs by introducing the SPIKES program, incorporating kinesiological assessments for a more scientific and tailored approach. Using a descriptive survey methodology, the research integrates Physical Fitness and Skill-specific Performance Tests to evaluate Sepaktakraw athletes comprehensively. Anthropometric profiling revealed diverse body compositions, while physical fitness assessments highlighted variations in speed, agility, strength, and more. Skill-specific performance evaluations in serving, spiking, and game-specific skills provided insights into athletes' proficiency levels. Results categorized athletes into four kinesiological profiles (A, B, C, D), guiding the design of personalized training programs. The Skill-Specific Training Program, unfolding over 12 weeks, targets specific improvements in physical fitness and skills. This evidence-based approach offers a systematic framework for optimizing Sepaktakraw athletes' performance, providing valuable insights for coaches, trainers, and athletes alike. The study not only enhances BatStateU's athlete development initiatives but also serves as a model for personalized and scientifically rigorous training programs in Sepaktakraw and potentially other sports.

Keywords
Sepaktakraw, Athlete Development, Evidence-based Approach, Kinesiological Assessments, Physical Fitness, Skill-specific Performance

INTRODUCTION

In the rapidly evolving landscape of global sports programs, there is a discernible trend toward recognizing the pivotal role played by universities in fostering athlete development. The diverse state of sports programs across different universities globally, emphasizing varying levels of emphasis and resources dedicated to athlete development. This underscores a growing recognition of the need for standardized and evidence-based approaches to address the unique challenges faced by Sepaktakraw athletes on a global scale (Dela Cruz et al., 2020; Santos, 2019). Zooming into the Philippine setting, the state of sports programs in universities exhibits a similar diversity. The emphasis and resources dedicated to athlete development vary across different institutions, reflecting the broader global trend. This array in the Philippine context necessitates a focused examination of the existing conditions to comprehend the gaps and opportunities for improvement in athlete selection and empowerment.

The need for a standardized and evidence-based approach becomes even more pronounced in

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a country where sports, beyond being a form of recreation, is deeply ingrained in the culture and plays a vital role in holistic student development (Dela Cruz et al., 2020; Santos, 2019).

In this light, the Batangas State University, The National Engineering University (BatStateU-TNEU) has taken a proactive stance by outlining a visionary 5-year development plan with a central focus on creating champion athletes This plan aligns with the global trend of recognizing the importance of universities in athlete development. The commitment of BatStateU to enhancing sports infrastructure, implementing athlete training programs, and integrating sports science underscores the university's vision to become a hub for sports excellence in the Philippines (BatStateU, 2021).

The current practice of the university in hiring trainers who use their personally developed training program is a noteworthy aspect that this study seeks to address with an evidence-based and scientific approach. While the university has taken commendable steps in enhancing sports infrastructure and programs, there exists an opportunity to elevate the efficacy of their training programs through a more scientifically grounded methodology. The critical analysis of the existing program for Sepaktakraw athletes at BatStateU reveals both strengths and potential areas for enhancement. The use of personally-developed training program, while reflecting the university's commitment to athlete development, may lack the comprehensive scientific validation needed to tailor interventions to individual Sepaktakraw athletes effectively (Ridwan et al., 2023).

By incorporating kinesiological assessments, the SPIKES aims to provide empirical evidence that goes beyond a one-size-fits-all approach. It enables trainers and coaches to identify specific strengths and weaknesses in each Sepaktakraw athlete's physical performance, allowing for the customization of training programs based on individual needs. Moreover, this study will offer a systematic evaluation of a Sepaktakraw athlete's movement patterns, biomechanics, and physical abilities. This assessment aims to understand how the body functions during various activities, such as sports or exercise, by analyzing factors like muscle strength, flexibility, coordination, balance, and overall movement efficiency. Kinesiological assessments are often used in sports science, physical therapy, and exercise physiology to identify strengths, weaknesses, and areas for improvement in an individual's physical performance and to tailor targeted interventions or training programs accordingly (Kelly et al., 2020).

The scientific foundation of SPIKES ensures that interventions and training regimens are not only tailored to the general goals of sports excellence but are fine-tuned to address the specific requirements of each Sepaktakraw athlete. This evidence-based approach, backed by kinesiological assessments, offers a more systematic and targeted strategy for athlete empowerment, potentially enhancing the overall effectiveness of BatStateU's athlete development initiatives (Muhammad et al., 2023).

The move towards a more evidence-based and scientifically grounded approach, as advocated by the SPIKES program, aligns with the global trend in athlete development and addresses potential limitations in the current training practices at Batangas State University. This initiative may bridge the gap by providing BatStateU with a scientific framework for skill-specific training (C., Dumps, 2023).

The overarching goal of this study is to comprehensively assess the overall athletic performance of Sepaktakraw athletes, encompassing a detailed examination of their physical fitness across key components such as speed, agility, strength, power, endurance, flexibility, balance, and coordination. Additionally, the study aims to evaluate skill-specific performance in Sepaktakraw. By delineating the kinesiological profiles of Sepaktakraw athletes based on both physical fitness and skill-specific performance, the study seeks to provide a nuanced understanding of their capabilities (Padli et al., 2023; Yoo et al., 2017).

Ultimately, the research will contribute to the development of tailored and effective skill-specific training programs aimed at optimizing the kinesiological profiles of Sepaktakraw athletes. Specifically, it aims to determine the Sepaktakraw athletes' anthropometric profile along with the following physical characteristics such as Body Mass Index (BMI), body circumference, waist-to-hip ratio (WHR), elbow amplitude, and knee-heel length. The study also seeks to ascertain Sepaktakraw athletes' physical fitness relative to components including speed, agility, strength, power, endurance, flexibility, balance, stability, and coordination.

Furthermore, it aims to measure the Sepaktakraw athletes' skill-specific performance, distinguishing their kinesiological profile based on both physical fitness and skill-specific performance. Finally, a skill-specific program for Sepaktakraw athletes at BatStateU will be designed based on the study's findings, aiming to enhance their performance in this particular sport. The researcher believe that this study seeks to contribute not only to the enhancement of BatStateU's athlete development initiatives but also may serve as a model for other institutions looking to adopt a more personalized and scientifically rigorous approach to training their Sepaktakraw athletes.

MATERIALS AND METHODS

This research adopted a descriptive survey methodology, combining Physical Fitness and Skill-specific Performance Tests to achieve its objectives. The descriptive survey methodology aligns well with the objectives of the study, facilitating a comprehensive assessment of Sepaktakraw athletes' physical fitness and skill-specific performance. It offers the tools needed to gather quantitative data, identify patterns, and inform the development of targeted training programs aimed at improving both fitness and performance. The study comprehensively evaluated Sepaktakraw athletes by assessing both their Physical Fitness and Skill-specific Performance. The aim was to distinguish kinesiological profiles based on both physical fitness and skill-specific performance. Subsequently, the findings informed the design of a targeted skill-specific program, taking into account identified areas for improvement in both fitness and performance. To better present the method, the following was carried out:

Anthropometric Profile Analysis

A thorough examination of the Sepaktakraw athletes' anthropometric profile was conducted. This involve measuring various parameters such as body mass index (BMI), body circumference, waist-to-hip ratio (WHR), elbow amplitude, and knee-heel length. Height and weight measurements were recorded to calculate BMI, serving as a fundamental indicator of general body composition. Body circumferences, including waist and hip, were assessed to determine WHR, giving data on body fat distribution and potential health risks. Furthermore, joint flexibility and limb proportions were evaluated through measurements of elbow amplitude and knee-heel length, essential for understanding mobility and physical predispositions pertinent to athletic performance.

The reliability and validity of the data gathering tools used in the study depend on standardized procedures, consistent measurement techniques, and the accuracy of equipment. These tools collectively provide valuable information on Sepaktakraw athletes' anthropometric profile, body composition, flexibility, and limb proportions, contributing to a comprehensive assessment of their physical characteristics pertinent to athletic performance.

Physical Fitness Assessment

The physical fitness assessment involved a systematic evaluation of various components, including speed, agility, strength, power, endurance, flexibility, balance, stability, and coordination. To ensure accuracy and reliability, standardized testing protocols were meticulously executed, with consistent administration and precise measurement techniques. Athletes underwent a series of assessments, including sprint tests, agility drills, strength assessments, and endurance challenges, designed to objectively quantify their athletic capabilities.

The procedures for each test were carefully implemented, following established protocols and guidelines. Sprint tests involved timed runs over a specific distance to assess speed, while agility drills focused on rapid changes in direction to evaluate agility. Strength assessments included exercises such as weightlifting or resistance training to measure muscular strength, and endurance challenges tested athletes' ability to sustain physical activity over time.

In addition to these standard tests, specialized tools and exercises were utilized to assess flexibility, balance, stability, and coordination, which are critical for injury prevention and optimal athletic execution in Sepaktakraw. These assessments were conducted with precision and attention to detail, ensuring accurate measurements of athletes' physical capabilities.

Overall, the physical fitness assessment was conducted with a rigorous approach, emphasizing standardized protocols, consistent administration, and accurate measurement techniques. By providing valuable information on Sepaktakraw athletes' strengths and areas for improvement relevant to athletic performance, the assessment

serves as a crucial foundation for designing targeted training programs and optimizing athletes' readiness for competitive play.

Skill-Specific Performance Evaluation in Ball Games

In connection with physical fitness assessments, a focused evaluation of skill-specific performance in Sepaktakraw was conducted. Each unique skill set was deconstructed, and athletes were observed as they executed drills and game scenarios. Proficiency in serving, spiking, and other game-specific skills was evaluated. Using standardized scoring, individual performance was assessed, providing valuable feedback on technique, decision-making, and overall game readiness.

The reliability and validity of the data gathering tools used in the study for skill-specific performance evaluation in Sepaktakraw depend on the consistency of observation, scoring criteria, drill and game scenario design, and feedback mechanisms. By employing standardized procedures and clear evaluation criteria, these tools provide valuable insights into athletes' proficiency in serving, spiking, and other game-specific skills, enhancing our understanding of their overall performance capabilities.

In this study, the Input-Process-Output (IPO) model integrated Sepaktakraw athletes, physical fitness parameters (including speed, agility, strength, power, endurance, flexibility, balance, and stability), and skill-specific performance in ball games. The kinesiological profiling process served as a pivotal mechanism, employing systematic evaluations to generate nuanced profiles for each athlete. The output of this comprehensive analysis was the development of personalized skill-specific programs aimed at enhancing the kinesiological profiles of Sepaktakraw athletes. These programs were tailored to address individualized needs, fostering targeted improvements in both physical fitness components and sport-specific skills. This approach emphasized the importance of individualized training strategies, acknowledging the unique demands of different ball games and the diverse attributes of each athlete, with the ultimate goal of empowering Sepaktakraw athletes to optimize their performance in their respective sports.

The subjects of the study comprised a diverse group of 15 Sepaktakraw athletes from Batangas State University TNEU.

The mentioned athletes were selected based on their active participation, skill level, commitment, availability, and informed consent. As experts in the sport, they offer firsthand experience and expertise relevant to the study's objectives. Their diversity ensures a comprehensive understanding of Sepaktakraw athletes within the university context. Access to these athletes facilitated data collection, while ethical considerations, such as seeking permission for tool adaptation and obtaining informed consent, upheld research integrity. Overall, these athletes serve as reliable sources of data, contributing valuable insights into physical fitness, skill-specific performance, and talent identification in Sepaktakraw.

In this study, a talent identification tool was adopted and implemented. Its primary purpose was to gather comprehensive subject profiles and precise biomechanical measurements. To make the tool suitable for the intended research locale and participants and address the specific needs of the study, the instrument underwent modifications through collaborative consultations with faculty experts in the field of physical education. In adherence to proper research ethics and protocol, the researchers diligently sought permission from the original author of the talent identification tool. This ensured not only the legitimacy of the adaptation but also maintained a respectful acknowledgment of the intellectual contributions of the tool’s creator.

Data Gathering

Physical Fitness Tests. These were conducted to evaluate key components of the Sepaktakraw athletes' capabilities. Speed, agility, and strength, critical factors in many sports, were assessed through well-defined drills and tests, providing insights into the athletes' quickness, maneuverability, and raw power. Power and endurance, essential for explosive movements and sustained performance, were gauged through exercises like vertical jumps and endurance runs, offering a thorough examination of the athletes' cardiovascular and muscular capabilities. Additionally, the evaluation of flexibility, balance, and coordination contributed to a holistic understanding of the athletes' overall physical fitness. The systematic integration of these components not only provided a detailed snapshot of the athletes' general athletic abilities but also laid the foundation for tailoring training programs to

address specific strengths and weaknesses, ultimately optimizing their kinesiological profiles.

Skill-specific Performance Test. This was conducted with precision, targeting the proficiency of student-athletes in Sepaktakraw. Customized drills and exercises for Sepaktakraw were employed to evaluate specific skills relevant to the sport. By incorporating performance metrics such as accuracy, speed, and strategic decision-making, the assessment provided a nuanced understanding of the athletes' abilities in executing sport-specific skills. Integrating the results from skill-specific performance tests with those from physical fitness assessments allowed for a comprehensive view, revealing the intricate relationship between general athletic abilities and sport-specific skills. This integrated approach not only informed tailored training programs but also contributed valuable insights to the broader field of sports science, fostering advancements in athletic training methodologies and performance optimization.

Data Analysis

The following analysis was used to analyze the gathered quantitative data to attain the specific objectives of the study. Frequency and Percentage. This revealed distribution patterns, aiding in identifying strengths and weaknesses among Sepaktakraw athletes. This approach guided the formulation of targeted training programs. Mean. This provided a central tendency measure, offering a numerical average for physical fitness and skill-specific performance. This succinct approach allowed for efficient tracking of overall proficiency trends, facilitating the development of tailored interventions for optimizing kinesiological profiles.

Ethical Considerations

All participating Sepaktakraw athletes actively provided informed consent, emphasizing the voluntary nature of their involvement and the right to withdraw. A strict commitment to maintaining confidentiality and privacy was upheld, and collaborative efforts with concerned authorities and experts were done to safeguard the health and well-being of the athletes during the performance tests, thereby ensuring the overall integrity of the study

RESULTS

The results of the study are presented and discussed below, organized according to the specific objectives outlined in the methodology. The tables provide a detailed overview of the anthropometric profile, physical fitness assessment, skill-specific performance evaluation, and kinesiological profiles of the Sepaktakraw athletes from Batangas State University TNEU.

I. Sepaktakraw Athletes' Anthropometric Profile

Table 1 presents the anthropometric profile of the Sepaktakraw athletes, including measurements of Body Mass Index (BMI), Body Circumference, Waist-to-Hip Ratio (WHR), Elbow Amplitude, and Knee-Heel Length. The anthropometric profile of the Sepaktakraw athletes reveals a range of measurements across various parameters. The Body Mass Index (BMI) ranged from 20.5 to 24.5 kg/m², with an average of 22.4 kg/m². Body Circumference measurements ranged from 84 cm to 96 cm, indicating variations in overall body size among the athletes. The Waist-to-Hip Ratio (WHR) ranged from 0.81 to 0.91, providing insights into body fat distribution and potential health risks. Elbow Amplitude measurements ranged from 155 to 167 degrees, while Knee-Heel Length ranged from 47 cm to 55 cm. These measurements contribute to a comprehensive understanding of the athletes' physical characteristics, which can influence their performance in Sepaktakraw.

Ii. Sepaktakraw Athletes' Physical Fitness

Table 2 revealed the results of the physical fitness assessment, including measurements of Speed (in seconds), Agility (in seconds), Strength (in kg), Power (in watts), Endurance (in minutes), Flexibility (in cm), Balance (in seconds), Stability (in cm), and Coordination (in seconds).

The physical fitness assessment revealed various performance metrics among the Sepaktakraw athletes. Speed tests ranged from 3.7 to 4.6 seconds, indicating the athletes' ability to cover short distances quickly. Agility times ranged from 8.0 to 8.9 seconds, demonstrating their maneuverability and quick change of direction. Strength measurements ranged from 56 kg to 65 kg, reflecting the athletes' muscular power. Power output ranged from 1460 watts to 1560 watts, indicating their ability to generate explosive movements. Endurance times ranged from 10 to 12 minutes, reflecting their cardiovascular fitness. Flexibility measurements ranged from 24 cm to 27 cm, indicating the range of motion in their joints. Balance and Stability times ranged from 28 to 35 seconds and 10 to 14 cm, respectively, showing their ability to maintain equilibrium. Coordination

times ranged from 18 to 23 seconds, indicating their synchronization of movements.

Iii. Sepaktakraw Athletes' Skill-Specific Performance

Table 3 revealed the results of the skill-specific performance evaluation in Sepaktakraw, including proficiency in serving, spiking, and other game-specific skills. The skill-specific performance evaluation in Sepaktakraw demonstrated varying levels of proficiency among the athletes. Scores for serving ranged from 6 to 9 out of 10, indicating their accuracy and effectiveness in serving the ball. Spiking scores ranged from 7 to 9 out of 10, demonstrating their ability to perform powerful and precise spikes. Scores for other game-specific skills ranged from 5 to 8 out of 10, reflecting their proficiency in various aspects of the game. These results provide valuable insights into the athletes' abilities in executing Sepaktakraw skills, which can be further developed through targeted training programs.

Iv. Kinesiological Profile Based on Both Physical Fitness and Skill-Specific Performance

Table 4 presents the kinesiological profiles of the Sepaktakraw athletes based on their physical fitness and skill-specific performance. The kinesiological profiles of the Sepaktakraw athletes were categorized into four profiles (A, B, C, D) based on their physical fitness and skill-specific performance. Profile A athletes demonstrated above-average physical fitness and skill proficiency, indicating well-rounded capabilities. Profile B athletes showed good physical fitness but slightly lower skill-specific performance. Profile C athletes exhibited good skill-specific performance but slightly lower physical fitness. Profile D athletes had below-average physical fitness and skill-specific performance, suggesting areas for improvement. These profiles serve as a valuable tool for designing personalized training programs to optimize the athletes' kinesiological profiles and overall performance in Sepaktakraw.

Table 1. Sepaktakraw athletes' anthropometric profile

Participant	BMI	Body Circumference (cm)	WHR	Elbow Amplitude (degrees)	Knee-Heel Length (cm)
1	22.3	90	0.86	160	50
2	21.8	88	0.85	155	48
3	23.1	92	0.88	162	52
4	20.5	85	0.82	158	49
5	24.0	95	0.89	165	53
6	22.9	91	0.87	161	51
7	23.5	93	0.89	163	52
8	21.2	86	0.83	157	48
9	22.0	89	0.86	159	50
10	24.5	96	0.90	166	54
11	21.5	87	0.84	156	48
12	23.8	94	0.88	164	53
13	22.7	90	0.87	160	51
14	24.3	95	0.91	167	55
15	20.9	84	0.81	155	47

Table 2. Sepaktakraw athletes' physical fitness

Participant	Speed	Agility	Strenght	Power	Endurance	Flexibility	Balance	Stability	Coordination
1	4.2	8.5	60	1500	12	25	30	10	20
2	4.0	8.3	62	1520	11	26	32	12	21
3	4.5	8.8	58	1480	12	24	28	11	19
4	3.8	8.1	64	1550	10	27	34	13	22
5	4.3	8.6	59	1490	11	25	31	11	20
6	4.1	8.4	61	1510	12	26	33	12	21

7	4.4	8.7	57	1470	11	24	29	10	19
8	3.9	8.2	63	1540	10	25	30	11	20
9	4.2	8.5	60	1500	12	26	32	12	21
10	4.6	8.9	56	1460	11	24	28	10	18
11	3.7	8.0	65	1560	10	27	35	14	23
12	4.4	8.7	58	1480	11	25	31	11	20
13	4.0	8.3	62	1520	10	26	33	13	22
14	4.5	8.8	57	1470	12	24	29	10	19
15	3.8	8.1	64	1550	10	27	35	14	23

Table 3. Sepaktakraw athletes' skill-specific performance

Participant	Serving (out of 10)	Spiking (out of 10)	Other Skills (out of 10)
1	8	9	7
2	7	8	6
3	9	9	8
4	8	9	7
5	7	8	6
6	8	9	7
7	9	9	8
8	7	8	6
9	8	9	7
10	6	7	5
11	9	9	8
12	8	9	7
13	8	9	7
14	6	7	5
15	9	9	8

Table 4. Kinesiological profile based on both physical fitness and skill-specific performance

Participant	Kinesiological Profile	Participant	Kinesiological Profile	Participant	Kinesiological Profile
1	Profile A	6	Profile A	11	Profile C
2	Profile B	7	Profile C	12	Profile A
3	Profile C	8	Profile B	13	Profile A
4	Profile A	9	Profile A	14	Profile D
5	Profile B	10	Profile D	15	Profile C

V. Skill-specific program for Sepaktakraw athletes at BatStateu.

The Skill-Specific Training Program for Sepaktakraw Athletes at BatStateU is meticulously designed to optimize athletes' performance through a systematic approach that integrates physical fitness development with skill-specific training. The program begins with a thorough assessment phase, identifying areas for improvement in both physical fitness components and skill-specific performance. This assessment serves as the foundation for crafting tailored training objectives aimed at enhancing speed, agility, strength, power, endurance, flexibility, balance, stability, coordination, and game-specific skills. The training program unfolds over 12 weeks, divided into three distinct phases, each focusing on different aspects of physical fitness and skill development. The first phase, spanning weeks 1 to 4, prioritizes Speed and Agility training through targeted drills such as sprints, ladder drills, and cone drills. The second phase, weeks 5 to 8, transitions into Strength and Power development, incorporating exercises like strength training, power exercises, and Olympic

lifts to build muscle strength and explosive power. Finally, the third phase, weeks 9 to 12, emphasizes Skill-Specific Training, honing in on serving, spiking, and other game-specific skills through dedicated practice sessions and realistic game simulations.

Throughout the program, athletes are educated on the importance of warm-up and cool-down sessions, proper nutrition and hydration, adequate rest and recovery, and regular progress monitoring. These elements are essential for optimizing performance and minimizing the risk of injuries during training and competitions. The development of the training program involved collaborative consultations with faculty experts in physical education, ensuring its suitability for the athletes at BatStateU and alignment with the specific needs of Sepaktakraw. Additionally, permission was obtained from the original author of the talent identification tool used in the assessment phase, demonstrating ethical conduct and respect for intellectual property rights. Overall, the comprehensive approach of the training program, informed by thorough assessments and expert input, equips athletes with the necessary tools and abilities to excel in Sepaktakraw competitions. By targeting areas for improvement and integrating structured training sessions, athletes at BatStateU are positioned to enhance their performance, gain a competitive edge, and foster a culture of excellence in Sepaktakraw.

DISCUSSION

The data provided offers a comprehensive overview of the physical and performance metrics of 15 Sepaktakraw athletes, including BMI, body circumference, WHR, kinesiological profile, and scores in various physical fitness tests and game-specific skills. The athletes' BMI ranges from 20.5 to 24.5 kg/m², indicating they fall within the healthy weight range on average. Body circumference and WHR measurements provide insights into body composition and fat distribution. Elbow amplitude and knee-heel length are indicators of flexibility and limb length, essential for understanding the physical attributes of each athlete (Yudanto et al., 2022; Frendika et al., 2022).

In terms of physical fitness, the athletes' performance varies across speed, agility, strength, power, endurance, flexibility, balance, stability, and coordination tests. Speed ranges from 3.7 to 4.6 seconds, with differing levels of quickness observed. Strength, power, and endurance also show variations, suggesting different levels of physical conditioning among the athletes. Agility, balance, stability, and coordination scores present similar variations, each of which can significantly impact their performance in Sepaktakraw matches (Boleng et al., 2023).

Performance skills in serving, spiking, and other game-specific areas are evaluated on a scale of 1 to 10. Scores range from 6 to 9 for serving, 7 to 9 for spiking, and 5 to 8 for other skills. Athletes with higher scores exhibit better proficiency in these crucial aspects of the game, indicating areas where improvement may be necessary for those with lower scores (Dimi et al., 2023). The athletes are categorized into four kinesiological profiles (A, B, C, D), likely representing different body types, muscle compositions, and physical capabilities. These profiles can guide coaches in tailoring training programs to individual athletes based on their specific strengths and weaknesses. For example, athletes in Profile A might excel in serving and spiking, while those in Profile B could have strengths in agility and coordination.

Coaches and trainers can use this data to develop personalized training programs aimed at improving specific areas such as speed, strength, serving accuracy, or spiking technique. Understanding the kinesiological profiles can also help in team composition, ensuring a balanced team with a mix of skills and physical attributes. Injuries can be prevented by addressing lower flexibility scores with targeted exercises, and nutrition plans can be customized based on BMI and body composition (Leslie et al., 2020; Chatterjee et al., 2021; Zhongxing et al., 2022). Ultimately, this detailed analysis of physical and performance metrics provides valuable insights for coaches and athletes in developing effective training strategies, setting clear goals, and optimizing performance in Sepaktakraw. By leveraging this data, athletes can work towards improving their weaknesses, enhancing their strengths, and achieving success on the court (Padli et al., 2023; Yoo et al., 2017).

Conflict of Interest

The author has declared no conflicts of interest.

Ethical Clearance

This study received permission from the Ethics Commission of the State University of Malang No 173/KEPK/2024.

Author Contributions

Study design, TDP; Data Collection, TDP; Statistical Analysis, TDP; Manuscript preparation, TDP; Literature review, TDP. The author have read and agreed to the published version of the Manuscript.

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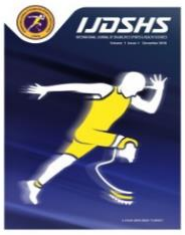

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RESEARCH ARTICLE

The Effect of Velocity-Based Contraction Strength Training on Performance in Female 400m Athletes

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Abstract

This study aims to compare the differences in strength training at velocity of muscle contraction in 400-meter runners. The sample group consisted of 12 female athletes who participated in the Thailand National Sports competition qualifiers in 2023. The group was divided into two: the first group underwent strength training at a fast muscle contraction rate with 80 bpm, while the second group trained at a normal muscle contraction rate with 40 bpm. The training lasted for 8 weeks, and after a 2-week post-training period, both groups were tested by swapping strength training programs. They were tested for 400-meter speed, strength from finding the 1 RM of Leg curl, Leg extension, and Leg press measured in kilograms, and explosive power from Squat jump, Countermovement jump, and Long jump. The data collected was analyzed to find the average, standard deviation, and one-way ANOVA with a statistical significance level set at .05. From the research's results, it was found that percentage change muscle contraction rates differs significantly between the two strength training formats: one with fast muscle contraction and the other with normal- muscle contraction rate (1.04±0.02 and 1.02±0.02, respectively) at a significance level of .05. Additionally, the strength and explosive power percentage change also significantly differ between the two strength training formats. Therefore, based on this study, it is possible to utilize the fast muscle contraction rate strength training format to enhance the athletic performance of athletes.

Keywords
Athlete, Strength Training, Velocity, Contraction

INTRODUCTION

Athletics encompasses physical activities that align with the natural mechanics of human movement. These activities include running, jumping, and throwing. These fundamental skills, inherent to various sports, rely on the use of our feet. Naturally, each type of athletic discipline demands speed, which significantly impacts competitive outcomes.

Short-distance running races are one of Thailand's successful ongoing sporting events. The 100-, 200-, and 400-meter races, as well as the 4x100- and 4x400-meter relays, comprise these events. Thai athletes have performed exceptionally well in these running events, both at the regional within Southeast Asia and during continental competitions such as the Asian Games (Kaewchuay, 2015). Notably, the Thai men's and women's sprint teams have achieved remarkable success over the past 40 years, competing at a level comparable to sporting like the Republic of China and Japan

The 400-meter sprint is a short-distance event that allows athletes to clearly develop both strength and explosive power (Mulasiwa & Sreesung, 2024). It also demonstrates differences in time duration more effectively than shorter sprints or spins (Iskra et al., 2016). In athletic training, focusing on the lower body is essential for developing strength

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(Okudaira et al., 2019). However, without specifying speed or rhythm during lifts, the athlete's progress may not align with the desired goals. To achieve an explosive power suitable for 400-meter sprinters, it's crucial to tailor the development accordingly.

Based on the concepts, the researcher has an idea to have 12 athletes train a strength training program, with the format being primarily lower body drills, and to set the muscle contraction rate with 40 bpm and 80 bpm. The researcher wants to study the development of strength and speed from running a 400-meter distance by athletes, which the results will help coaches plan to further improve the strength training program for athletes.

MATERIALS AND METHODS

Participant

The dependent variable's effect size on the independent variable determines the sample size. calculated using the following settings and the G*Power program (version 3.1.9.7) T-test is a test family. Test of statistics: Means: Variation from a constant (one example); Power analysis type: Compromise; Effect size: 0.6; β /α ratio : 1; Power of test (1- β err prob): 0.82; Total sample size: 10. Then, ten volunteers (Kantor et al., 1984; Wallace, 1989)were randomly selected from 240 students according to the following criteria

Inclusion Criteria: Female with no issues of pain in the front thigh muscles, knee joints, and ankles. Must have regular track and field training at least 3-5 days per week and participated in the national sports competition, selection round, in the year 2023. Exclusion Criteria: The sample group has an unexpected event that makes it impossible to continue the research from 1 time onwards, and the sample group voluntarily withdraws during data collection.

The population is 40 female athletics between the ages of 18-22 years who participated in the 48th Thailand National Games qualify round. The sample in this research were 12 females. Subject must be training 3-5 days/week. Thailand National Sports University Research Ethics Committee for Research Involving Human Projects, Thailand Approved the study protocol (SCI 042/2023).

The sample group was tested for physical characteristics, including weight, height, and body fat percentage. They were tested for 400-meter speed, strength test form 1RM of Leg curl, Leg extension, and Leg press, explosive power from Squat jump, Countermovement jump, and long jump.

This study divides the participants into groups of 6 people based on their 400-meter running times, aiming for the closest possible average between the two groups. First group trained with a normal muscle contraction 40 bpm., second group trained with a fast muscle contraction 80 bpm. The training duration was 8 weeks. and after a 2-week post-training period, both groups were tested by swapping strength training programs.

Training Protocol

The exercise program involves a sample group performing strength training at 80% of one-repetition maximum (1RM) for the Leg Press, Leg Extension, and Leg Curl exercises. Each exercise consists of 3 sets, with 8 repetitions per set. Additionally, participants will listen to the rhythmic signals from a metronome during each training session. This training program spans 8 weeks.

Measurement of speed

400-meter test (Hanon et al., 2010)

The 400-meter test measures the time it takes to complete 400 meters as quickly as possible. This test measures the ability to run quickly over a distance. procedure: To start, athletes behind the starting timer gate line. On the command ‘ready, start; The subject is to run the 400m route as fast as possible.

Measurement of strength

One repetitions maximum test. (Reynolds et al., 2006)

The one-repetition maximum test finds out how much weight a person can lift in a single rep. It is a common way to find out how strong isotonic muscles are. You can use a one-rep maximum calculator to figure out how much weight you can lift in one rep. To find your one-repetition maximum score.

1RM = weight x (1 + (reps / 30))

Measurement of power

Squat Jump (Samozino et al., 2008)

The vertical jump test is modified to assess explosive leg power with the squat jump. Arm swinging or countermovements are not permitted during this test. Reducing the effect of variations in arm coordination by keeping the arms still isolates the leg muscles. Method: The athlete stands straight below the yardstick. Throughout the test, hands are put on the hips and stay there. While maintaining a straight trunk, the athlete squats down until their

knees are bent to a 90-degree angle. The athlete resets the mat, leaps as high as they can, and falls back on it with both feet striking the ground at the same time. The highest rating obtained from a minimum of three tries is noted.

Counter Movement Jump (de Campos Jr et al., 2019)

The Movement Against It When you jump, you can see how powerful your legs are. The athlete stands straight below the yardstick, either with socks on or without, and puts equal weight on both feet. During the test, hands are put on the hips and stay there. When all is set, the athlete squats until their knees are 90 degrees bent. After that, they leap as high as they can and simultaneously land with both feet on the mat. Between trials, there should be a good break. You have to jump with both feet, without taking any steps or shuffling at the start. There can't be a pause at the bottom of the squat.

Standing Long Jump (Zhou et al., 2020)

Standing Long Jump is a test of how strong your legs are when you jump. The athlete stands behind a line on the ground, with their feet spread out a little. The take-off and landing are both done on two feet, and arm swings and knee bends are used to move forward. The person tries to jump as high as they can and land on all fours without falling backwards.

Data Analysis

The statistical analysis was done with SPSS 21.0 software, which stands for Statistical Package for the Social Sciences. The distribution of the data was examined for normalcy using the Kolmogorov-Smirnov test. The independent t-test was used to compare the variable means and standard deviations because the data were normally distributed., The significance level was set at $p<0.05$

RESULTS

The sample group found an age of 20.33±1.37 years, weight 55.67±4.98 kg, height was 1.65±3.74 meters and the percentage of total body fat was 17.55±3.94 (Table 1).

Table 1. Baseline characteristics

	$\bar{x}$±S.D.
Age (year)	20.33±1.37
Weight (Kg.)	55.67±4.98
Height (meter.)	1.65±3.74
Percent of bodyfat	17.55±3.94

Table. 2 Showed the speed distance 400-meter normal contraction pre training, post training, and percentage change, which are 65.83±2.66, 64.83±3.33, and 1.02±0.02 respectively. Fast contraction before training, after training, and percentage change, the values are 68.33±8.84, 65.50±7.90, and 1.04±0.02 respectively. The speed distance of 400 meters Post training compared to Pre training with both strength training patterns differed significantly at the .05 level, and percentage change for both strength training patterns also differed significantly at the .05 level.

Table 2. Speed 400 meter from training both types of strength.

Training Test	Strength training (s)	
	Normal Contraction	Fast Contraction
Pre training	65.83±2.66	68.33±8.84
Post training 8 week	64.83±3.33*	65.50±7.90*
Percentage changes	1.02±0.02	1.04±0.02#

* significant difference same group ($P<0.05$), # significant difference between group ($P<0.05$)

Table. 3 Showed the one repetition maximum of leg press normal contraction pre training, post training, and percentage change, which 249.00±34.11, 258.17±32.17 and 1.04±0.03 respectively. Leg extension normal contraction pre training, post training, and percentage change,

which 58.67±12.77, 62.50±12.27 and 1.07±0.04 respectively. Leg curl normal contraction pre training, post training, and percentage change, which 47.50±11.37, 52.67±12.54 and 1.11±0.04 respectively. one repetitions maximum of leg press fast contraction pre training, post training, and percentage change, which 259.67±27.29, 274.83±25.00 and 1.06±0.02 respectively. Leg extension fast contraction pre training, post training, and percentage change, which 58.00±8.22, 60.33±8.24 and 1.04±0.05 respectively. Leg curl fast contraction pre training, post training, and percentage change, which 40.67±6.11, 44.17±6.13 and 1.09±0.03 respectively. found that the maximum strength of the leg press, leg extension, and leg curl exercises post training compared to pre training with both strength training patterns differed significantly at the .05 level.

Table 3. One repetition maximum test from training both types of strength.

Training Test		Strength training (kg)	
		Normal Contraction	Fast Contraction
Leg Press	Pre training	249.00±34.11	259.67±27.29
	Post training 8 week	258.17±32.17*	274.83±25.00*
	Percentage changes	1.04±0.03	1.06±0.02
Leg Extension	Pre training	58.67±12.77	58.00±8.22
	Post training 8 week	62.50±12.27*	60.33±8.24*
	Percentage changes	1.07±0.04	1.04±0.05
Leg curl	Pre training	47.50±11.37	40.67±6.11
	Post training 8 week	51.50±11.81*	44.17±6.13*
	Percentage changes	1.09±0.03	1.09±0.03

* significant difference same group (P<0.05)

Table 4. Explosive power test from training both types of strength.

Training Test		Strength training (cm.)	
		Normal Contraction	Fast Contraction
Squat jump	Pre training	36.50±6.79	37.33±7.10
	Post training 8 week	41.00±4.97*	40.67±7.76*
	Percentage changes	1.15±0.02	1.09±0.06
Counter movement jump	Pre training	40.33±4.74	41.17±8.68
	Post training 8 week	44.83±4.32*	43.83±8.30*
	Percentage changes	1.12±0.15	1.07±0.04
Long jump	Pre training	187.67±16.32	195.67±17.90
	Post training 8 week	194.83±20.14	199.83±18.87*
	Percentage changes	1.04±0.07	1.02±0.01

* significant difference same group (P<0.05)

Table. 4 Showed the explosive power of squat jump normal contraction pre training, post training, and percentage change, which 36.50±6.79, 41.00±4.97 and 1.15±0.02 respectively. Leg extension normal contraction pre training, post training, and percentage change, which 40.33±4.74, 44.83±4.32 and 1.12±0.15 respectively. Leg curl normal contraction pre training, post training, and percentage change, which 47.50±11.37, 52.67±12.54 and 1.11±0.04 respectively. explosive power of squat jumps fast contraction pre training, post training, and percentage change, which 37.33±7.10, 40.67±7.76 and 1.09±0.06 respectively. Leg extension normal contraction pre training, post training, and percentage change, which 41.17±8.68, 43.83±8.30 and 1.07±0.04 respectively. Leg curl normal contraction pre training, post training, percentage change, which 195.67±17.90, 199.83±18.87 and 1.02±0.01 respectively. The explosive power of the squat jump and countermovement jump post training compared to pre training with both strength training patterns differed significantly at the .05 level. However, the explosive strength of the long jump post training compared to pre training with the strength training pattern involving a fast contraction differed significantly at the .05 level.

DISCUSSION

In this research speed test, the researchers used a 400-meter test, which is a distance equivalent to actual competition. The field surface was a standard athletics track, and the test was conducted in lane number 3. Found strength training patterns within an 8-week period had a statistically significant effect on the speed of running 400 meters at the .05 level (Zarzeczny et al., 2011). However, percentage change in the strength training pattern with a high muscle contraction rate and percentage change in the strength training pattern with a normal muscle contraction rate also differed significantly at the .05 level. This is because in short-distance track competitions, athletes must use a fast muscle contraction speed, which corresponds with the training program used. The modulation of training speeds elicits significant neuromuscular adaptations (Sengsai et al., 2019), enhancing both motor unit recruitment efficiency and the neuromuscular system's capacity to execute concentric contractions more effectively (Phogat & Ahlawat., 2015; Yousif et al., 2019). In the maximum strength test (one repetition maximum) in leg press, leg extension, and leg curl exercises because athletes use the lower body muscles as the primary muscles in competition (Imtanabut et al., 2023), and the defined strength training pattern uses these three exercises in training. It was observed that both strength training patterns within an 8-week period had a statistically significant effect on maximum strength at the .05 level. This corresponds with the development of strength in athletes which requires an 8-week training period, and in developing explosive power (Ameti et al., 2021) it is necessary to have muscle strength at an appropriate level before training to develop explosive power(Ogata et al., 2003).

In this explosive strength test, squat jump, countermovement jump, and long jump exercises because athletes primarily use their lower body muscles in competition (Singh & Singh, 2013) and these exercises involve explosive force in both static and dynamic forms (Phungern & Yimlamai, 2020). Additionally, they involve exerting explosive force vertically under the influence of gravity and horizontally (Markovic et al., 2007). It was observed that both strength training patterns over an 8-week period had a statistically significant effect on the explosive force in the squat jump and countermovement jump at the .05 level.

Conclusion

Strength training with a high rate of muscle contraction can better develop athletes because short-distance runners require speed, strength, and explosive power (Ditroilo & Marini, 2001; Mulasiwa & Sreesung, 2024). This corresponds to movements that use the highest possible frequency of leg movement, akin to training with high muscle contraction (Balsalobre-Fernández et al., 2013). However, athletes must have a good base level of strength before adjusting their training program to a higher rate of muscle contraction, which can reduce the duration of competition (Miguel & Reis, 2004). Therefore, a training program that increases the rate of muscle contraction can be adapted to help athletes reduce their competition times.

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Conflict of interest

The authors declare no conflict of interest.

Ethics

The Thailand National Sports University Research Ethics Committee for Research Involving Human Subjects approved the study protocol (SCI 042/2023). Informed consent was obtained from the parents, and assent was obtained from the children before their inclusion in the study.

Author Contributions

KS, NS, and MP in Study Design; KS in Data Collection; KS and MP in Statistical Analysis Manuscript preparation (KS, NS, and MP); data interpretation (KS); literature search (KS, NS). After reading the published version of the manuscript, all authors have given their approval.

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RESEARCH ARTICLE

Effectiveness of Circuit and Fartlek Exercises to Increase Aerobic Endurance in Adolescent Futsal Players

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Abstract

Aerobic endurance is an important component in futsal sports games, so it requires an exercise that can increase aerobic endurance. This study aims to evaluate the effectiveness of circuit training with fartlek exercises to increase aerobic endurance futsal players Bina Darma. The research method used was an experiment with the design of the control group pre-test post-test. The study population of 40 Bina Darma futsal players was divided evenly into two groups, namely the circuit training group and the fartlek training group consisting of 20 samples. Each group performed the exercises for 8 weeks with a frequency of 3 times a week. Aerobic endurance measurements were taken before and after the exercise program using the Bleep Test. Analysis Data obtained from VO2 max test will be analyzed using statistical software SPSS 23. Statistical analysis that will be used is an Paired Samples Test to compare the increase in aerobic endurance between circuit training group and fartlek exercise group. The results showed a significant increase in aerobic endurance in all groups after the exercise programme. The results of this study showed that the circuit training group was more significant than the fartlek training group with very high statistical significance ($p < .001$), showing that the difference between circuit training and fartlek training in improving aerobic endurance was significant. In conclusion, circuit training is a more effective option for improving aerobic endurance in Bina Darma futsal players. Choosing the right type of sport can increase the aerobic endurance of futsal players.

Keywords
Circuit Training, Fartlek, Aerobic Endurance, Futsal

INTRODUCTION

The aerobic endurance of futsal players is crucial to support modern futsal matches that require players to be physically active throughout the match (Travassos et al., 2018). This is important because futsal players with good aerobic endurance have a significant competitive advantage (Nabo et al., 2021). Increased aerobic endurance can help players perform better on the pitch, reduce the risk of injury and increase their productivity during matches (Endrawan & Aliriad, 2023). A better understanding of the most effective training methods is a must in the effort to improve the performance of futsal players (Satria et al., 2023). Improved aerobic endurance is a key aspect of futsal players' training that can have a significant

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impact on their performance on the pitch (Figueiredo Machado et al., 2023).

Maintaining aerobic endurance is crucial for optimal performance in futsal games due to the high intensity and fast movements required in a limited space (Helgerud et al., 2023; Mosteoru et al., 2023). Futsal matches are short, which demands optimal aerobic energy levels. However, players often struggle to adjust to the high intensity, short duration, and limited recovery time between matches (Li et al., 2023; Ziyaiyan et al., 2023). Futsal players with good aerobic endurance can maintain high performance levels throughout matches, with effective defence and consistent attack, as well as quick recovery. Research indicates that incorporating specific exercises to improve aerobic endurance can provide significant benefits, such as better fitness, quick recovery, and consistent performance (Vibarel-Rebot et al., 2023; Volterrani et al., 2023). However, there is still uncertainty about the most effective training method to achieve maximum improvement in aerobic endurance (Rahman, 2018). Increasing aerobic endurance is an important factor in the training of futsal players, given the nature of the game, which relies heavily on prolonged physical activity (Lago-Fuentes et al., 2021).

Circuit training and fartlek training are two training methods that have great potential for improving aerobic endurance in futsal players (Festiawan et al., 2020; Muryadi et al., 2021). Circuit training involves a series of different physical exercises, from strength to cardiovascular, performed sequentially with little or no rest in between (Festiawan et al., 2021). This approach allows players to work at high intensity for relatively short periods of time, increasing their aerobic and anaerobic capacity (Kharisma & Mubarok, 2020). Fartlek exercises emphasise variations in intensity and speed during training, reflecting the nature of futsal matches, which often involve alternating periods of high and low intensity (Hermanzoni, 2019; Pratama & Kushartanti, 2018). This training allows players to develop the ability to adapt to sudden changes in the tempo of the game, which is an important skill in the modern world of futsal (Karatrantou et al., 2023; Molinaro et al., 2023).

The main difference between this study and the previous one is the focus on two training methods that have the potential to increase aerobic endurance in futsal players (Satria, 2018), namely circuit training and fartlek training. Focus on general problems encountered in futsal matches, whereas this study is more specific in explaining the two training methods. The difference of this study may be the emphasis on the effectiveness of circuit training and fartlek training in improving the aerobic and anaerobic capacity of futsal players.

As sport science has developed, several previous studies have provided valuable insights into training methods that can improve aerobic endurance in futsal players (Atakan et al., 2019; Matias et al., 2023). Several studies have shown that circuit training and fartlek exercises have the potential to significantly improve aerobic endurance. The main problem to be solved in this study is to determine the most effective training methods to improve aerobic endurance in Bina Darma futsal players (Bahtra et al., 2020; Saputra et al., 2022). As part of this problem, we will also compare the effectiveness of circuit training exercises and fartlek exercises.

Recent evidence from the world of sport has identified circuit training and fartlek exercises as potential methods to improve aerobic endurance. Several recent studies in the exercise and fitness literature have supported the benefits of both types of exercise in improving aerobic endurance (Astuti et al., 2022). Research (Almy & Sukadiyanto, 2014) showed a significant increase in aerobic endurance in participants who underwent an 8-week circuit training programme. Research by (Rahman, 2018) showed an equally significant increase in aerobic endurance in participants who undertook fartlek training over the same period. There is a need to relate this knowledge specifically to the context of futsal players. In addition, a direct comparison betweenn these two types of training in Bina Darma futsal players has not been carried out in detail. Previous studies Implement regular circuit training sessions that focus on a combination of cardiovascular, strength and endurance exercises. The improvement of aerobic endurance in futsal players has a strong theoretical basis (Apriantono et al., 2023), but no research has explicitly compared the effectiveness of circuit training and fartlek training in futsal players. Therefore, there are gaps in knowledge that need to be filled, particularly in assessing the most effective training methods in this context.

Circuit training and fartlek exercises have their respective advantages and potential, and this study will provide insight into the most effective

training methods for improving aerobic endurance in futsal bina darma players. The main objective of this study was to investigate and compare the effectiveness of circuit training and fartlek exercises in improving aerobic endurance in Futsal Bina Darma players. This study aims to provide a deeper understanding of the most effective training methods for improving aerobic endurance in futsal players, particularly in the Bina Darma environment. The benefit of this research is the application of training methods that have been shown to be effective in specific contexts, in the hope of providing more accurate guidance to futsal coaches and players to maximise their training and improve their performance on the field.

MATERIALS AND METHODS

This study adopts an experimental research design with a post-test pre-test control group design (Andriani et al., 2017). The population of this study is all futsal players who are members of Bina Darma futsal team, totaling 40 players. Ethics Committee approval required This article was approved by the Ethics Committee of Health Research Islamic Hospital Malang, Malang City, East Java, Indonesia with number (No.26/ KEPK/RSI-U/V/2024). Participants provide informed consent with a volunteer form that includes details about the research, risks, benefits, confidentiality and rights of participants. The study will strictly adhere to all the principles contained in the WHO Ethical Guidelines 2011 and CIOMS 2016, prioritising the rights and well-being of participants in the design, procedures and confidentiality measures.

The study sample was randomly selected from a total of 20 players aged 18-20 years, who were included in the category of junior players with 2 years of futsal experience. Participants were randomly assigned to a circuit training group, and fartlek exercise group. The details of the study participants are shown in Table 1.

Table 1. Research participants

Sample	Gender	Age (Years)	Height (Cm)	Weight (Kg)	IMT
1	Male	18	170	68	23.5
2	Male	18	172	70	23.7
3	Male	18	168	66	23.4
4	Male	18	175	75	24.5
5	Male	18	167	65	23.3
6	Male	20	176	78	25.2
7	Male	20	169	67	23.5
8	Male	18	177	74	23.6
9	Male	20	173	72	24.1
10	Male	19	171	69	23.6
11	Male	19	174	73	24.1
12	Male	20	178	77	24.3
13	Male	19	172	68	23.0
14	Male	18	167	66	23.7
15	Male	20	175	76	24.8
16	Male	18	170	67	23.2
17	Male	19	176	75	24.2
18	Male	20	169	65	22.8
19	Male	18	173	72	24.1
20	Male	18	171	70	23.9

Furthermore, the sample was divided into 2 groups, the circuit training group and the fartlek group, each with 10 players. The data collection tool used in this study is the bleep test to measure the aerobic endurance of futsal players. Measurements were taken before and after the training programme to obtain VO2 max data. The pre-test was carried out before the start of the training programme to measure the baseline aerobic endurance of each player using the bleep test. After an 8-week training programme at a frequency of 3 times per week, a post-test was carried out using the

same Bleep test to measure improvements in aerobic endurance. The data obtained from the pre- and post-test results were analysed using SPSS 23 statistical software with paired sample t-tests to compare the results between the circuit training group and the fartlek training group. The details of 8-week training programme are shown in table 2 and table 3.

Table 2. Circuit training exercise program for 8 weeks

Week	Day	Exercise 1 (30 sec)	Exercise 2 (30 sec)	Exercise 3 (30 sec)	Exercise 4 (30 sec)	Exercise 5 (30 sec)	Rest (1 minute)	Total Sessions
1	Monday	Jumping Jacks	Push-ups	Squats	Plank	Mountain Climbers	Rest	3 round
	Wednesday	Burpees	Lunges	Bicycle Crunches	High Knees	Tricep Dips	Rest	3 round
	Friday	Jumping Jacks	Push-ups	Squats	Plank	Mountain Climbers	Rest	3 round
2	Monday	Burpees	Lunges	Bicycle Crunches	High Knees	Tricep Dips	Rest	3 round
	Wednesday	Jumping Jacks	Push-ups	Squats	Plank	Mountain Climbers	Rest	4 round
	Friday	Burpees	Lunges	Bicycle Crunches	High Knees	Tricep Dips	Rest	4 round
3	Monday	Jumping Jacks	Push-ups	Squats	Plank	Mountain Climbers	Rest	4 round
	Wednesday	Burpees	Lunges	Bicycle Crunches	High Knees	Tricep Dips	Rest	4 round
	Friday	Jumping Jacks	Push-ups	Squats	Plank	Mountain Climbers	Rest	4 round
4	Monday	Burpees	Lunges	Bicycle Crunches	High Knees	Tricep Dips	Rest	4 round
	Wednesday	Jumping Jacks	Push-ups	Squats	Plank	Mountain Climbers	Rest	5 round
	Friday	Burpees	Lunges	Bicycle Crunches	High Knees	Tricep Dips	Rest	5 round
5	Monday	Jumping Jacks	Push-ups	Squats	Plank	Mountain Climbers	Rest	6 round
	Wednesday	Burpees	Lunges	Bicycle Crunches	High Knees	Tricep Dips	Rest	5 round
	Friday	Jumping Jacks	Push-ups	Squats	Plank	Mountain Climbers	Rest	5 round
Week	**Day**	**Exercise 1 (45 sec)**	**Exercise 2 (45 sec)**	**Exercise 3 (45 sec)**	**Exercise 4 (45 sec)**	**Exercise 5 (45 sec)**	**Rest (45 minute)**	**Total Sessions**
6	Monday	Jumping Jacks	Push-ups	Squats	Plank	Mountain Climbers	Rest	6 round
	Wednesday	Burpees	Lunges	Bicycle Crunches	High Knees	Tricep Dips	Rest	6 round
	Friday	Jumping Jacks	Push-ups	Squats	Plank	Mountain Climbers	Rest	6 round
7	Monday	Jumping Jacks	Push-ups	Squats	Plank	Mountain Climbers	Rest	6 round
	Wednesday	Burpees	Lunges	Bicycle Crunches	High Knees	Tricep Dips	Rest	6 round
	Friday	Jumping Jacks	Push-ups	Squats	Plank	Mountain Climbers	Rest	6 round
8	Monday	Jumping Jacks	Push-ups	Squats	Plank	Mountain Climbers	Rest	6 round
	Wednesday	Burpees	Lunges	Bicycle Crunches	High Knees	Tricep Dips	Rest	6 round
	Friday	Jumping Jacks	Push-ups	Squats	Plank	Mountain Climbers	Rest	6 round

Table 3. Fartlek training exercise program for 8 weeks

Week	Day	Light Running	Sprint	Light Running	Walk	Total Sessions	Total Duration
1	Tuesday	5 minutes	1 minutes	2 minutes	1 minutes	3 round	27 minutes
	Thursday	10 minutes	1 minutes	2 minutes	1 minutes	2 round	28 minutes
	Saturday	5 minutes	30 Second	2 minutes	1 minutes	4 round	34 minutes
2	Tuesday	5 minutes	1 minutes	2 minutes	1 minutes	4 round	36 minutes
	Thursday	10 minutes	1 minutes	2 minutes	1 minutes	3 round	42 minutes
	Saturday	5 minutes	1 minutes	2 minutes	1 minutes	5 round	45 minutes
3	Tuesday	5 minutes	1 minutes	2 minutes	1 minutes	3 round	27 minutes
	Thursday	10 minutes	1 minutes	2 minutes	1 minutes	2 round	28 minutes
	Saturday	5 minutes	30 Second	2 minutes	1 minutes	4 round	34 minutes
4	Tuesday	5 minutes	1 minutes	2 minutes	1 minutes	4 round	36 minutes
	Thursday	10 minutes	1 minutes	2 minutes	1 minutes	3 round	42 minutes
	Saturday	5 minutes	30 Second	2 minutes	1 minutes	5 round	45 minutes
5	Tuesday	10 minutes	1 minutes	2 minutes	1 minutes	4 round	56 minutes
	Thursday	15 minutes	1 minutes	2 minutes	1 minutes	3 round	57 minutes
	Saturday	10 minutes	30 Second	2 minutes	1 minutes	4 round	54 minutes
6	Tuesday	10 minutes	1,5 minutes	2 minutes	1 minutes	4 round	58 minutes
	Thursday	15 minutes	1,5 minutes	2 minutes	1 minutes	4 round	78 minutes
	Saturday	10 minutes	1,5 minutes	2 minutes	1 minutes	4 round	58 minutes
7	Tuesday	10 minutes	1,5 minutes	2 minutes	1 minutes	4 round	58 minutes
	Thursday	15 minutes	1,5 minutes	2 minutes	1 minutes	4 round	78 minutes
	Saturday	10 minutes	1,5 minutes	2 minutes	1 minutes	4 round	58 minutes
8	Tuesday	10 minutes	1,5 minutes	2 minutes	1 minutes	4 round	58 minutes
	Thursday	15 minutes	1,5 minutes	2 minutes	1 minutes	4 round	78 minutes
	Saturday	10 minutes	1,5 minutes	2 minutes	1 minutes	4 round	58 minutes

RESULTS

The Data collected consisted of two tests, namely a Bleep test to measure the aerobic endurance of athletes in each circuit training exercise and fartlek exercise. Data collection was conducted in two stages, namely before treatment (pre-test) and after treatment (post-test). The purpose of the post-test is to compare the results of the pre-test and post-test. Thus, the data obtained include two tests, namely aerobic endurance athletes and stamina athletes, both in the pre-test and post-test. The study reported the pre- and post-test endurance results for the circuit training exercises in Table 4, where the participants were divided into aerobic system categories from "very good" to "less than once". Before the exercise, the majority of participants were in the "less than once" category with 70% of cases, followed by the "less" category with 10% of cases, while none were in the "very good" or "good" categories. After the exercise, the distribution of categories changed, with the majority of participants in the "moderate" category (50%), followed by the "less" category (40%), while none were in the "very good" or "good" category.

Table 4. Results of pre-test and post-test aerobic endurance in circuit training

Category	Pre-test	Pre-test	Post-test	Post-test
Very Good	0	0%	0	0%
Good	0	0%	0	0%
Moderate	2	20%	5	50%
Less	1	10%	4	40%
Less Than Once	7	70%	1	10%

Table 5 presents a descriptive analysis of pre- and post-test stamina in ten different samples using the bleep test method. The table shows that the mean pre-test score was 32.08, while the post-test score increased to 35.45, indicating an increase in the participants' endurance after training. The standard deviation of the pre-test was 2.89 and the post-test was 3.04, indicating a slightly greater variation in performance after training. The maximum score on the post-test was 39.20, an increase from 36.60 on the pre-test, while the minimum score increased from 27 to 31.20. Overall, the results of the analysis showed that the circuit training exercise programme resulted in a significant increase in the participants' endurance. Average post-test performance was higher than pre-test, with most samples showing improvement. A slightly higher standard deviation on the post-test showed greater variation in post-test results, which could be due to variations in individual responses to exercise.

One-sample test results for circuit training exercises in Table 3 In a one-sample t-test for circuit training, a statistical t-value of 35,162 with 9 degrees of freedom showed a very high statistical significance ($p < .001$) in the pre-test, indicating that the mean aerobic endurance prior to the exercise programme was significantly different from zero. Similarly, in the post-test, a statistical t-value of 36,820 with 9 degrees of freedom showed very high statistical significance ($p < .001$), indicating that the average aerobic endurance after the exercise programme was also significantly different from zero. The mean increase in aerobic endurance from pretest to post-test was 35.45, with a 95% confidence interval between 33.2720 and 37.6280.

Table 5. Descriptive analysis of pre-test and post-test aerobic endurance before and after circuit training exercises**.**

Name	Bleep Test (Pre-test)	Bleep Test (Post-test)	Difference
Sample 1	27	31.2	6.2
Sample 2	30.8	35.3	4.6
Sample 3	33.9	38.5	3.7
Sample 4	32	32.8	0.8
Sample 5	33.4	35.3	2
Sample 6	28.6	32.4	3.9
Sample 7	36.6	38.5	2
Sample 8	30.5	32.8	2.4
Sample 9	34	38.5	3.7
Sample 10	34	39.2	5.5
Average	32.0800	35.4500	3.48
Std Dev.	2.88513	3.04458	-0.14108
Max	36.60	39.20	3.7
Min	27	31.20	5.4

The study presented the results of the pre- and post-test endurance of the fartlek exercises in Table 6, which grouped the participants by aerobic system category from "very good" to "less than once". Before the exercise, the majority of participants were in the "less than once" category with 90% of cases, followed by the "less" category with 10% of cases, while none were in the "very good" or "good" categories. After the exercise, the distribution of categories changed, with the majority of participants being in the "moderate" category (50%), followed by the "less" category (30%), while none were in the "very good" or "good" categories.

Table 6. Results One-Sample Test circuit training exercises

	Test Value = 0					
					95% Confidence Interval of the Difference	
	t	df	P-Value	Mean Difference	Lower	Upper
Pre-test	35.162	9	.000	32.08000	30.0161	34.1439
Post-test	36.820	9	.000	35.45000	33.2720	37.6280

Table 7 shows that the mean pre-test score was 30.27, while the post-test score increased to 33.75, indicating an increase in the participants' endurance after training. The standard deviation of the pre-test was 3.08 and the post-test was 2.94, indicating relatively similar variations in performance before and after exercise. The maximum score on the post-test was 38.20, up from 34.50 on the pre-test, while the minimum score increased from 25 to 30.40. The results of the analysis showed that the fartlek exercise programme was also successful in increasing the endurance of the participants. Average post-test performance was higher than pre-test, with most samples showing improvement. Nearly equal standard deviations showed similar variation in pre-test and post-test results.

Table 7. Results of pre-test and post-test aerobic endurance in fartlek training

Category	Pre-test	Pre-test	Post-test	Post-test
Very Good	0	0%	0	0%
Good	0	0%	0	0%
Moderate	0	0%	5	50%
Less	1	10%	3	30%
Less Than Once	9	90%	2	20%

Table 8 shows the results of the one-sample t-test for fartlek training. The results showed that in the pre-test, the statistical t-value of 31.024 with 9 degrees of freedom showed a very high statistical significance ($p < .001$), indicating a significant difference between the mean aerobic endurance before the exercise programme and the zero value. Meanwhile, in the post-test, the statistical t-value of 36,773 with 9 degrees of freedom also showed a very high statistical significance ($p < .001$), indicating a significant difference between the average aerobic endurance after the exercise programme and the baseline value. The mean increase in aerobic endurance from pre-test to post-test was 33.77, with a 95% confidence interval between 31.6926 and 35.8474. It can therefore be concluded that the fartlek exercise programme was effective in improving aerobic endurance in the study subjects.

Table 8. Descriptive analysis of pre-test and post-test aerobic endurance before and after fartlek training

Name	Bleep Test (Pre-test)	Bleep Test (Post-test)	Difference
Sample 1	25	31.3	4.3
Sample 2	28.7	33.2	4.4
Sample 3	32.8	36.5	3.6
Sample 4	30	30.9	0.9
Sample 5	31.3	33.2	1.8
Sample 6	26.5	30.5	3.9
Sample 7	34.5	36.5	1.9
Sample 8	28.4	30.9	2.4
Sample 9	32.8	36.5	4.5
Sample 10	32.7	38.2	5.2
Average	30.2700	33.7500	3.37
Std. Deviation	3.08547	2.94439	0.15945
Max	34.50	38.20	2.6
Min	25.00	30.40	4.2

Table 9 shows the results of the paired t test for differences between circuit training and fartlek training. The mean difference between the two types of exercise is 1.68, with a standard deviation of 0.70206 and a standard error of 0.22201. The 95% confidence interval for the difference is between 1.17778 and 2.18222. A statistical t-value of 7.567 with 9 degrees of freedom indicates a very high statistical significance ($p <.001$), showing that the difference between circuit training and fartlek

training in improving aerobic endurance was significant.

Based on the pretest data, the average bleep test score for circuit training is 35.45 and 33.75 for fartlek training. The standard deviation is 3.04 for the circuit training and 2.94 for the fartlek training. In general, bleep test results are slightly higher on average in circuit training. The almost equal standard deviation indicates that the variation in the results is also relatively similar. Based on the results of the post-test bleep test, both exercises showed similar effectiveness in increasing aerobic endurance. The paired t-test results in Table 10 showed that the difference between circuit training and fartlek training in increasing aerobic endurance was significant. It can therefore be concluded that there is a significant difference in the effectiveness of circuit training and fartlek training in improving aerobic endurance in the study subjects. Based on the results of the paired difference test between circuit training and fartlek training, it can be concluded that there are significant differences between the two types of exercise in improving aerobic endurance in the study subjects. The mean difference between circuit training and fartlek training was 1.68, indicating that circuit training has a higher mean increase in aerobic endurance compared to fartlek training. In addition, a high t-statistic (7.567) with a very high statistical significance (p<.001) confirms that this difference did not occur by chance. Therefore, based on these results, it is likely that circuit training is more effective in improving aerobic endurance than fartlek training in the study subjects. The difference between the two is not very great in terms of average results. Therefore, the choice between these two types of exercise should be based on the preferences and needs of each individua

Table 9. Results One-Sample fartlek training

	Test Value = 0					
					95% Confidence Interval of the Difference	
	t	df	P-Value	Mean Difference	Lower	Upper
Pre-test	31.024	9	.000	30.27000	28.0628	32.4772
Post-test	36.773	9	.000	33.77000	31.6926	35.8474

Table 10. Results Paired Samples Test Post test Circuit training and Post test Fartlek training

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	P-Value
Pair 1	Circuit training - Fartlek training	1.68000	.70206	.22201	1.17778	2.18222	7.567	9	.000

DISCUSSION

The results of this study showed that circuit training and fartlek exercises significantly increased the participants' endurance, as reflected in the pre- and post-test results. In particular, in the circuit training exercise, the majority of participants moved from the "less than once" to "moderate" category. In the case of the fartlek exercise, the majority of participants moved from the "less than once" to "moderate" category. These results indicate the effectiveness of both types of exercise in increasing aerobic endurance. It is important to note that these findings can be linked to a number of previous theories and studies. Have highlighted the importance of interval training, such as fartlek, in improving aerobic capacity (Scheer et al., 2021). Study indicated that circuit training exercise can increase the aerobic endurance of Bina Darma University soccer players. The t test showed that t_ (count) = 6,564> t_ (table) = 1,740 so that the accepted Ha is significant. This study confirms the importance of interval training in improving aerobic endurance and provides empirical support, particularly in sports such as football. Our results

support their findings by showing a significant improvement in post-test scores. Furthermore, circuit training exercises, which combine elements of resistance exercise with cardiovascular exercise, have been supported by previous research (Nobari et al., 2023). Our results confirm that this approach can be effective in increasing endurance. What is new is the direct comparison between these two types of training in the context of increasing endurance (Bae & Kasser, 2023; Ma et al., 2023). Previous research has tended to focus on the effects of each type of training separately (Edwarsyah et al., 2017). Our results suggest that both can provide significant benefits, but there may be individual factors that influence the choice of exercise that is more effective for an individual.

The concept of aerobic endurance, as defined by the principles of cardiorespiratory exercise (Dwi Juniarsyah et al., 2021), encompasses various elements such as exercise intensity, duration, and frequency (Chen et al., 2022; Mancha-Triguero et al., 2022). The aim is to improve the efficiency of the heart and lungs, as well as the body's capacity to transport and utilize oxygen. Regular and measured exercise at an appropriate intensity level gradually increases the body's ability to supply oxygen to muscles, increase blood flow, and strengthen the lungs (Belli et al., 2022; Scoubeau et al., 2022). This leads to increased efficiency of the cardiovascular system and oxygen capacity in the body (Sinurat, 2019).

Have highlighted the importance of interval training, such as fartlek, in improving aerobic capacity (Scheer et al., 2021). Our results support their findings by showing a significant improvement in post-test scores. Furthermore, circuit training exercises, which combine elements of resistance exercise with cardiovascular exercise, have been supported by previous research (Ambroży et al., 2022; Rodrigues et al., 2022). Our results confirm that this approach can be effective in increasing endurance (Edwards et al., 2023; Pechstein et al., 2022). What is new is the direct comparison between these two types of training in the context of increasing endurance. Implement regular circuit training sessions that focus on a combination of cardiovascular, strength and endurance exercises.

However, it is important to recognise that an exercise program must be tailored to individual needs and conditions (Maurer et al., 2019; Van de Velde et al., 2019). In the context of this study, it is important to note that the pre- and post-test results provide a brief overview of changes in the participants' endurance. The limitation of this study lies in the nature of the exercise, which only uses circuit training and fatlek training, the types of samples used are not diverse and the number is small, so in the future it is necessary to increase the number of exercises and other types of exercises that compare the effect between exercise methods and exercise model development. Future studies could consider additional measures or further observations to improve understanding of the effects of these exercises on broader aspects of health and performance. It is also important to consider the motivation and commitment of participants to the exercise programme. Further research can deepen the analysis of psychological aspects that may affect the effectiveness of exercise in the long term.

From the pretest data, it was seen that the average Bleep test score for circuit training was slightly higher (35.45) compared to fartlek training (33.75), although the difference was not statistically significant. The score variability between the two groups was also relatively similar, indicated by almost the same standard deviation (3.04 for circuit training and 2.94 for fartlek training). However, post-test results showed that both exercises had the same effectiveness in increasing aerobic endurance. Statistical analysis using paired t-tests showed a significant difference between circuit training and fartlek training in increased aerobic endurance. Circuit training showed a higher average improvement (1.68) compared to fartlek training, and this difference did not occur by chance with high t-statistical values (7.567) and very high statistical significance ($p < .001$). These results are consistent with the findings of other studies that

also observed a greater increase in aerobic endurance with circuit training compared to fartlek training. Although the difference between the two types of exercises is not very large in terms of average results, it is quite statistically significant.

Interval and circuit training are proven effective approaches to improving aerobic capacity, particularly in the context of improving athletic performance (Boraczyński et al., 2021; Menz et al., 2021). This approach involves a period of high intensity followed by a lighter recovery period, forcing the heart and lungs to work harder in a short period . Increased aerobic capacity allows the body to use oxygen more efficiently, which has a direct impact on the increased volume and strength of the heart and lungs (Gavanda et al., 2022; Selland et al., 2022; Yue et al., 2022). Interval training in particular provides an intense challenge to the cardiorespiratory system, which in turn significantly increases aerobic capacity (Arslan et al., 2022; Hendker & Eils, 2021; Son et al., 2022). This technique is particularly relevant in the context of futsal, where players are often required to go through a period of intense activity followed by a short period of recovery.

Circuit training, on the other hand, involves a series of resistance or cardiovascular exercises performed sequentially with little or no rest between each exercise (Anderson et al., 2021; Lee et al., 2021; Satria, Ramadhan, et al., 2023). This approach, combined with interval training, can be very beneficial in increasing aerobic endurance (Aliriad et al., 2023, 2024; S Adi et al., 2023). In the context of physical preparation for futsal, where the intensity of the game is high and the duration of the match relatively long, an increase in aerobic endurance is particularly important. Although circuit training and interval training in general can improve aerobic endurance, it is important to consider more specific futsal exercises. The principles of cardiorespiratory exercise and the concept of aerobic endurance have direct implications for improving the performance of futsal players. By developing an appropriate training program that includes interval training, circuit training, and futsal-specific exercises, players can maximize their potential on the pitch.

Tailoring training programs to individual needs is essential for the effective preparation of futsal players. An individual and personalized approach to the design of a training program, taking into account individual strengths, weaknesses, fitness levels, and goals, will enable players to achieve their best performance on the futsal pitch. Therefore, the integration of interval and circuit training into training programs, together with an individualized approach, will play a crucial role in improving the aerobic capacity and performance of futsal players.

In practice, the choice between circuit training and fartlek training should preferably be based on the preferences and needs of each individual. Factors such as personal preferences, training goals and physical condition can influence the choice of suitable exercises. In addition, setting up an effective exercise program also takes into account variations in the type of exercise and its intensity o achieve optimal results in increased aerobic endurance.

Conclusions

The conclusion of this study is that both circuit training and fartlek training significantly increased aerobic endurance in the participants. Although the pre-test results showed a slight advantage in the Bleep test scores for circuit training, this difference was not statistically significant. The score variability between the two groups was also relatively similar. However, the post-test results showed that the effectiveness of both types of exercise in improving aerobic endurance was equally significant. Statistical analysis using paired t-tests showed that circuit training resulted in a greater average increase in aerobic endurance compared to fartlek training. This difference does not occur by chance and is statistically significant. This is consistent with the results of previous studies, which also found a greater increase in aerobic endurance with circuit training. In practice, the choice between circuit training and fartlek training should be based on an individual's preferences, training goals and physical condition. In addition, it is important to design an effective exercise programme that takes into

account the variety of exercise types and their intensity. In conclusion, the results of this study make an important contribution to the understanding of the effectiveness of circuit training and fartlek in improving aerobic endurance. A suggestion for future research is to expand the sample to include different genders and a larger number of participants. Research can also explore the effect of participants' motivation and commitment to exercise programmes. In addition, studies could consider additional measures or further observations to better understand the effects of these exercises on broader aspects of health and performance.

Conflict of interest

The authors declare no conflict of interest.

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Ethics Statement

Ethical clearance (No.26/KEPK/RSI-U/V/2024). for this research was obtained from the Research Ethics of Health Research Ethics Committee of Malang Islamic hospital, Malang City, East Java, Indonesia

Author Contributions

Study Design, MHS; Data Collection, MHS, JJ ; Statistical Analysis, MHS, JJ, MD and LMYI; Data Interpretation, MHS, JJ and MD; Manuscript Preparation, MD, LMYI, KA and KD; Literature Search, KA and KD. All authors have read and agreed to the published version of the manuscript

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RESEARCH ARTICLE

Effect of Self-Differentiation on Trait Anxiety and Authenticity of University Students

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Abstract

The aim of this study is to analyze the effect of self-differentiation on trait anxiety and authenticity in university students. The sample consists of a total of 333 university students (244 female and 89 male) studying in various departments of a state university who volunteered to participate in the study. Differentiation of Self Inventory—Short Form (DSI-SF) was used to measure self-differentiation levels; "Trait Anxiety Scale" was used to measure trait anxiety levels; and "Authenticity Scale" was used to measure the authenticity levels of university students. The results obtained were analyzed both with SPSS and AMOS programs. The correlation between variables was observed with SPSS analysis. The analyses were tested at .05 and .01 significance levels using SPSS 25.0 package programme. The PROCESS (Model 4) Macro was used in SPSS to examine the mediating effect of anxiety in the relationship between self-differentiation and authenticity. The findings of the research indicated that the relationship between self-differentiation and authenticity in university students was partially mediated. The study also demonstrated the positive predictive value of self-differentiation at the level of authenticity in university students. The findings were then discussed in relation to the existing literature, with some suggestions for future research made.

Keywords
Self, Self-Differentiation, Anxiety, Trait Anxiety, Authenticity

INTRODUCTION

Individuals with low self differentiation cannot differentiate between emotions and real life; they act more dominantly based on their emotions, prioritize their emotions in their decisions, spend most of their energy in search of love, and become vulnerable since they cannot differentiate cognitive activities from emotions. These individuals spend their lives trying to receive approval, experience a negative struggle against people they cannot receive approval from, and have to deal with many physical and emotional problems throughout their lives (Goldenberg & Goldenberg, 2008). On the other hand, individuals with high self differentiation recognize other individuals' emotions, empathize with their emotions in sync, and have an emotional intellect that includes appreciating their own emotions (Goleman, 1995). It was found that individuals with high self differentiation are distinctive in understanding that human behavior consists of a complex structure and that these behaviors are caused by many variables, not a single variable (Hill, Hasty, & Moore, 2011), that they have low depression and trait anxiety levels (Solomon, Dekel, Zerach, & Horesh, 2009), and that, at the same time, they have high levels of self-regulation and forgiveness (Jankowski, Sandage, & Hill, 2013). On the other hand, it was found that individuals with low self differentiation also have weak socialization, emotional intelligence, and communication skills (Goldenberg & Goldenberg, 2008). Studies showed that there is a significant relationship between high self differentiation and peer attachment styles of university students (Vick, 2005), that sensitive and accepting parenting styles

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and support in romantic relationships are important factors that positively affect individuals' self differentiation (Freeman & Almond, 2009), and that individuals with high self differentiation have good physical health and social relationships (Gharehbaghy, 2011), while Daiman (2018) examined that interpersonal functions have a significant impact on holistic self-development and self differentiation in a research with university students.

Tiryaki-Güven (2020) determined that there is a positive relationship between university students and family functioning, self differentiation, social problem solving, and solving relationships between psychological symptoms. Individuals with high self differentiation also tend to behave authentically. Authenticity is the tendency to behave by taking the individual's feelings, thoughts, and attitudes into account (Goldman & Kernis, 2006). An individual with a true self both connects in a mature way and feels continuity, stability, and reciprocity by practicing comfortable self-regulation (Akbay, 2015). When the opposite characteristics of authentic individuals with self differentiation are considered, the behavior of the depressed individual emerges. Authenticity, which is known as being oneself or the true self (Yalom, 2000; Lacoste, Leimgruber, & Breyer, 2014), has been identified as a feature of identity achievement and an element of mental health and psychological acceptance (Lopez & Rice, 2006). On the other hand, Kernis & Goldman (2005) defined authenticity as self-actualization, the state of the individual being open to new experiences, living in the moment, trusting his or her own inner experiences, being free and creative with all his or her functions, and being fully consistent with his or her beliefs, discourses, and behaviors (Bowens, 1999). While ideal authenticity emphasizes avoiding the effects of weak willpower, not assimilating other individuals' standards, being devoted to intimate life projects, and determining psychological, social, and material rewards in this direction (Feldman, 2014), phenomenological existentialism emphasizes that the focus should be on authentic experiences instead of past experiences (Corey, 2008).

When we do not live authentically, we may alienate ourselves or our surroundings (Orange, 2002). On the other hand, it was determined that ontological well-being has a mediating role in the relationship between authenticity, mental health, and life satisfaction and that the mediating effect between autonomous and autonomous-relational self-construal and subjective well-being is significant (Jane et al., 2016). In another study, it was found that authentic tendency has a relationship with psychological well-being (Lenton et al., 2016). It was found that individuals with a high authentic tendency have improved skills in coping with problems and stress, have positive personality traits of creativity and self-differentiation (Jani et al., 2016; Orange, 2002; Thomaes et al., 2017), and show fewer symptoms of depression (Impett et al., 2008; Wood et al., 2008). A low authentic tendency may indicate fear of life, a weak character pattern, and a lack of self-awareness, as well as psychosocial personality disorders. It was determined that individuals with a high authentic tendency have significantly low anxiety levels (Hall & Theriot, 2016).

Anxiety causes many negative situations in individuals, such as panic, fear, a low sense of self, and despair (Richardson, 2002; Yohannes & Alexopoulos, 2014). The intensity of anxiety depends on the balance between the primary process where an individual evaluates the threat situation and the ability to cope with the potential threat (Benard, 2004) and the secondary process in which he or she evaluates the security situation (Beck, Emery, & Greenberg, 2011). Anxiety was found to have a negative relationship with psychological survival (Min et al., 2013), a positive relationship with stress (Williams, Domanico, Marques, Leblanc, & Turkheimer, 2012), a significantly positive relationship (Hill, Hasty, & Moore, 2011) with uncertainty about the future (Dugas, Gosselin, & Ladouceur, 2001), a positive relationship with depression, and a negative relationship with self differentiation (Solomon, Dekel, Zerach, & Horesh, 2009). Certain symptoms appear when the anxiety state occurs. Cognitive symptoms include an excessive focus of the individual's attention on internal and external stimuli. Emotional symptoms include states of restlessness, concern, anger, and agitation. Behavioral symptoms consist of escape, avoidance, and freezing reactions. Trait anxiety is the tendency to perceive the events a person experiences and his or her situation within these events as generally stressful (Min et al., 2013; Williams, Domanico, Marques, Leblanc, & Turkheimer, 2012). It was observed that individuals with high trait anxiety levels are hurt more easily and are more pessimistic.

The trait anxiety level determines the frequency and severity of state anxiety that an individual will experience in dangerous situations. Accordingly, individuals who are under pressure and have high trait anxiety levels are expected to show faster and more frequent state anxiety symptoms when compared to individuals with low trait anxiety levels (Vasey & Ollendick, 2000). This process will negatively affect the self differentiation and authenticity processes of individuals. Based on this, the current research aims to examine the effect of university students' self differentiation on trait anxiety and authenticity.

MATERIALS AND METHODS

Research Model

In accordance with the purpose of this study, a relational survey model based on quantitative research methods and general scanning models is used. The scanning model describes past and present situations as they are and is applied to ensure that individuals learn and develop desired behaviors. A general scanning model involves conducting research on the entire population or sample group in order to make a general judgment about the population. The relational scanning method aims to determine the common variance between two or more variables. The relational scanning model aims to determine whether or not variables change together and if so, how this happens (Karasar, 2011).

Participants

The study group for the research consists of a total of 333 university students (224 females-73.3% – 89 males-26.7%) who are studying in various departments of one state university in the 2022–2023 academic year and agreed to participate in the research voluntarily. The participants, distributed according to classes, consist of 333 students; 299 of whom are 1st graders (89.8%), 25 of whom are 2nd graders (7.5%), 8 of whom are 3rd graders (2.4%), and 1 of whom is a 4th grader (0.3%). Approval was granted by the Uşak University Social and Human Sciences Scientific Research and Publication Ethics Board (approval number: 2023-67, date: 16.03.2023). Written permission was obtained from the owners of the scales, and informed consent was obtained from the families of the children participating in the study.

Data Collection Instruments

Data collection was transmitted electronically to the participants so that the students could fill out the form created via Google Form. Students who agreed to volunteer were included in the study. In line with the study, "Differentiation of Self Inventory—Short Form (DSI-SF) is used to determine the self differentiation of university students; "Authenticity Scale" is used to determine the authenticity level of the students; and "Trait Anxiety Scale" is used to determine their trait anxiety levels.

Differentiation of Self-Inventory—Short Form (DSI-SF):

While "Differentiation of Self Inventory", which was developed by Skowron & Freidlander (1998) and later revised by Skowron & Schmit (2003), consisted of 4 subscales and a total of 46 items, it was reduced to 20 items by Drake, Murdock, Marszalek, & Barber (2015) via a short-form study to provide convenience to researchers. 4 subscale structures were preserved in the new form. The items are six-point Likert-type and are scored between 1 (does not reflect me at all) and 6 (reflects me strongly). While the emotional reactivity, emotional detachment, and telescoping dimensions consist of reverse-scored items, only one item in the taking I position is reverse-scored. Items of emotional reactivity, emotional detachment, and telescoping subscales represent low vertical differentiation, and therefore they are scored in reverse. High scores obtained from the scale represent a high level of differentiation. Subscale points are calculated by taking the averages depending on the number of items in that subscale. Similarly, the average of the four subscale scores gives the total score of the scale (Drake et al., 2015). While Cronbach's alpha internal consistency coefficients related to taking I position, emotional detachment, telescoping, and emotional reactivity dimensions of the original scale and the total score of the scale were found to be .88, .79, .68, .70 and .80, respectively, five-week apart test-retest reliability coefficients were found to be .85, .81, .72, .74 and .82 (Drake et al., 2015). The adaptation of the Differentiation of Self Inventory Short Form (DSI-SF) into Turkish was made by Sarıkaya et al. (2018). Internal consistency and test-retest reliability analyses were conducted regarding the DSI-SF Turkish form total score and subscale scores. In the study, the test was repeated two weeks apart, and the reliability coefficients were found to be .86 for the DSI-SF total score, .80 for emotional

reactivity, .73 for emotional detachment, .70 for telescoping, .73 for taking I position. The findings show that the Differentiation of Self Inventory Short Form is a valid and reliable measurement tool (Sarıkaya et al., 2018).

When looking at the reliability of the scale within the scope of this research, Cronbach's alpha coefficient was found to be .56 for taking I position subscale, .70 for the telescoping with others subscale, .74 for the emotional detachment subscale, .73 for the emotional reactivity subscale, and .81 for the self differentiation subscale.

Authenticity Scale (AS):

The scale was developed by Wood et al. (2008) to verify the three-component structure they conceptualized based on a humanistic approach. The Scale is a 12-item, 7-point Likert-type tool consisting of the dimensions of self-alienation, authentic life, and acceptance of external influence, each with four items. The researchers confirmed that the three dimensions they obtained in both explanatory and confirmatory factor analyses merged into a higher dimension in the second-level analysis. The Cronbach's alpha internal consistency coefficients were found to be .78 for self-alienation, .78 for acceptance of external influence, and .69 for authentic life. In addition, the scale was retested twice, with an interval of two and four weeks, and the reliability coefficients were found to vary between .85 and .91. Wood and his friends examined the relationship of the scale with some mental health symptoms and found that the authentic life dimension has a positive relationship with happiness, and that self-alienation and acceptance of external influence have a positive relationship with stress and anxiety and a negative relationship with happiness. In addition, the same study found that all three dimensions of authenticity showed strong relationships with subjective and psychological well-being. The total authenticity score of the scale can also be obtained by subtracting the scores of the self-alienation and acceptance of external influence sub-dimensions from the authenticity sub-dimension score.

Trait Anxiety Scale (TAS):

The State and Trait Anxiety Inventory, which was adapted to Turkish culture by Öner & Le Compte (1983) and includes norm studies along with validity and reliability studies, consists of a total of 40 items, including the State Anxiety Scale consisting of 20 items and the Trait Anxiety Scale consisting of 20 items. The Trait Anxiety Scale, which consists of 20 items, was used in this study. The Trait Anxiety Scale indicates how the individual should generally feel. Reliability coefficients determined by alpha correlations, which is a generalized form of the Kuder-Richardson 20 formula, were found to be between 0.83 and 0.87 for the "Trait Anxiety Scale". These findings indicate that Turkish scales have high item homogeneity and internal consistency. According to the "Item Remainder" correlation technique, which provides detailed information about the reliability and validity of the items that make up the scale, the item reliability correlation of the Turkish form for the Trait Anxiety Scale is between 0.34 and 0.72. Reliability coefficients obtained from the test-retest method of the scale show that it changes between 0.71 and 0.86 for the Trait Anxiety Scale. The Turkish translation of Trait Anxiety Scale was carried out using two different techniques: experimental concept validity and criterion validity (Öner & Le Compte, 1983).

Data Analysis

The purpose of the study and how to use the data collection tools were explained to the participants before the application, and the application was carried out by a researcher in a classroom environment. Before the data was included in the analysis, the measurement tools were checked, and incorrect forms were not included in the analysis. The analysis was conducted through the SPSS 16. program at .05 and .01 significance levels. In the study, Pearson-correlation analysis was used for statistics of the relationship between dependent and independent variables; PROCESS (Model 4) Macro in SPSS was used to examine the mediating effect of anxiety in the relationship between self-differentiation and authenticity.

RESULTS

Findings of the Correlation Analysis

Pearson correlation analysis was conducted to see the relationship between self differentiation levels (taking I position, emotional detachment, telescoping, emotional reactivity), and trait anxiety levels with authenticity levels (self-alienation, authentic life, acceptance of external influence) of university students, and the findings are presented in Table 1.

Table 1. Descriptive statistics and correlation values

	1	2	3	Avg.	SD.	Kurt.	Skew.
1	1	.476**	.379**	74.0751	12.22716	0.84	0.555
2		1	.365**	53.1562	7.94595	1.602	0.276
3			1	48.8889	9.40695	0.346	1.108

** Correlation is significant at the 0.01 level (2-tailed).

(1. Total Score for Self-Differentiation, 2. Total Score for Trait Anxiety, 3. Total Score for Authenticity)

When the analysis findings in Table 1 are considered, it was found that there was a moderately positive significant relationship between the total self differentiation level, the total trait anxiety level (r= .476, p<.001), and the total authentic level (r= .379, p<.001), and a moderately significant relationship between the total trait anxiety level (r=.365, p<.001) and the total authenticity level. The results of the analysis conducted to examine the mediating effect of trait anxiety in the relationship between self differentiation and authenticity are given in Table 2 below:

Table 2. Mediation test between variables: direct and indirect relationships

Model Paths		**Average Effects with 95% Confidence Interval**	
Total Effect	**Effect Value**	**Lower Limit**	**Higher Limit**
Self differentiation → Authenticity	.29	.21	.37
Direct Effect			
Self differentiation → Anxiety	.31	.25	.37
Anxiety → Authenticity	.28	.15	.41
Self differentiation → Authenticity	.20	.12	.29
Indirect Effect			
Self differentiation → Anxiety → Authenticity	.09	.04	.13

*p <.05, **p <.01, ***p <.001

SPSS PROCESS (Model 4) was used to examine the mediating effect of trait anxiety in the relationship between self differentiation and authenticity in university students. The findings of the analysis are given in Table 2. It was determined that the total effect of self differentiation in university students on authenticity is significant (β = .29, p < .001, 95% GA = [.21, .37]). When anxiety was included in the analysis as a mediating variable, the findings showed that self differentiation significantly predicted anxiety (β = .31, p < .01, 95% GA = [.25, .37)]), and that anxiety significantly predicted authenticity (β = .28, p < .001, 95% GA = [.15, .41]). In addition, it was seen that the predictive effect of self differentiation on authenticity is decreasing, that it is still significant (β = .20, p < 0.001, 95% GA = [.12, .29]), and that the indirect effect is also significant (β = .09, p < .001). As a result, the findings showed that anxiety partially mediated the relationship between self differentiation and authenticity.

DISCUSSION

When the results of the study are analyzed, it was found that self differentiation in individuals has a significant effect on authenticity. This finding is similar to many studies in the literature. It was found that young adults with low self-esteem are not accepted socially, while young adults with high self-esteem have high levels of socialization and self-differentiation (Schouten, 2007). While Kwon & Lee (2014) determined that self differentiation mediates the relationship between perceived parenting attitudes and the career decision-making of university students and the caring attitudes of parents and their level of career decision-making, Daiman (2018) determined that interpersonal functions have a significant impact on holistic self-development and self differentiation in the study they conducted with university students. On the other hand, it was determined that there is a positive and significant relationship between life satisfaction and true self-presentation and that social networks play an important role in helping young adults recognize different aspects of themselves and create a coherent identity

(Valkenburg, Schouten, & Peter, 2005). This finding is similar to the fact that individuals who achieved self differentiation show a significant relationship with their authenticity (Gil-Or et al., 2015); authentic individuals also maintain the balance between autonomy and relationality in their lives and close relationships (Harter et al., 1997; Schmid, 2005). It was shown in the research that self differentiation is an important predictor of the level of depression in adolescent individuals (Anderson & Sabatelli, 1992) and that differentiation is a predictive feature of adolescent individuals' anxiety, fear, and anxiety levels (Tuason & Friedlander, 2000).

When trait anxiety is included in the analysis as a mediating variable, the findings show that self differentiation significantly predicts anxiety. The findings from the research are seen to be supported by the studies in the literature. It was concluded that individuals with low self differentiation levels experience depression (Hooper & DePuy, 2010), social, state, and trait anxiety (Peleg-Popko, 2002; Sarıkaya, Boyacı, İlhan, & Aldemir, 2018; Skowron & Friedlander, 1998), and self-alienation frequently. On the other hand, it was concluded that individuals with high self differentiation develop low anxiety (Skowron & Friedlander, 1998), high levels of relationship satisfaction and authenticity (Chickering, Dalton, & Stamm, 2015), high psychological well-being (Skowron, Stanley, & Shapiro, 2009), more sustainable attitudes towards life (Clarken, 2011), and healthy interpersonal relationships (Skowron, Stanley, & Shapiro, 2009). In another finding of the study, it was determined that trait anxiety in individuals significantly predicts authenticity. In the study, it was concluded that there is a significant relationship between individuals' authenticity levels and subjective well-being (Me´nard & Brunet, 2010) and that authenticity has a mediating role in the relationship between conscious awareness and finding meaning in life (Allan, Bott, & Suh, 2015). The results of this research support the findings of the research. As a result of the research, it was concluded that trait anxiety partially mediates the relationship between self differentiation and authenticity. It was found that when trait anxiety levels increase, both psychological endurance level and authenticity decrease (Wolfadt, Hempel, & Miles, 2003). It was observed that individuals with high levels of trait anxiety hurt more easily and are more pessimistic. It was determined that the trait anxiety level determines the frequency and severity of state anxieties that the individual will experience in dangerous situations and reduces self-distinctiveness (Vasey & Ollendick, 2000). In another study, it was concluded that individuals with high authentic tendencies take responsibility for their own lives, experience less anxiety, and create a system of values independent of society's and other people's expectations (Tou, Baker, Hadden, & Lin, 2015). These results show a parallel with research findings. The study is limited to the data received from students studying at one state university. This study can be conducted with other variables and a more widespread sample. It is recommended that field researchers conduct studies that include the variables of psychological well-being, authenticity, and self-esteem, as this will contribute positively to the literature.

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Conflict of Interest

The authors have stated that they have no potential conflicts of interest regarding the research, authorship, and/or publication of this article.

Ethical Aspects of The Study

Approval was granted by the Uşak University Social and Human Sciences Scientific Research and Publication Ethics Board (approval number: 2023-67, date: 16.03.2023).

Authors' Contributions

Each author contributed equally to the manuscript in terms of data collection, statistical analyses, and conceptual framework. All authors reviewed the final manuscript.

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RESEARCH ARTICLE

Effects of Sensory-Motor Perception and Movement Trainings in 2-6 Years Old Children Having Developmental Problems on Development Area and Emotional and Behavioral Problems

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Abstract

This study aimed to examine the effects of sensory-motor perception and movement training on the developmental areas and emotional and behavioral problems of children with neurodevelopmental problems. The sensory-motor perception and movement training program applied in this work focused on the personal and social, fine and gross motor, receptive and expressive language, emotion, and behavior issues of 15 children aged 2 to 6 years consisting of nine children with Autism Spectrum Disorder, three children having Speech Disorder, and three children having General Development Delay. The program was applied for 18 weeks, six days a week and two hours per day, for a total of 216 hours. The Denver-II development scale and the Child Behavior Checklists (separately for ages of 2-3 and 4-6) were used to create the pretest-posttest design. Using these data, the positive impacts of training on development areas as well as emotional and behavioral issues were measured. According to the Wilcoxon signed-rank test results, children's Denver-II development scale and its sub-dimensions' scores after sensory-motor perception and movement training improved significantly ($p<0.05$). When the pretest and posttest averages of Child Behavior Checklist for children aged 2-3 and 4-6 were compared, internalizing, externalizing, and overall scores decreased significantly after sensory-motor perception and movement training ($p<0.05$). In conclusion, children with developmental problems aged 2 to 6 who received sensory-motor, perception, and movement training showed significant decrease in anxiety levels, significant reduction in aggressive and destructive behavior, and significant improvement in fine- and gross-motor abilities as well as language and social skills.

Keywords
Disabled, Children, Behaviour, Sensory-Motor, Trainin

INTRODUCTION

Sensory, motor perception and movement training mainly target the first stages of development, especially the 0-6 age period. During this period, some children have problems in one or more of the neurodevelopment areas (sequential thinking, motor systems, social thinking, language, attention control, memory, environmental regulation, higher thinking). Children with developmental problems appear as children with poor body and space perception, limited vocal and physical imitation skills, unable to interact with their environment and unable to create purposeful movements (Bishop, 2010; Little, 2000; Meriem et al., 2020; Samad et al., 2024).

It is important to process the knowledge of how to use our hands and body in tasks that require skill such as using any tool such as a pencil or fork, building a structure such as a house or tower from

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toy blocks, arranging the room (Blanche Erna et al., 1999). However, children who have developmental problems have difficulties in planning the movement, creating a sequence of actions, and organizing the movement. The ability to transform the received sensory information into purposeful motor movement and to organize the sequence of movements in a coordinated way is weak. When the central nervous system (CNS), deep sense, tactile, movement and balance senses perform an organized process, it becomes easier for the child to plan and organize the movement.

Predicting the force, speed and steps required for the movement, estimating the movement using the most accurate prediction for the expected result with the idea of movement, developing a strategy, establishing a bridge between thought and behavior, and the diagram drawn to perform the action are important in the interaction of the child and the environment (Blanche Erna et al., 1999; Hashemi et al., 2024).

The sensory processing ability of the central nervous system (CNS) affects the sensory-motor map development of the child's body and forms the basis for interactions with the environment. With the motor-movement ability of the CNS, it forms the basis for the development of basic movement skills and the provision of more complex movement skills. Sensory processing, motor skills and movement skills of the CNS are necessary for the development of thought and behavior skills, intention, expectation, cause-effect, object relations, and basic mental skills (such as eating, doing homework) (Ayres, 1979; Ayres et al., 1987).

Studies in the literature have generally been made on motor skills, and it has been observed that motor development affects the development of other developmental periods. Iwanaga et al. (2000) examined 10 pre-school children with Asperger's and 15 high-functioning children with autism in terms of motor problems. In the study, 50% of Asperger's syndrome and 67% of high-functioning autism patients had motor impairment, visual motor integration, visuospatial perception problems and three-dimensional perception problems. It has been emphasized that motor delay is seen more intensely in children with Asperger's in the early period.

Yanardağ (2007) attributed the motor development loss of educable mentally retarded children to insufficient physical activities and suggested that the physical fitness and motor development of children is mostly due to insufficient education and not being given the opportunity to participate in games. Piek and Dyck (2004) stated that children with developmental delay and behavioral problems should be included in activities that will develop basic motor skills appropriate to their developmental stages in a planned way. A study in the literature shows that the self-talk of the child with ASD, who was given movement training, at the beginning of the practice greatly decreased at the end of the practice and there was an increase in meaningful verbal expressions (Orhan, 2014). In another study, it was observed that the basic speaking skills and advanced speaking skills of children with ASD who do sports are more advanced than the children who do not do sports (Esen, 2010).

Rosenthal-Malek and Mitchell (1997) stated that after the exercise program applied to five adolescents with autism, self-stimulating behaviors decreased, children's attention span and personal performance increased, and abnormal behaviors and self-harming behaviors decreased. İlhan (2007) applied a special physical training program to educable mentally retarded children aged 8-12, 88 experimental and 57 control groups. According to the results of the pre-test and post-test results, it is observed that there was a decreasing difference in the neurotic and behavioral problems of the children in the experimental group compared to the control group.

In another study, it was observed that the perception and interpretation of the world of children with ASD is different from the perception and interpretation of the world of children with normal development, and when the incoming information cannot be received through the senses in a healthy way, children have difficulties in interpreting this information and giving their feedback. It has also been observed that sensory-motor activities applied to individuals with ASD have a positive effect on their skills in development areas (Fazlıoğlu-Özlü, 2004).

In this direction, in this study, we aim to examine the effects of sensory-motor perception and movement training on the developmental areas and emotional and behavioral problems of 2–6 years old children with neurodevelopmental problems, in line with the development principles outlined above.

MATERIALS AND METHODS

Research Model/Design

The research, using a semi-experimental design, was carried out with the approval of the ethics committee of T. C. Istanbul Arel University, with the letter numbered 10432314-200.00.00-15 on 21/05/2014. Participants were provided with informed consent, with the volunteer form covering research details, risks, benefits, confidentiality, and participant rights. The research strictly adheres to the ethical principles of the Declaration of Helsinki, prioritizing participant's rights and well-being in design, procedures, and confidentiality measures. Families were included in the study on a voluntary basis by giving information about the research. The research was carried out at the Duyusal Bütünleme Özel Eğitim Merkezi (Sensory Integration Special Education Center) in Bahçelievler, Istanbul. The environment has been prepared in accordance with individuals with developmental problems.

Research Sample

The research group consists of a total of 15 children, 9 boys with Autism Spectrum Disorder (ASD), 3 boys with Language Disorder (LD) and 3 boys with General Developmental Delay (GDD), between the ages of 2-6, who are in neurodevelopmental disorder according to the DSM-5 diagnostic scale, from the departments of child psychiatry and child development neurology in Istanbul.

Data Collection Tools

Denver II Developmental Test and Child Behavior Rating Scale (CBRS) 2-3 years and Child Behavior Rating Scale (CBRS) 4-18 years old were used in the pre-test and post-test to the research sample (Yalaz et al., 2013).

Research Instruments and Procedures

Sensory-Motor Perception and Movement Training Protocol

We planned the practice of sensory-motor perception and movement training as 2 stages. In stage 1, we applied one-to-one individual activities. In stage 1, we performed the basic movement skills of the activities will be taught in stage 2. In stage 2, we applied specially prepared study activities on 13 objectives under 3 headings. Stage 1 (One-to-one individual activities) lasted 2 weeks and Stage 2 (Group activities) lasted 16 weeks. The sensory-motor perception movement training included Raising Motor Skills (Gross motor movements, Fine motor movements, Motion control, and Body flexibility), Social Organization (Queue taking skill, Queue waiting skill, Adaptation, and Collaborative action), and Independence (Self-confidence, Independent chain motor development, Creating continuity, Generalization, and Taking independent action).

Table 1. Application activity program

Activity No	Activity Name	Activity Goal	Purpose of the Activity	Weeks of the Activity	Total Time
1	Disabled road exercises	Improving walking ability and height perception	Increasing motor skills	1	60 min.
2	Disabled road exercises with the group	Improving walking ability, height perception and joint attention	Increasing motor skills	1	90 min.
3	Targeted road exercises	Improving walking ability and height perception, creating motion control	Increasing motor skills	1	60 min.
4	Targeted road exercises with the group	Improving walking ability, height perception and joint attention	Increasing motor skills	1	90 min.
5	Targeted road exercises with sandbags	Developing the ability to walk in different directions and depth perception	Increasing motor skills	1	60 min.
6	Targeted road exercises using sandbags with the group	Developing the ability to walk in different directions, depth perception and joint attention	Increasing motor skills	1	90 min.
31	Creating a tactile stimulus with a brush	Recognizing body parts, creating bodily awareness and self-confidence	Building social organization, independence	1-2-3-4-5-6-7-8-9-10-11-12-13-14-15-16	960 min.
7	Imitation on the trampoline	Recognizing body parts and improving body perception	Increasing motor skills	2-3	120 min.

8	Imitation on the trampoline with the group	Recognizing body parts, increasing body perception, and developing joint attention	Increasing motor skills, building social organization	2-3	180 min.
9	Stair climbing exercise	Recognizing body parts, developing body perception and fine-gross motor muscle	Increasing motor skills, building social organization	2-3	120 min.
10	Stair climbing exercise with the group	Recognizing body parts, developing body perception, fine-gross motor muscle, joint attention and queue taking skills	Increasing motor skills, building social organization	2-3	180 min.
11	Hammock exercise	Creating spatial awareness, developing gross motor muscle	Increasing motor skills	3	60 min.
12	Sticker sticking exercise	Creating body and directional awareness, developing fine-gross motor muscle	Increasing motor skills	3-4	120 min.
13	Sticker sticking exercise with the group	Creating body and directional awareness, developing fine-gross motor muscle, waiting time, and joint attention	Increasing motor skills, building social organization	4	Sticking 120 stickers
14	Twist exercise	Increasing spatial and temporal awareness, developing hand-eye coordination and gross motor	Increasing motor skills	4	60 reps
15	Object matching exercise with the group by making a twisting motion	Increasing spatial and temporal awareness, developing hand-eye coordination and gross motor, queue taking and queue waiting skills	Increasing motor skills, building social organization	4-5	24 reps
16	Colored cube insertion exercise with somersaults	Increasing spatial and temporal awareness, developing hand-eye coordination and gross motor	Increasing motor skills	5	60 reps
17	Colored cube insertion exercise with somersaults with the group	Increasing spatial and temporal awareness, developing hand-eye coordination and gross motor, queue taking and queue waiting skills	Increasing motor skills, building social organization	5-6	24 reps
18	Sticker sticking exercise by doing a camel walk	Developing body, spatial and temporal awareness, hand-eye coordination and gross motor	Increasing motor skills	6	30 reps
19	Sticker sticking exercise by doing a camel walk with the group	Developing body, spatial and temporal awareness, hand-eye coordination and gross motor, queue taking and queue waiting skills, collaborative skills	Increasing motor skills, building social organization	6-7	24 reps
20	Sticker sticking exercise by doing a spider walking motion	Developing body, spatial and temporal awareness, hand-eye coordination and gross motor	Increasing motor skills	7-8	60 reps
21	Sticker sticking exercise by doing a spider walking motion with the group	Developing body, spatial and temporal awareness, hand-eye coordination and gross motor, queue taking and queue waiting skills, collaborative skills	Increasing motor skills, building social organization	7-8	24 reps
22	Build a tower with colored cubes by making a snake move	Increasing body, spatial and temporal awareness, developing fine-gross motor	Increasing motor skills	8-9-10	90 reps
23	Build a tower with colored cubes by making a snake move with the group	Developing body, spatial and temporal awareness, developing fine-gross motor, queue taking and queue waiting skills, adaptive behavior and collaborative skills	Increasing motor skills, building social organization	9-10	60 reps
24	Standing exercise while walking the camel	Increasing awareness of the place, creating movement control, ensuring the adaptation process to the group, increasing waiting time	Building social organization, independence	9-10	84 min.
25	Chain movement exercise	Creating continuity, developing independent chain movement	Building social organization, independence	10-11-15-16	72 reps
26	Chain movement exercise with the group	Creating continuity, developing independent chain movement, queue taking and queue waiting skills	Building social organization, independence	11-15	24 reps

27	Ringing exercise with the group	Developing the ability to act independently, increasing self-confidence, creating continuity	Building social organization, independence	11-12-13-14-15-16	108 reps
28	Opening and closing activity with the group	Developing space awareness, collaborative skills, balance, self-confidence, independent action	Building social organization, independence	12-13-15-16	120 reps
29	Build towers and attach stickers to objects with spider walking with the group	Developing body awareness, joint attention, collaborative skills, queue taking and queue waiting skills, creating continuity	Building social organization, independence	12-13-14-16	48 reps
30	The activity of throwing the ball to the circle with the group	Developing body and space awareness, throw-holding skills, joint attention, queue waiting skills, creating continuity, generalization	Building social organization, independence	13-14-15-16	240 reps
32	Model imitation exercises with the group	Developing body awareness, collaborative skills, queue waiting skills, increasing attention span and generalization	Building social organization, independence	8-9-10-11-12-13-14-15-16	432 reps

Data Analysis

In our research, we analyzed the data with the Denver II Developmental Test and behavioral scales of Child Behavior Rating Scale (CBRS) 2-3 years and Child Behavior Rating Scale (CBRS) 4-18 years old, using the Wilcoxon signed-rank test in the SPSS 21.0 statistical software. We evaluated the analyzes in two parts as 2-3 years old and 4-6 years old groups. We used frequency and percentage values, which are descriptive statistics, to determine the socio-demographic characteristics of all age group subjects and their families. Due to the small sample size (less than 30), we used the Wilcoxon signed-rank test, which is a non-parametric alternative to the t-test.

RESULTS

As seen in Table 2, there are 8 children in total who are 2-3 years old, and 7 children in total who are between 4-6 years old. A total of 15 children participated in the study.

In the examination performed according to the diagnosis, we determined that 2 children in the 2-3 age group had Language Disorder, 2 children had General Developmental Delay and 4 children had Autism Spectrum Disorders. In the 4-6 age group, we also determined that the majority (5 children) were diagnosed with ASD, and thus most of the participants (9 children) were children diagnosed with ASD.

Table 2. Demographic characteristics of the research group by age

Diagnosis	Age					
	2-3 Years		4-6 Years		Total	
	f	%	*f*	%	*f*	%
Language Disorder (LD)	2	25.00	1	14.29	3	20.00
General Developmental Delay (GDD)	2	25.00	1	14.29	3	20.00
Autism Spectrum Disorders (ASD)	4	50.00	5	71.43	9	60.00
Total	8	100.00	7	100.00	15	100.00

Table 3, we applied Wilcoxon Signed Rank Test to test whether there was a significant difference between the pre-test and post-test in the overall score of 4-18 age CBCL, which are the sub-dimensions of the scale, internalizing and externalizing, applied before and after the sensory-motor perception and movement training given to the participants in the 4-6 age group. As a result of the analysis, we detected the statistically significant difference in the internalizing sub-dimension ($z = -2.366$, $p<0.05$), the externalizing sub-dimension ($z = -2.371$, $p<0.05$) and the CBRS overall ($z = -2.366$, $p<0.05$) scores. When is examined, it is seen that the observed positive ranks are in favor of the post-test score when the average and the total of the rank are considered. According to the results, it can be said that the sensory-motor perception and movement training has a positive effect on children's emotional and behavioral problems (negative rank is 7, positive rank is 0).

Table 3. Wilcoxon signed rank test analysis results applied to 4-6 age research group, 4-18 CBRS internalizing, externalizing, overall pre-test and post-test scores

		n	Average	Total	z	p
Age 4-18 Post-test internalizing score Age 4-18 Pre-test internalizing score	Negative Ranks[a]	7	4.00	28.00	-2.366	.018
	Positive Ranks[b]	0	.00	.00		
	Equal[c]	0				
	Total	7				
Age 4-18 Post-test externalizing score Age 4-18 Pre-test externalizing score	Negative Ranks[a]	7	4.00	28.00	-2.371	.018
	Positive Ranks[b]	0	.00	.00		
	Equal[c]	0				
	Total	7				
Age 4-18 Post-test CBRS Overall score Age 4-18 Pre-test CBRS Overall score	Negative Ranks[a]	7	4.00	28.00	-2.366	.018
	Positive Ranks[b]	0	.00	.00		
	Equal[c]	0				
	Total	7				

a- Age 4-18 Post-test < Age 4-18 Pre-test, b- Age 4-18 Post-test >Age 4-18 Pre-test, c- Age 4-18 Post-test = Age 4-18 Pre-test

Table 4 shows the results of the Wilcoxon Signed Ranked Test performed to test whether there is a difference in the internalization and externalization scores, which are the sub-dimensions of the scale, as well as the CBRS (Child Behavior Rating Scale) applied before and after the sensory-motor perception and movement training given to 2-3 years old. As a result of the analysis, there is a statistically significant difference between the pre-test and post-test values in the internalizing sub-dimension ($z = -2.524$, $p<0.05$), externalizing sub-dimension ($z = -2.521$, $p<0.05$), and CBRS overall ($z = -2.527$, $p<0.05$) scores. Considering the average and total of the ranks, it is seen that the observed positive ranks are also in favor of the post-test score. According to the results, it can be said that the applied sensory-motor perception and movement training has a positive effect on children's emotional and behavioral problems (negative rank is 8, positive rank is 0).

Table 4. Wilcoxon signed rank test analysis results applied to 2-3 age research group, CBRS internalizing, externalizing, overall pre-test and post-test scores

		n	Average	Total	z	p
Age 2-3 Post-test internalizing score Age 2-3 Pre-test internalizing score	Negative Ranks[a]	8	4.50	36.00	-2.524	.012
	Positive Ranks[b]	0	.00	.00		
	Equal[c]	0				
	Total	8				
Age 2-3 Post-test externalizing score Age 2-3 Pre-test externalizing score	Negative Ranks[a]	8	4.50	36.00	-2.521	.012
	Positive Ranks[b]	0	.00	.00		
	Equal[c]	0				
	Total	8				
Age 2-3 Post-test CBRS Overall score Age 2-3 Pre-test CBRS Overall score	Negative Ranks[a]	8	4.50	36.00	-2.527	.012
	Positive Ranks[b]	0	.00	.00		
	Equal[c]	0				
	Total	8				

a- Age 2-3 Post-test < Age 2-3 Pre-test, b- Age 2-3 Post-test >Age 2-3 Pre-test, c- Age 2-3 Post-test = Age 2-3 Pre-test

Table 5 shows the results of the Wilcoxon Signed Ranked Test performed to test whether there is a difference in the personal social development, fine motor development, gross motor development and language development scores, which are the sub-dimensions of the scale, as well as the Denver II Developmental Scale applied before and after the sensory-motor perception and movement training given to 4-6 age group (children included in the abnormal development group: children with two or more developmental delay score). As a result of the analysis, there is a statistically significant difference between the pre-test and post-test values in the personal social development ($z = -2.032$, $p<0.05$), fine motor development ($z = -2.023$, $p<0.05$), language development ($z = -2.366$, $p<0.05$), gross motor development ($z = -2.366$, $p<0.05$), and Denver II overall ($z = -2.375$, $p<0.05$)

scores. Considering the average and total of the ranks, we observed that there is a significant difference in favor of the post-test between pre-test and post-test developmental delay scores of personal social development, fine motor development, gross motor development, language development subscales of sensory-motor perception and movement training.

Table 5. Wilcoxon signed rank test analysis results applied to 4-6 age research group, Denver II developmental scale sub-dimensions and overall pre-test and post-test scores

		n	Average	Total	z	p
Post-test personal social development Pre-test personal social development	Negative Ranks[a] Positive Ranks[b] Equal[c] Total	5 0 1 7	3.00 .00	15.00 .00	-2.032	.042
Post-test fine motor development Pre-test fine motor development	Negative Ranks[a] Positive Ranks[b] Equal[c] Total	5 0 2 7	3.00 .00	15.00 .00	-2.023	.043
Post-test language development Pre-test language development	Negative Ranks[a] Positive Ranks[b] Equal[c] Total	7 0 0 7	4.00 .00	28.00 .00	-2.366	.018
Post-test gross motor development Pre-test gross motor development	Negative Ranks[a] Positive Ranks[b] Equal[c] Total	7 0 0 7	4.00 .00	28.00 .00	-2.366	.018
Post-test Denver II Overall Pre-test Denver II Overall	Negative Ranks[a] Positive Ranks[b] Equal[c] Total	7 0 0 7	4.00 .00	28.00 .00	-2.375	.018

a- Post-test < Pre-test, b- Post-test > Pre-test, c- Post-test = Pre-test

Table 6. Wilcoxon signed rank test analysis results applied to 2-3 age research group, Denver II developmental scale sub-dimensions and overall pre-test and post-test scores

		n	Average	Total	z	p
Post-test personal social development Pre-test personal social development	Negative Ranks[a] Positive Ranks[b] Equal[c] Total	8 0 0 8	4.50 .00	36.00 .00	-2.521	.012
Post-test fine motor development Pre-test fine motor development	Negative Ranks[a] Positive Ranks[b] Equal[c] Total	6 0 2 8	3.50 .00	21.00 .00	-2.207	.027
Post-test language development Pre-test language development	Negative Ranks[a] Positive Ranks[b] Equal[c] Total	6 0 2 8	3.50 .00	21.00 .00	-2.201	.028
Post-test gross motor development Pre-test gross motor development	Negative Ranks[a] Positive Ranks[b] Equal[c] Total	8 0 0 8	4.50 .00	36.00 .00	-2.524	.012
Post-test Denver II Overall Pre-test Denver II Overall	Negative Ranks[a] Positive Ranks[b] Equal[c] Total	8 0 0 8	4.50 .00	36.00 .00	-2.521	.012

a- Post-test < Pre-test, b- Post-test > Pre-test, c- Post-test = Pre-test

Table 6 shows the results of the Wilcoxon Signed Ranked Test performed to test whether there is a difference in the personal social development, fine motor development, gross motor development

and language development scores, which are the sub-dimensions of the scale, as well as the Denver II Developmental Scale applied before and after the sensory-motor perception and movement training given to 2-3 age group (children included in the abnormal development group: children with two or more developmental delay score).

As a result of the analysis, there is a statistically significant difference between the pre-test and post-test values in the personal social development ($z = -2.521$, $p<0.05$), fine motor development ($z = -2.207$, $p<0.05$), language development ($z = -2.201$, $p<0.05$), gross motor development ($z = -2.524$, $p<0.05$), and Denver II overall ($z = -2.521$, $p<0.05$) scores. Considering the average and total of the ranks, we observed that there is a significant difference in favor of the post-test between pre-test and post-test developmental delay scores of personal social development, fine motor development, gross motor development, language development subscales and pre-test and post-test developmental delay scores of sensory-motor perception and movement training (negative rank is 8, positive rank is 0).

DISCUSSION

In this study, we aim to examine the effects of sensory-motor and movement training on social and personal development, fine motor development, gross motor development, language development, emotion and behavior problems in children aged 2-6 years diagnosed with Autism Spectrum Disorder, Language Disorder, General Developmental Delay, which are defined in Neurodevelopmental Disorders according to the DSM-5 diagnostic scale.

We evaluate the data analysis of the research group in two groups as 2-3 years old and 4-6 years old. In the Denver II Developmental Scale, we consider social and personal development, fine motor development, gross motor development, language development and general development as subscale. We apply the Child Behavior Rating Scale (CBRS) for 2-3 years old and 4-18 years old children in order to determine whether there is a difference between the internalizing, externalizing sub-test and general behavioral problem pre-test and post-test average scores regarding children's behavioral problems.

In the results section and the Denver II Developmental Test, we found a significant difference in favor of post-test between the pre-test developmental delay scores and the post-test developmental delay scores regarding the personal and social development subscale of sensory-motor perception and movement training applied to the 2-3 years old and 4-6 years old research group children diagnosed with Autism Spectrum Disorder, Language Disorder, and General Developmental Delay.

It can be said that sensory-motor perception and movement training studies are positively effective in personal and social sense in children with developmental problems. Our findings are in parallel with the studies in the literature. Findings of exercise, sensory motor and movement training and physical training practices in the literature show that they have positive effects on personality and social development in children with developmental problems and normally developing (Aksay & Alp, 2014; Babkes, 1999; Beyazoğlu, 2014; Çelik et al., 2010; Erol, 2014; Esen, 2010; Fazlıoğlu-Özlü, 2004; İlhan, 2007; Namlı, 2012; Orhan, 2014; Rosenthal-Malek & Mitchell, 1997; Yanardağ, 2007).

In the Denver II Developmental Test, we find a significant difference in favor of post-test between the pre-test developmental delay scores and the post-test developmental delay scores of the fine motor and gross motor development subscales of sensory-motor perception and movement training applied to children aged 2-3 years and 4-6 years with a diagnosis of Autism Spectrum Disorder, Language Disorder and General Developmental Delay. We also observe that the most significant improvement in the research group was in motor skills. We detect that the motor skill development of 12 children in the 15-child research group reached the normal level of development, and a delay between 2% and 5% in 3 children. Our findings seem to be consistent with the results of many previous studies. Studies have generally been carried out on motor skills, and it has been observed that motor skills development affects the development of other developmental periods. Iwanaga et al. (2000) examined 10 pre-school children with Asperger's and 15 high-functioning autistic children in terms of motor problems. In the study, motor impairment was observed in 50% of those with Asperger's syndrome and 67% of those with high-functioning autism, and it was also observed that these children had visual motor integration, visuospatial perception problems and three-dimensional perception problems. It has been

emphasized that motor delay is seen more intensely in the early period in Asperger children. Yanardağ (2007) attributed the motor development loss of educable mentally retarded children to insufficient physical activities, and suggested that the physical fitness and motor development of children was mostly due to insufficient education and lack of opportunity to participate in games. Piek and Dyck (2004) stated that children with developmental delays and behavioral problems should be included in activities that will develop basic motor skills appropriate to their developmental stages in a planned way.

In the Denver II Developmental Test, we find a significant difference in favor of post-test between the pre-test developmental delay scores and the post-test developmental delay scores of the language development subscales of sensory-motor perception and movement training applied to children aged 2-3 years and 4-6 years with a diagnosis of Autism Spectrum Disorder, Language Disorder and General Developmental Delay. We observe that sensory-motor perception and movement training applied to the research group activates the receptive language and expressive language as language development. We also observe that there are improvements in expressive verbal language as a result of the increase in understanding in the receptive language. In a study supporting our findings, it was found that the self-talk of the child with ASD who received movement training at the beginning of the application was greatly reduced at the end of the application and there was an increase in their meaningful verbal expressions. (Orhan, 2014). In another study, it was observed that the basic speaking skills and advanced speaking skills of children with ASD who do sports are more advanced than the children who do not do sports (Esen, 2010).

In the Denver II Developmental Test, we find a significant difference in favor of post-test between the pre-test developmental delay scores and the post-test developmental delay scores of the general development scale of sensory-motor perception and movement training applied to children aged 2-3 years and 4-6 years with a diagnosis of Autism Spectrum Disorder, Language Disorder and General Developmental Delay. After the sensory-motor perception and movement training, there were positive improvements in self-care skills, pencil holding skills, understanding and applying commands as general improvement in the sample group. In gross motor skills, we observe that developmental gaps are completed in the developmental points of basic movement schemes such as displacement activities (running, jumping), manipulative movements (catching, throwing), and balance movements (walking on a balance board, standing on one leg). In addition, we find that 10 children have reached the normal development level, and 5 children have a developmental delay between 2-14%. In a study, it was observed that swimming techniques can be taught to a child with autism by teaching with a fixed time delay, and according to the results of the research, it was stated that there was a great increase in the rate of responding appropriately to the cues with a fixed time delay given to the autistic individual. With the individualized swimming and physical activity program applied, it was observed that the individual with autism acquired basic swimming skills compared to their peers and could swim in free, backstroke and breaststroke styles. In addition to these gains, it has been observed that the program implemented contributes to the reduction of the intensity of autism symptoms and to increase the performance in developmental areas in individuals with autism (Kafkas & Özen, 2014). In another study, the effect of movement training on the social skills of a child with autism was examined. A child with autism participated and during 12 lessons of 30 minutes, double-leg forward multiple jumps, right-left multiple forward multiple jumps and zigzag forward multiple jumps of these movements were studied. In the evaluation of the development of social behavior during education, analysis was conducted by reporting the observations, opinions and comments of three independent observers and practitioners. After the movement training applied to the autistic child, it was observed that the child with autism improved some physical characteristics, as well as increased attention span, improved the cooperative skills, and a significant increase in the child's self-confidence (Orhan, 2014).

We find that there is a significant difference between the pre-test and post-test average scores in the evaluation of internalizing, externalizing and general behavior in relation to children in the 2-3 year and 4-18 age Children Behavior Rating Scale. In line with the findings of our research, we find that sensory-motor perception and movement trainig provides positive developments in the emotional and problematic behaviors of the children in the

research group. Before the study, we observed that, in general, the sample group had high levels of anxiety, low attention span, exhibited emotional behaviors, intensely engaged in self-stimulation behaviors, and some children had destructive and aggressive behaviors. After sensory-motor perception and movement training, we observe that their anxiety levels decrease, their attention span increases, they adapt to the environment, their self-stimulation behaviors are mostly over, and there are decreases in other children. In addition, we find that children who exhibit destructive and aggressive behavior before training provide movement control. In this context, there are studies in the literature that support our findings. In their study, Rosenthal-Malek and Mitchell (1997) observed that after the exercise program applied to five adolescents with autism, the individuals' self-stimulating behaviors decreased, their attention span and personal performance increased, and their abnormal and self-harming behaviors decreased. In another research, İlhan (2007) applied a special physical training program to educable mentally retarded children aged 8-12, 88 experimental and 57 control groups. According to the pre-test and post-test results, it was stated that there was a decreasing difference in the neurotic and behavioral problems of the children in the experimental group compared to the control group.

Orhan (2014) stated that movement training not only improves some physical characteristics of children with autism, but also reduces some behavioral problems, increases attention span, improves the ability to act jointly, and provides a significant increase in the self-confidence of children with ASD. In the observation analysis performed on a child diagnosed with autism, it was observed that play and water therapies increased behavioral problems in the first weeks of the application but reduced some of the behavioral problems and eliminated some behavioral problems after the application was completed (Beyazoğlu, 2014).

According to the pre-test results of the research group, we observe that children's recognizing their bodies, receiving and interpreting incoming stimuli, motor skill development, and behavioral reactions differ from those of children with normal development. These differences make it difficult for children to interact with the social environment. A study has revealed that the perception and interpretation of the world of children with ASD is different from the perception and interpretation of the world of children with normal development, and that when the incoming information cannot be received through the senses in a healthy way, children have difficulties in interpreting this information and giving their feedback. It has been stated that sensory-motor studies applied to individuals with ASD positively affect their skills in the areas of development (Fazlıoğlu-Özlü, 2004).

In another study, it is emphasized that programs that develop motor skills are important for individuals with autism, and that children with autism continue training programs to improve their motor skills, which is effective in reducing the problems of selectivity in perception (Connor, 1990). Günal (2007) stated that there are significant sensory integrity, motor and cognitive problems in children with ASD, that these problems negatively affect the level of independence and quality of life of children in daily living activities, and that fine and gross motor skills of children with ASD affect the level of independence in daily living activities.

Yanardağ (2007) studied 8 male children with autism in the 5-7 age range for the research sample group and divided the group into two according to their average age. A specially prepared exercise program for 40 minutes, 3 days a week, for 12 weeks was applied to the groups divided into pool group and land group, and the errorless teaching technique was used. Pre-test and post-test were applied to the sample groups. When the test results of both groups were compared before and after the training, a statistically significant difference was found between the motor ability test and physical fitness test results, except for balance and bilateral coordination tests. After the training, the self-stimulation behaviors of the subjects in the land group decreased by 52.8%, while there was a decrease of 34% in the pool group. In the study, it was argued that the motor development loss of trainable mentally retarded children was attributed to insufficient physical activities, and the physical fitness and motor development of children was mostly caused by insufficient education and not being given the opportunity to participate in games. It has been observed that children who do not participate in activities or are not taken into the game by their friends regress in terms of physical and motor fitness factors and suffer from skill loss to a large extent.

Trainings programs prepared in line with the needs of children with ASD, GDD and Language Disorder are important for special children to know themselves developmentally and to perceive the environment.

Adapting the educational practices prepared for individuals to the developmental problems experienced by children is important in terms of entering the inner world of the child who is disconnected from communication and perceiving his/her own existence in the social-environmental life.

When evaluated in terms of lack of communication and intense anxiety-fear, repetitive self-stimulation movements, perceptual distortions, and obsessive behaviors, which are evident in ASD symptoms, we see that these situations that emerged in the pre-test in our study contain significant differences in the post-test. As a result of the examinations, we can say that there is a significant change in children's anxiety-fear levels, increase in their self-confidence, openness to communication, and adaptation to the environment, there is extinction in internal-impulsive and repetitive movements, and obsessive behaviors decrease.

Overcoming these problems, which are the most challenging for the families of children with ASD in social and environmental life, are the most important topics in terms of family-child, child-environment, family and environment. The fact that these problems can be overcome is an important motivation for families, and it is very important for the environment to accept the child and family. As a result, the methods created aim to rehabilitate the individual with ASD and to include the child in social-environmental life. It is important that these contributions of our research to children can be transformed into social-environmental experiences. The use of methods that can affect outside of limited time and areas and contribute to the lives of children in the outside world will be an important gain for individuals with ASD.

We observe that at the end of the sensory-motor perception and movement training applied to the development problems experienced by children with Language Disorder and General Developmental Delay, which are the other two diagnoses of our study, children generally complete their personal-social, language, fine-gross motor development stages and their behavior problems decrease.

Finally, we present some recommendations:

For Research,

In the field of special education, experimental studies can be conducted on sensory-motor perception and movement education for other diagnoses in neurodevelopmental disorders. The effect of sensory-motor perception and movement training on cognitive development can be examined. New studies can be carried out by increasing the number of research groups within the framework of the sensory-motor perception and movement training program. Sensory-motor perception and movement training program can be examined by forming a control group from children with developmental problems to whom special education methods are applied.

For Practice,

We think that working in cooperation with experts in studies for children with developmental problems will be more effective in the education of children with developmental delays. By establishing cooperation with the families of children with developmental problems, a sensory-motor perception and movement training program can be created in which the family will be present and the diagnostic characteristics of the children are taken into account, and individual and group studies can be carried out. The sensory-motor perception and movement training program should be included in the education processes of children with developmental problems.

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Conflict of Interest

Authors declare that they have no conflict of interest.

Ethics Statement

The study protocol was approved by the ethics committee of T. C. Istanbul Arel University, with the letter numbered 10432314-200.00.00-15 on 21/05/2014. Participants were provided with informed consent, with the volunteer form covering research details, risks, benefits, confidentiality, and participant rights. The research strictly adheres to the ethical principles of the Declaration of Helsinki, prioritizing participant's rights and well-being in design, procedures, and confidentiality measures.

Author Contributions

Conception and Design of the Study, EY; Data Collection, RG; Data Analysis and

Interpretation, RG and EY; Drafting the Article, RG. All authors have read and agreed on the published version of the manuscript.

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RESEARCH ARTICLE

Examining the Relationship between Foot Medial Arch Height and Short and Medium Distance Running Performances and Some Variables in Athletes

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Abstract

In this study, the relationship between foot medial arch height, age, height, body weight, body mass index (BMI), calf and thigh thickness and 100-meter and 3000-meter running performances in athletes was investigated. 28 athletes competing in national competitions, with an average age of 18.29±5.68 years, were included in the study on a voluntary basis. The right foot medial arch heights, heights, body weights, calf and thigh thicknesses of the participants were determined. BMI's were calculated. Also, 100 m and 3000 m. running times were determined. Data analyzes were performed using descriptive statistics and correlation tests. As a result of the analysis, 100 m running performance had a negative relationship with the values of height (r= -.377), body weight (r= -.466), BMI (r= -.428) and thigh circumference (r= -.433). It was observed that there was a relationship with the calf circumference measurement value (-.496) at the p<0.01 level. On the other hand, it was determined that the relationship between foot medial arch height (r= -.178) was not significant (p>0.05). On the other hand, 3000 m running performance was negatively affected by height (r= -.493), body weight (r= -.641), BMI (r= -.625) and calf girth thickness (r= -.623). It was determined that it showed significance at the p<0.01 level. It was also determined that there was a significant relationship with medial arch height in a negative direction (r = -.404) and at p < 0.05. As a result, it can be said that foot medial arch height, height, body weight, BMI, thigh and calf circumference thickness values are effective on short and medium distance running performances.

Keywords
Running Performance, Foot Medial Arch Height, BMI, Calf, Thigh

INTRODUCTION

Flat and high feet are serious health problems that can lead to gait irregularities and postural disorders in all age groups (Mickle et al., 2006). These deformities, in addition to disrupting walking patterns, can also cause foot, leg and waist pain. This can affect daily activities such as playing sports, standing for long periods of time, and walking. In a strong foot, muscle activity that allows the foot to adjust when it encounters unevensurfaces during movement plays a role in balance. Foot posture may vary between runners as well as between healthy individuals (Morris, 1977). The foot is divided into the following three categories based on arch height. Pes planus (PP), normal and pes cavus (PC) foot types. PP, also known as flat feet, where excessive pronation causes the ankle to be unable to stabilize the body, reducing its ability to properly absorb shock, but

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running speed is unaffected (Franco, 1987). On the other hand, it has been reported that individuals with flat feet feel fatigue in their feet more easily (Ledoux & Hillstrom, 2002).

The medial longitudinal arch (MLA) of the foot is involved in shock absorption and force transmission in the standing position and during gait (Fiolkowski et al., 2003). Changes in height can alter plantar pressure distributions (Jonely et al., 2011), and affect force absorption (Subotnick, 1985), muscle activity (Denyer et al., 2013; Murley et al., 2009), stability and gait (Cote et al., 2005). Foot morphology; It is closely related to many functions such as balance, walking, standing on one or two legs, jumping, and squatting (Jankowicz-Szymanska et al., 2015). The arch of the foot is the area between the heel and the heel on the bottom of the foot. The arch consists of three separate arches forming a triangle. Two are longitudinal (medial and lateral) arches and one is transversely arched. These arches are formed by the tarsal and metatarsal bones and are supported by the ligaments and tendons in the foot. The arch shape is designed to resemble a bow; It bears the weight of the body and absorbs the shock of movement. The flexibility of the foot provided by the arches is a feature that facilitates daily locomotor functions such as walking and sprinting

The foot, which carries the entire body weight and undertakes the task of adapting to the ground structure, has 3 contact points with the ground, the first metatarsal, the fifth metatarsal and the calcaneus, and among these contact points there are 3 arches: transverse, lateral longitudinal and medial longitudinal (Ledoux & Hillstrom, 2002). In vertical standing position, body weight is distributed equally on both feet. 60% of the weight on the foot is carried by the heel and 40% by the metatarsal heads. 1/3 of the weight carried in front is taken by the 1st metatarsal head, and 2/3 is distributed among the other metatarsal heads. The medial longitudinal arch is more flexible and higher. Its height from the ground is 15-18 mm (Mann, 1991).

The main arch that affects the foot structure is the medial longitudinal arch (MLA). This provides an elastic connection between the forefoot and hindfoot. This ensures that most of the plantar forces occurring during load bearing are dissipated before they reach the femur and leg bones. Problems and alignment disorders that arise specifically from the MLA, such as pes cavus and pes planus, ultimately affect the function of the lower extremity muscles and joints (Franco, 1987; Torun & Çay, 2018).

Arch structure is affected by various factors. Based on age and gender, it has been reported that older adults tend to have a stiffer arch than middle-aged and younger individuals, and women are more likely to have feet with lower arches compared to men (Zhao et al., 2020). It has also been suggested that there is a relationship between body mass index (BMI) and belt structure. In a comparative study, it was noted that the values of the height and width parameters of the belt in overweight and obese individuals are greater than in those with normal body weight. Additionally, other factors such as sports training, shoes, and bilateral asymmetry have been shown to affect foot structure and function (Obrien & Tyndyk, 2014). Various anthropometric and training characteristics have been identified as variables predicting race performance in endurance and ultra-endurance athletes. Various anthropometric characteristics (e.g. body mass, body fat, skinfold thicknesses, height, limb length and girth), training characteristics (e.g. speed during training units, duration of training units, training volume) and physiological variables in endurance and ultra-endurance athletes (i.e. maximum oxygen uptake, anaerobic threshold, lactate threshold, respiratory threshold) have been stated to be important determining variables for race performance (Knechtle, 2014). Here, ultra-endurance performance is defined as activity exceeding six hours (Zaryski & Smith, 2005). The arch of the foot plays an important role in supporting body weight, absorbing ground reaction forces, and maintaining balance during weight-lifting activities or sports. Changes in arch structure inevitably have a profound impact on physical activity and sports (Obrien & Tyndyk, 2014).

Since running is a linear movement of the whole body, the horizontal component of dynamic balance momentum is much more important than the vertical component for speed performance. After preparation for ground contact, the emphasis is shifted to vertical propulsion for sprinting at maximum speed (Lundberg et al., 1989). Although sprinting is a combination of pushing and pulling, focusing on vertical pushes will enable the athlete to actively accelerate his/her thigh towards the ground during the flight phase and increase leg stiffness after the contact time with the ground is achieved. This will reduce ground contact time,

recovery mechanics and increase step frequency and length (Morris, 1977).

In effective running, the foot must hit the ground as close to gravity as possible. If the foot strikes ahead of the line of gravity, the reaction force to this forward and downward thrust will be a backward and upward force that acts to retard forward and backward motion (Kitaoka et al., 1997). The more precisely the horizontal force is directed backwards, the greater its effect. But sprinting consists of a series of ballistic steps in which the body is thrown forward repeatedly like a projectile. These forces are largely absorbed by the arches of the foot (Thordarson et al., 1995).

It is a very important issue to investigate the direction and level of the relationship between variables such as foot medial arch height, age, height, body weight, BMI, calf and thigh circumference thickness values, and 100-meter and 3000-meter running performances. This research is of great importance to understand the factors affecting sports performance and to help athletes train more effectively.

MATERIALS AND METHODS

Participant

The study was conducted with 28 volunteer athletics athletes. Chronological ages, sports ages, heights, body weights, thigh and calf thicknesses, and medial longitudinal arch heights were determined. Additionally, body mass index (BMI) values were calculated and participants' 100-meter and 3000-meter running times were determined. Approval for this study was received from the Bayburt University Rectorate Ethics Committee with the letter dated 01.04.2024-196963 (decision number:72). Participants were informed about the study risks, benefits, confidentiality, and participant rights through the volunteer form covering the research, and their consent was given. The research strictly adhered to the ethical principles of the Declaration of Helsinki, prioritizing participant's rights and well-being in design, procedures, and confidentiality measures.

Data Collection Techniques

To date, no consensus has been reached regarding the measurement of the foot arch. There is no single, globally accepted and agreed-upon method for measuring medial arch height clinically or radiologically. Clinical examination depends on the examiner and is not objective. Many methods for objective measurement of the medial longitudinal arch (MLA) have been described in the literatüre (Forriol & Pascual, 1990; Staheli et al., 1987). These can be roughly divided into direct and indirect methods. Direct methods include anthropometric measurements and radiological evaluations (Staheli et al., 1987; Viladot, 1992). Indirect measurements are footprints and photographic analyzes (Saltzman et al., 1995; Volpon, 1994). Significant debates regarding the validity of these measurement methods still continue (Razeghi & Batt, 2002).

Medial Arch Height Measurement

Participants were asked to sit on a bench with their feet bare. While the legs were extended straight and the feet were in their natural position, a non-flexible plate was extended between the starting point of the thumb metatersal and the lowest part of the calcaneus bone, so as not to create any pressure on the feet. It was then determined by measuring the area between the navicula bone and the plate (the highest area). This method was not used in medial arch height measurements made while standing, as increasing body weight may affect the arch height due to the pressure created. With increasing BMI, pressure on the sole of the foot increases, causing collapse or disappearance of the medial longitudinal arch when standing (Mosca, 2010). During foot arch measurements, only the right foot was measured. The reason for this is that there is no significant difference between the left and right foot (Shariff et al., 2017). Therefore, the right side was used to represent the overall feet of the participants.

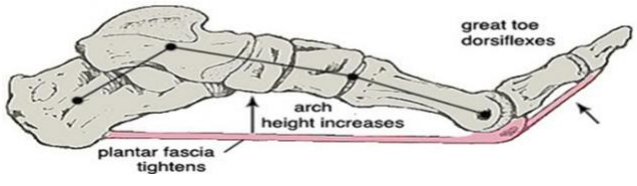

Figure 1. Foot arch height

Height

Participants' heights were measured using a meter while standing barefoot on a flat surface.

Body Weight

Body weight was measured using an electronic precision scale while the athletes were wearing shorts and barefoot.

Thigh Circumference

The individual was asked to open his feet shoulder-width apart (M. Quadriceps in extension). The athlete was asked not to tense both thigh muscles. Measurements were taken from the widest area close to the groin. Measurement values from both thighs were collected and averaged by dividing by two.

Calf Circumference

Measurements were made at the widest point of the calf, with the subject standing and upright, with the legs slightly open and the body weight distributed equally on both feet. Measurement values of both calves were collected and averaged by dividing by two.

BMI

BMI values of the participants were calculated by dividing body weight (kg) / height in meters squared (m2).

Running Times

Both the 100 m and 3000 m running times of the participants were determined using a stopwatch.

Statistical Analysis

SPSS (Version 26.0) package program was used to analyze the data obtained as a result of measurements and calculations. It was determined whether the data were normally distributed or not by the Shapiro–Wilk test. Tabachnick and Fidell (Tabachnick et al., 2013) reported that in the normality test, skewness and kurtosis values being between +1-5 and -1.5 indicate that the data is normally distributed. The skewness and kurtosis values of the study data being between +1.5 and -1.5 were considered as an indication that the data were normally distributed. Pearson Correlation Test was applied to analyze normally distributed data. The significance level was determined as $p<0.05$. In relationships that provide a $p<0.05$ value in the correlation test, if the correlation (r) value is below 0.30, it is interpreted as low, if it is between 0.30-0.70, it is interpreted as a medium relationship, and if it is between 0.70-1.00, it is interpreted as a high relationship (Büyüköztürk et al., 2016).

RESULTS

Table 1. Descriptive information about the variables included in the study

Variables	n	Minimum	Maximum	Average	Standard deviation
Height (cm)	28	145	185	167,29	9,63
Body weight (kg)	28	30	75	51,25	12,56
BMI (kg/m^2)	28	11,02	23,53	18,12	3,14
Calf (cm)	28	27,0	44,0	33,62	5,08
Thigh (cm)	28	34	62	47,07	8,27
Medial arch height (cm)	28	1,5	3,0	2,25	,60
100 m running time (sec)	28	11,23	17,21	13,89	1,74
3000 m running time (min)	28	9,00	16,02	12,26	2,12

When Table 2 is examined, it can be seen that the age variable has a positive relationship with body weight, height, BMI, thigh and calf circumference thickness, medial foot arch height at the level of $p < 0.01$, and a negative relationship with the 3000 m running time at the level of $p < 0.01$. detected. It was revealed that body weight had a negative relationship with 100 m running time at $p<0.05$, 3000 m running time with $p<0.01$, and a positive relationship with all other variables at $p<0.01$. When the height values of the participants were considered, it was determined that there was a positive relationship between them at the level of $p < 0.01$ with BMI, thigh circumference, calf circumference and medial arch height of the foot. On the other hand, it was determined that there was a negative relationship with the 100 m running time at the level of $p<0.05$ and with the 3000 m running time at the level of $p<0.01$. In BMI values, there is a positive relationship between thigh and calf circumference thicknesses and foot medial arch height at the level of $p<0.01$, a negative relationship with the 100 m running time at the level of $p<0.05$ and the 3000 m running time at the level of $p<0.01$. It was seen to be. It was revealed that the perimeter thickness of the femur (thigh) region had a positive and significant ($p<0.01$) relationship with the calf circumference and medial arch height of the foot. In addition, it was determined that the relationship between 100 m and 3000 m running times was

negative and the significance levels were p<0.05 and p<0.01, respectively. It was revealed that calf circumference had a positive and significant relationship with the medial arch height of the foot (p<0.05), and a negative and significant relationship with 100 m and 3000 m running distances (p<0.01). On the other hand, it was determined that the relationship between foot medial arch height and 100 m running time was negative but not significant (p>0.05), and it was also negative but significant (p<0.05) with 3000 m running time. Finally, the relationship between 100 m time and 3000 m running time was found to be positive and significant (p<0.01).

Table 2. Correlation of some variables of the participants with each other (n=28)

Variable		Age (years)	Body weight (kg)	Height (cm)	BMI (kg/m^2)	Thigh circumfer en ce (cm)	Calf circumfe rence (cm)	Foot arch (mm))	100 m time (sec)
Body weight (kg)	r	,810**							
	p	,000							
Height length (cm)	r	,621**	,749**						
	p	,000	,000						
BMI (kg/m2)	r	,726**	,899**	,387*					
	p	,000	,000	,042					
Thigh circumference (cm)	r	,861**	,936**	,733**	,829**				
	p	,000	,000	,000	,000				
Calf circumference (cm)	r	,804**	,864**	,691**	,745**	,927**			
	p	,000	,000	,000	,000	,000			
Foot arch (mm)	r	,515**	,485**	,544**	,347	,499**	,405*		
	p	,005	,009	,003	,071	,007	,032		
100 m running time (sec)	r	-,286	-,428*	-,385*	-,334	-,433*	-,496**	-,178	
	p	,140	,023	,043	,083	,021	,007	,366	
3000 m running time (min)	r	-,540**	-,625**	-,497**	-,549**	-,605**	-,623**	-,404*	,803**
	p	,003	,000	,007	,002	,001	,000	,033	,000

*P<0,05; ** p<0,01

DISCUSSION

The average age of the participants included in the study was 17.29 ± 5.68 years. It was observed that the age values of the participants had a significant positive (r = .810) relationship with their body weight values, at the p = .000 level. It was revealed that the age variable showed a positive (r = .621) and significant (p = .000) relationship with height. Another feature that shows a positive (r = .726) and significant (p = .000) relationship with the age variable is BMI. Thigh and calf circumference thickness is another feature that increases significantly (p<0.01) as age increases. It was determined that the height of the medial arch of the foot, which was the focus of the study, increased significantly (p = .005) with increasing age (r = .515). On the other hand, one of the features that decrease as age increases is the 100 m (r = -.285) and 3000 m (r = -.540) running times. However, it was revealed that this decrease was not significant (p = .140) in the 100 m running time, but was significant (p = .003) in the 3000 m running time. Research and expert opinions on flat feet (Mickle et al., 2006; Staheli et al., 1987) do not recommend any treatment for flat feet in children. They suggest that this condition can often resolve on its own as children grow older. However, another study (Dare & Dodwell, 2014) suggests that the chance of natural recovery of flat feet decreases after the age of 10. In addition, there is also a study (Chang et al., 2010) reporting that flat feet tend to decrease with increasing age. The research results overlap with the literature data above. This can be explained by the fact that the bone structure takes its final shape with increasing age. On the other hand, the improvement in short and medium distance running performance with increasing age can be expressed by the increase in both muscle mass and step length caused by height increase with age.

The average body weight of the participants is 51.25 ± 12.56 kg. There was a positive and significant difference between body weight and height (r = .749; p = .000), with BMI (r = .899; p = .000), and with thigh circumference (r = .936; p = .000). It was revealed that there was a positive and significant relationship with calf circumference (r = .864; p = .000) and medial arch height (r = .485; p = .009). It was determined that there was a negative (r= - .428) significant relationship with the 100 m

running time (p= .023), and a negative and significant relationship with the 3000 m running time (p= -.625; p= .000). A study conducted on university students (Bjelopetrovich, 2016) revealed that there is a positive relationship between foot arch index and body weight. On the contrary, there is also a study (Mickle et al., 2006) that reveals a negative relationship between the height of the medial arch and body weight. Atamtürk (Atamtürk, 2009), in his study on individuals between the ages of 18-60, reported that there was no significant relationship between flat and high feet and body weight. On the other hand, according to the study results, short and middle distance running performance decreases as body weight increases. This is as important as the amount of load the feet carry, as well as the duration of the load. As the running distance increases, the athlete's fatigue will increase accordingly. This will be reflected in your performance.

Among the variables included in the study, as height increased, BMI, thigh and calf circumference values, and medial arch height also increased. It was determined that the relationship between them was positive and significant ($p < .05$). On the other hand, there was a negative (r= -.385) and significant (p=.043) relationship with 100 m running performance and a negative (r= -.497) and significant (p=.007) relationship with 3000 m running performance. determined. In a study (Atamtürk, 2009), it was stated that there was no significant relationship between flat feet or high arches and height. In tall people, the body center of gravity is higher. This means there is less balance. In tall people, the higher medial arch height may be related to the need to bear more body weight and maintain balance. Being taller results in longer strides. Since the study group consists of athletes, the factor affecting BMI is muscle mass rather than fat. However, the increase in muscle mass affects running performance.

Another variable studied is BMI. It was determined that there was a positive (r=.829) and significant (p=.000) relationship between BMI and thigh circumference thickness. It was also determined that there was a positive (r = .745) and significant (p <.01) relationship with calf circumference thickness. When its relationship with medial arch height was examined, it was revealed that it was positive (r = .347) but not significant (p = .071). It was seen that there was a negative relationship between 100 m and 3000 m, respectively (r=-.334), (r=-.549). Their significance levels are p = .083 and p = .002, respectively. In a study conducted on adult individuals (Rosende-Bautista et al., 2021), it was reported that there was a positive relationship between medial arch height and BMI values in both men and women. In another study (Atamtürk, 2009) in which the relationship between flat feet (pes planus) and high arch (pes cavus) morphology and anthropometric characteristics was investigated, it was reported that flat feet or high arch status was not related to BMI. Another study (Rejeki et al., 2017), which revealed that there was no relationship between BMI and medial arch height, was conducted on 5-6 year old children. The reason for not finding a relationship between BMI and medial arch in the literature may be due to the fact that the study groups were composed of children who had not yet completed their development process, and the participants in the study were athletic athletes, whose BMI average was quite low (18.12±3.14 kg/m^2). Because it is known that BMI will not give accurate results in children, pregnant women and muscular athletes.

The participants' thigh circumference thickness had a positive (r= .927) and significant relationship with their calf circumference thickness (p= .000), and the medial arch height had a positive (r= .499) and significant relationship (p= .007). appeared. On the other hand, it was determined that there was a negative relationship with the 100 m running time at the level of p = .021, and with the 3000 m running time at the level of p = .001. The main muscle groups that make up the thigh area are quadriceps and hamstring muscle groups. Developing these muscles through training in addition to the natural growth process can positively affect both medial arch height and running performance.

The study revealed that as calf circumference thickness values increased, medial arch height also increased. It was determined that this increase was significant at the p = .032 level. However, it was revealed that there was a negative and significant (p <.01) relationship with 100 m and 3000 m running times. The medial longitudinal arch is an anatomical feature that aids shock absorption and terrain adaptation at heel strike and mid-stance, subsequently allowing effective driving on the toes (Windlass effect) (Madhav et al., 2018). The shape of the bones, ligaments and muscle tone in the legs play an important role in supporting the arch (Chang et al., 2010).

What is the relationship between the medial arch height of the foot, which inspired the study, and short and medium distance running performances? An attempt was made to find an answer to the question in the light of the data obtained. It was determined that medial arch height had a negative (r = -.178) relationship with 100 m running performance, but this relationship was not significant (p = .366). It was also found to have a negative relationship (r= -.404) with 3000 m running performance. However, the difference between this relationship and the previous one is that it is significant (p=.033).

In the study conducted by Usman et al. (Usman et al.) on runners, they reported that the 100 m running times of runners with high medial arch height were shorter than those with normal and low medial arch height. Another study (Scott & Winter, 1991) reported that those with high-arched feet and normal-arched foot types made forefoot contact faster than those with low-arched foot types. It has also been reported that in the high-arched foot type, hindfoot contact is rare and less time is spent on the hindfoot compared to the low-arched foot type. In their study on individuals with flat feet and normal medial arch height, Sharma and Upadhyaya (Sharma & Upadhyaya, 2016) reported that there was a significant difference in 100 m running performance in favor of participants with normal arch height. In the same study, it was stated that there was a significant difference in 12-minute running performance in favor of participants with normal arch height. It has been stated that high-arched foot type is more beneficial for short distance runners (Morris, 1977). In another study on this subject (Morita et al., 2015), it was reported that foot arch height in children was related to 50-meter sprint time. The shock level that movements create in the human body increases from head to foot. The same situation applies to the load carried by these joints. The bone and muscle structure that makes up the belt can be effective in preventing injuries and creating movements. The medial arch of the foot also ensures that body weight is evenly distributed across the calcaneus and metatarsals. Dorsiflexion of the fingers combined with planter flexion of the ankle allows the body to be moved forward. It is thought that this may positively affect running performance.

Conclusion

Depending on the study results, it can be said that medial arch height increases as age, height, body weight, thigh and calf thickness increase. It can be stated that medial arch height has a negative relationship with both 100 m and 3000 m running performance. However, it was determined that the relationship between medial arch height and 100 m running performance was not significant. Studies with larger participation are needed.

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We thank all participants who voluntarily participated in this study.

Conflict of interest

There is no conflict of interest between the authors in this article.

Ethical statement

Before conducting this study, the necessary permissions (dated and numbered, 01.04.2024-196963 and decision number; 72) were obtained from the Bayburt University ethics committee. Participants were informed with a volunteer consent form. Additionally, all principles of the Declaration of Helsinki were complied with.

Authors Contribution

Study Design, HBT and HK; Data Collection, HBT and HE; Statistical Analysis, HBT; Data Interpretation, HBT and HK; Manuscript Preparation, HBT, HE, and OBI; Literature Search, HBT, OBI and. All authors have read and agreed to the published version of the manuscript

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RESEARCH ARTICLE

Sexual Developmental Characteristics of Intellectually Disabled Adolescents in Türkiye: A Cross-Sectional Analysis

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Abstract

Purpose: This study aimed to examine the sexual development characteristics of adolescents with intellectual disability in terms of several variables. The data were collected with the Personal Information Form and the Sexual Development Characteristics Scale of Children with Adolescent Mental Disabilities. **Method:** Independent samples tests, one-way ANOVA tests, and Bonferroni post hoc analyses were conducted to compare the descriptive characteristics of the adolescents and parents with their scale scores. Multiple linear regression analysis was employed to examine the relationships between the dependent and independent variables. Significant differences were identified between certain subdimensions of the scale and the variables. **Findings:** The sexual arousal subdimension of the scale accounts for 12% of the variance in the dependent variable, the knowledge about physical development subdimension accounts for 10% of the variance in the dependent variable, the sexual satisfaction subdimension accounts for 6% of the variance in the dependent variable, and the sexual self-care subdimension accounts for 11% of the variance in the dependent variable. This difference was explained by the independent variables (R^2 adjusted= .12, .10, .06, .11, respectively). **Conclusion:** In this study, it was found that the sexual development characteristics of adolescents with intellectual disability were affected by the educational status of the mother, the place of residence of the family, the help of the spouse in childcare, the gender of the child, the verbal communication status of the child, the degree of inadequacy of the child, and the ability to meet the personal needs of the child.

Keywords
Adolescence, Intellectual Disability, Sexual Development, Disabilitiy

INTRODUCTION

Adapting to the physiological and psychological changes of adolescence can be challenging for any young person. For adolescents with intellectual disabilities, these changes can present even greater difficulties (Kozan & Hamarta, 2019). Adolescence, which occurs between the ages of 10 and 19, is the transition from childhood to adulthood. This phase is a distinct and crucial stage of human development, essential for laying the groundwork for future health. During adolescence, individuals undergo significant physical, cognitive, and psychosocial changes (WHO, 2023). Since the cognitive development process of adolescents with intellectual disability, whose cognitive development rates are slower than those of their peers, cannot be completed in adolescence, most children cannot develop abstract thinking skills (Madi, 2016). This situation prevents them from participating sufficiently in social life. For this reason, they do not have the opportunity to obtain information from their typically developing peers, and they are less likely to observe such information. As a result, they cannot exhibit appropriate social and sexual behaviors (Kijak, 2011). Therefore, it is crucial to closely observe and assess the sexual development characteristics and any related issues

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in children throughout various stages of their development (Madi, 2016).

Studies examining the sexual development and sexual behavior characteristics of adolescents with intellectual disability have revealed that these adolescents experience more severe sexual behavior problems and display inappropriate sexual behaviors more often than their healthy peers (Akrami & Davudi, 2014; Goli et al., 2020; Hartini et al., 2021). A recent study revealed that a significant proportion of adolescents with intellectual disability have sexual behavior problems. The results showed that among adolescents with intellectual disability, 35.1% have any sexual behavior problems, and the frequency of displaying any inappropriate sexual behavior in society is as high as 27% (Karaca & Çiçek, 2022). Research indicates that adolescents with intellectual disabilities are at high risk for sexual behavior problems due to insufficient privacy, lack of awareness of social and ethical rules, and the imbalance between their emotional and cognitive development and sexual development. Additionally, caregivers' reluctance to address sexual health contributes to this issue, and there is limited knowledge on the topic (Hartini et al., 2021; Eastgate, 2011; Holland-Hall & Quint,2017; Kassa et al., 2016). However, parents must have sufficient knowledge about sexual development to understand their children's sexual development characteristics and attitudes toward sexuality. The findings of this study suggest that determining the sexual development characteristics of adolescents with intellectual disability will guide the prevention of inappropriate sexual attitudes and behaviors and contribute to the planning of sex education programs at the stage of creating content. In this context, this study aimed to examine the sexual development characteristics of children with intellectual disability in adolescence in terms of several variables.

MATERIALS AND METHODS

Participants and Setting

This cross-sectional study was conducted in Türkiye with mothers of adolescents aged 10 to 18 years with intellectual disabilities. Participants attended from the city center in northeastern Türkiye. The study population consisted of adolescents with intellectual disabilities attending Special Education Practice Schools, Special Education Vocational Schools, and Special Education and Rehabilitation Centers in Türkiye between May and June 2023, along with their mothers. Mothers who met the following criteria were included in the study: they were accessible through a whole-count method (not using sample selection), had no communication barriers, and agreed to participate.

The study population consisted of 90 people. The study ultimately included 73 participants, representing approximately 82% of the eligible population within the specified criteria.

Procedure

Prior to starting the study, approvals were secured from the ethics committee and relevant institutional authorities. Participants were informed about the study following the guidelines of the Declaration of Helsinki, and their consent was obtained through informed consent forms. Only volunteer participants were included. Additionally, institutional permission was obtained from the Provincial Directorate of National Education before the research began. The researcher provided information about the study and collected written or verbal informed consent from mothers who volunteered and had no communication barriers. These mothers were then included in the study. Data were collected using the Personal Information Form and the Sexual Development Characteristics of Children with Intellectual Disability Adolescents Scale, administered face-to-face by the researcher. Completing these forms took approximately 15 minutes per participant.

Measures

Personal Information Form

He questioned the mothers' sociodemographic characteristics, such as age, education, employment, income status, family type, number of children, and information, such as age, gender, comorbidity, and dependency/ independence, in the daily activities of the adolescents with intellectual disability.

The Sexual Development Characteristics Scale of Children with Intellectual Disability Adolescents

Gürbüz and Eratay (2020) developed the scale. The scale, which is a five-point Likert-type scale (1 "Totally Agree," 2 "Agree," 3 "I am undecided," 4 "I do not agree" and 5 "I do not agree at all"), consists of a total of 36 items. The Cronbach's alpha internal consistency coefficients of the scale ranged from 0.712 to 0.905. The sexual development characteristics scale for adolescents

with intellectual disabilities comprises nine dimensions, each represented by specific subdimensions. The internal consistency of these subdimensions was assessed using Cronbach's alpha values, indicating the reliability of each subdimension within the scale:

- Sexual arousal (6 items): Cronbach's alpha = 0.865
- Need for information (6 items): Cronbach's alpha = 0.850
- Privacy and social trust (4 items): Cronbach's alpha = 0.777
- Knowledge about physical development (4 items): Cronbach's alpha = 0.768
- Sexual harassment (3 items): Cronbach's alpha = 0.905
- Drive to achieve sexual satisfaction (4 items): Cronbach's alpha = 0.739
- Sharing sexual issues (3 items): Cronbach's alpha = 0.853
- Emotional change (3 items): Cronbach's alpha = 0.791
- Sexual self-care (3 items): Cronbach's alpha = 0.712

The overall Cronbach's alpha reliability coefficient for the entire scale was calculated as 0.850. In the current study, the Cronbach's alpha value for the entire scale was found to be 0.81. Additionally, subdimensional Cronbach's alpha values ranged from 0.70 to 0.89, indicating varying degrees of internal consistency across the different aspects of the scale. These values collectively demonstrate the reliability of the scale in measuring sexual development characteristics among adolescents with intellectual disabilities.

Statistical Analyses

The statistical analysis was performed using SPSS version 26.0 for Windows (SPSS, Chicago, IL, USA). Normal distribution of the data was assessed based on skewness and kurtosis coefficients falling within the range of -1 to +1 (Hair et al., 2013). Descriptive statistics including number, percentage, mean, and standard deviation (SD) were used to summarize continuous variables. Parametric tests were selected due to the normal distribution of the data. Independent samples t-tests and one-way ANOVA were utilized to compare descriptive characteristics among children and parents based on scale scores. Bonferroni post hoc analysis was employed for detecting specific group differences when comparing more than two groups with equal variances. Furthermore, multiple linear regression analysis using the enter method was conducted to explore relationships between dependent and independent variables. Statistical significance was set at $p < 0.001$ and $p < 0.05$.

Ethics Approval

This study was conducted with the approval of the Ethics Committee of Bayburt University with reference number (ACP-2023-164/8). All participants provided voluntary informed consent before participating in the study. The study protocol was conducted in compliance with the principles outlined in the Declaration of Helsinki and other relevant ethical guidelines. We ensured the privacy and confidentiality of the participants' data throughout the study. Any personal identifying information was kept confidential and was only accessible to the research team. Only aggregated and anonymized data were used for analysis and reporting purposes.

RESULTS

Table 1 compares the sociodemographic data and some characteristics of mothers and children with the scale subdimension total score averages. 13.7% of the children included in the study were diagnosed with Down syndrome, 9.6% with learning disabilities, 43.8% with intellectual disabilities, and 27.4% with autism. The score was 117.73±16.78. The subdimension total scores of the scale are shown in Table 2. There was a significant difference between the full scores of the knowledge about physical development (KPD) subdimension of the scale and the educational status of the mother and the place of residence of the family ($p<0.05$). There was a significant difference between the total score for the sexual harassment (SH) subdimension and the score for the spouse's help with childcare ($p<0.05$).

A significant difference was found between the average total score of the sexual satisfaction (SS) subdimension of the scale and between the child's gender and the child's verbal communication status ($p<0.05$). As a result of the post hoc analysis performed in terms of the child's verbal communication status variable, it was determined that the mean scores of the subdimensions of sexual satisfaction were lower for the children who had difficulty speaking than for the children who did not or could not talk.

Table 1. Comparison of mothers' and children's characteristics with average subscale scores (n= 73)

Variables	n (%)	Sexual arousal	Information requirement	Privacy and social trust	Information on physical development	Sexual harassment	Sexual satisfaction	Sharing sexual issues	Emotional change	Sexual self-care
			Average age of mothers: 41.52±0.81		Average age of children: 12.01±0.39					
Educational Status										
Primary School	52(71.2)	13.84±6.59	21.73±5.54	11.21±4.25	10.80±4.53	12.42±2.65	16.28±3.83	12.78±2.42	8.92±3.71	9.17±3.86
Middle School and Above	21(28.8)	14.95±5.11	22.95±5.60	9.76±4.38	8.47±2.63	12.85±2.45	17.00±4.84	13.23±2.21	10.71±3.75	9.14±3.59
		t=.689	t=.849	t=1.307	**t=2.203**	t=.645	t=.664	t=.734	t=1.857	t=.031
		p=.493	p=.399	p=.195	**p=.031***	p=.521	p=.509	p=.465	p=.067	p=.975
Residential area										
Village and District	23(31.5)	7.08±1.47	22,86±6.63	10.69±4.87	10.60±4.80	12.34±2.85	17.60±4.28	13.73±1.83	9.00±3.93	9.39±4.39
Provincial center	50(68.5)	5.80±0.82	21.72±5.01	10.84±4.07	9.92±3.92	12.64±2.48	15.98±3.99	12.54±2.49	9.64±3.75	9.06±3.47
		t=.096	t=.849	t=1.307	**t=2.734**	t=.645	t=.664	t=.734	t=1.857	t=.031
		p=.983	p=.399	p=.195	**p=0.008***	p=.521	p=.509	p=.465	p=.067	p=.975
Husband's help with childcare										
No	26(35.6)	13.82±7.08	22.76±5,24	11.26±5.02	10.00±4.21	11.69±2.93	16.65±4.69	13.03±2.34	9.46±3.74	8.38±3.79
Yes	47(64.4)	14.32±5.80	21,70±5,74	10.53±3,89	10.21±4.23	13.02±2.27	16.40±3.83	12.85±2.39	9.42±3.86	9.59±3.71
		t=.264	t=.784	t=.697	t=.206	**t=2.149**	t=.246	t=.323	t=.039	t=1.323
		p=.790	p=.436	p=.498	p=.838	**p=0.035***	p=.807	p=.748	p=.969	p=.190
Gender										
Girl	31(42.5)	14.16±6.48	22.03±6.07	11.29±5.21	9.48±4.61	12.29±2.90	17.90±3.39	12.96±2.31	9.12±4.08	8.09±3.49
Boy	42(57.5)	14.16±6.04	22.11±5.20	10.42±3.52	10.61±3.85	12.73±2.35	15.45±4.34	12.88±2.42	9.66±3.59	9.95±3.79
		t=.004	t=.066	t=.796	t=1.144	t=.727	**t=2.702**	t=.154	t=.596	**t=2.133**
		p=.997	p=.948	p=.430	p=.257	p=.470	**p=0.009***	p=.878	p=.553	**p=0.036***
Child's Degree of Disability										
Light [1]	34(46.6)	15.47±5.68	22.88±5.67	9.79±4.26	9.00±3.82	12.70±3.04	16.38±4.24	12.70±2.52	9.76±3.74	10.11±3.68
Medium[2]	29(39.7)	13.13±5.64	21.58±5.29	11.34±3.93	10.96±4.15	12.44±2.41	16.24±3.98	12.86±2.38	8.68±3.74	8.96±3.84
Heavy[3]	10(13.7)	12.70±8.74	20.80±6.05	12.60±5.01	11.60±4.94	12.30±1.25	17.60±4.37	13.80±1.54	10.50±4.08	6.50±2.50
		F=1.454	F=.729	F=2.090	F=2.518	F=.127	F=.418	F=.839	F=1.085	**F=3.933[a]**
		p=.241	p=.486	p=.131	p=.088	p=.881	p=.660	p=.436	p=.344	**p=.0.024****
Verbal communication status of the child										
Speaks well and is understandable[1]	29(39.7)	14.51±5.88	22.13±5.99	9.86±4.70	9.44±4.07	12.96±2.55	17.41±3.69	13.03±2.62	9.86±4.16	10.13±4.24
Has Difficulty Speaking[2]	34(46.6)	13.76±5.95	22.26±5.42	10.85±3.86	9.91±3.60	12.23±2.71	15.08±4.45	12.70±2.18	8.85±3.20	8.91±3.08
Does not or Cannot Speak[3]	10(13.7)	14.50±8.22	21.30±5.10	13.30±3.91	12.90±5.62	12.40±2.31	18.60±2.45	13.30±2.31	10.20±4.58	7.20±3.85
		F=.130	F=.116	F=2.467	F=2.726	F=.633	**F=4.361[b]**	F=.297	F=.783	F=2.510
		p=.879	p=.891	p=.092	p=.072	p=.534	**p=0.016****	p=.744	p=.477	p=.146
Personal needs of the child										
He/she can meet his personal needs or control his needs.[1]	25(34.2)	14.40±6.53	21.88±5.89	11.12±4.52	9.36±4.46	12.64±3.09	16.84±4.19	12.92±2.84	9.52±3.74	9.92±3.88
Help is provided, but he/she also helps.[3]	34(46.6)	14.05±5.22	22.97±5.12	10.02±3.80	10.35±4.13	12.70±2.40	16.55±4.10	13.14±1.87	9.79±3.87	9.58±3.71
Depends on other people to meet personal needs.[3]	14(19.2)	14.00±8.00	20.28±5.86	12.07±4.98	11.00±3.94	12.00±2.11	15.71±4.28	12.35±2.56	8.42±3.77	6.78±2.83
		F=.027	F=1.190	F=1.229	F=.763	F=.385	F=.335	F=.548	F=.645	**F=3.787[c]**
		p=.975	p=.310	p=.299	p=.470	p=.682	p=.716	p=.581	p=.528	**p=0.027****

*Independent T test **One-way ANOVA [a]Bonferroni= 1>3 [b]Bonferroni= 3>2 [c]Bonferroni= 1>3

Table 2. The min and max values of the scale and its subdimensions-total scores

Scale Subdimensions	n	Min	Max	Mean	SD
Sexual arousal	73	6	30	14.16	6.18
Information requirement	73	8	30	22.08	5.55
Privacy and social trust	73	4	20	10.79	4.31
Information on physical development	73	4	20	10.13	4.20
Sexual harassment	73	4	15	12.54	2.59
Sexual satisfaction	73	6	20	16.49	4.13
Sharing sexual issues	73	6	15	12.91	2.36
Emotional change	73	3	15	9.43	3.79
Sexual self-care	73	3	15	9.16	3.76
Sexual development scale total	73	74	156	117.73	16.78

SD: Standard deviation

The score was 117.73±16.78. The subdimension total scores of the scale are shown in Table 2.

Table 3. Multiple linear regression analysis model of scale subdimensions according to several variables

Scale subdimensions	Variables					95,0 Cl		
		B	SE	β	t	p	Lower	Upper	Model fit
Sexual arousal	(Constant)	24.811	3.771	-	6.580	.000	17.289	32.333	**Adj. R^2 = 0.12**
	Gender	.021	1.388	.002	.015	.988	-2.748	2.790	
	Child's Degree of Disability	-1.706	.973	-.195	-1.753	.084	-3.647	.236	**F = 4.323**
	Sexual development education	-4.647	1.466	-.351	-3.171	**.002**	-7.571	-1.723	
Information on physical development	(Constant)	9.185	2.712	-	3.387	.001	3.773	14.596	**Adj. R^2 =0.10**
	Educational Status	-2.762	1.053	-.300	-2.622	**.011**	-4.863	-.660	
	Husband's help with childcare	.035	.989	.004	.036	.972	-1.938	2.008	**F = 3.020**
	Gender	.754	.965	.089	.781	.437	-1.171	2.679	
	Diagnosis of the child's illness	1.083	.448	.277	2.416	**.018**	.189	1.977	
Sexual satisfaction	(Constant)	20.962	2.046	-	10.246	.000	16.882	25.043	**Adj. R^2 = 0.06**
	Gender	-2.488	.950	-.300	-2.620	**.011**	-4.381	-.594	
	Verbal communication status of the child	-.316	.687	-.053	-.460	.647	-1.687	1.054	**F = 3.461**
Sexual self-care	(Constant)	9.161	1.808	-	5.068	.000	5.556	12.767	**Adj. R^2 = 0.11**
	Gender	1.588	.846	.210	1.877	.065	-.099	3.275	
	Child's Degree of Disability	-1.495	.594	-.281	-2.515	**.014**	-2.681	-.309	**F = 5.607**

Adj. R^2: Adjusted R square; B: Partial regression coefficient; β: Standard partial regression coefficient; 95% CI: 95% confidence interval

In line with the literature, the relationships between several maternal and child variables and the subdimensions of the scale of sexual development characteristics of adolescents were analyzed using a multiple linear regression model (Table 3). In the analysis of some variables of mothers and children, there was a significant model in the evaluation of goodness of fit (F/p) regression coefficients (R/R^2) ($p<0.05$). It was determined that 12% of the variance in the dependent variable of the sexual arousal (SA) subdimension of the scale was explained by the independent variables (R^2 adjusted= .12), and it was a statistically significant negative predictor of the child's sexual development education status ($p<0.05$). Ten percent of the variance in the KPD subdimension of the scale was explained by the independent variables (R^2 adjusted= .10). Moreover, the education level of the mother was a statistically significant negative predictor, while the child's education level was a

positive predictor ($p<0.05$). Six percent of the variance in the SS subdimension of the scale was explained by the independent variables (R^2 adjusted= .06), and the gender of the child was a statistically significant negative predictor ($p<0.05$). Eleven percent of the variance in the dependent variable of the SSC subdimension of the scale was explained by the independent variables (R^2 adjusted= .11), and it was a statistically significant negative predictor of the child's degree of disability ($p<0.05$, Table 3).

DISCUSSION

This study aimed to examine the sexual development characteristics of children with intellectual disabilities and the influencing factors from the perspective of mothers. The changes and developments that occur during adolescence do not only constitute the content of the adolescence period. These changes and results are significant because they affect the life and health of individuals (WHO, 2023). While parents are an essential source of information about the development of their children, if they do not know about evolution and the principles of action, they make the individuals they raise pay the price of their ignorance (Akbaba, 2004). In this study, we found that the mother's education level and the family's place of residence affected the KPD subdimension of the scale. Our study findings showed that as the educational status of mothers decreased, they needed more information about physical development. In the study of Gürbüz (2018), it was found that the educational status of the parents was not a significant variable in the need for information on physical development. In our study, it was determined that mothers living in villages and towns needed more information. In Türkiye, some services, such as education and health, are concentrated in city centers.

For this reason, it is more difficult for families living in rural areas to access information. This situation explains why mothers living in villages and districts need more information. For this reason, it is more difficult for families living in rural areas to access information. This situation explains why mothers living in villages and districts need more information. It is more difficult for families living in rural areas to access information. This situation explains why mothers living in villages and districts need more information.

In this study, we found that spouses' help with childcare affected the SH subdimension of the scale. Mothers whose spouses helped take care of the child reported that their children's sexual abuse behaviors were more common than those of mothers whose spouses did not help. The sexual feelings, beliefs, and sexual practices expected in a particular life period constitute the sexual development of that period (Gürbüz, 2018). Awareness of the sexuality of children with intellectual disability can cause many problems (such as sexual harassment, emotional break-ups, and adolescent pregnancies) (Austin & Scıarra, 2013).

In this study, we found that the child's gender and verbal communication status affected the SS subdimension, that girls had higher SS subdimension scores than did boys, and that children who did not speak or could not speak more than did the other children. The difficulties of children who do not speak or cannot express themselves may have caused them to exhibit sexual satisfaction behaviors. In the present study, mothers of adolescents with intellectual disability reported that girls had greater sexual satisfaction than boys did. In addition, in our current study, we found that the independent variable predicting the SS subdimension of adolescents with intellectual disability was the gender of the child. This finding suggests that girls have a greater urge to achieve sexual satisfaction. However, contrary to our study findings, Gürbüz (2018) reports that mothers think boys with intellectual disabilities experience more sexual satisfaction than girls do. Sex differences among children and different satisfaction stages can affect their sexual satisfaction. Studies have shown that as adolescents with intellectual disability approach adolescence, anxiety, irritability, and tension increase, these situations increase sexual arousal, and the fact that children do not know what to do for their sexual satisfaction needs increases this tension even more (Akrami & Davudi, 2014; Isler et al., 2009). Educating parents about sexual development for their children and informing their children about sexual satisfaction by taking into account the developmental level of their children can alleviate the effects of possible tension and nervousness.

In the present study, we found that the gender of the child, the degree of disability, and the fulfillment of personal needs affect the SSC subdimension of the scale. The results of the study

showed that mothers think that girls are not able to perform sexual self-care regarding their sexual development compared to boys. The results showed that mothers think that children with severe disabilities cannot perform sexual self-care regarding their sexual development, compared to those with mild disabilities. It has also been shown that mothers think that children who are dependent on another individual to meet their personal needs are not able to provide sexual self-care regarding their sexual development, compared to children who can meet their personal needs. The fact that both sexes have similarities and differences in sexual development characteristics suggests that females need more sexual self-care. Another study supporting our findings revealed that adolescent girls need more sexual self-care (Gürbüz, 2018). It can be assumed that the degree of disability of children and their ability to meet their personal needs affect their sexual self-care behaviors. Nevertheless, teaching the necessary skills in line with their developmental level is necessary to encourage their independence in children with disabilities (Murphy & Elias, 2006). According to the study results, it is thought that it would be beneficial for mothers to obtain information to support adolescents with intellectual disability in meeting their sexual self-care needs.

In our study, we found that providing sexual development education was a significant predictor of the sexual compatibility (SC) subscale among adolescents with intellectual disabilities. The comprehensive sexual development training offered to mothers and adolescents with intellectual disabilities aimed to promote a healthier and safer sexual life for these adolescents. Sexual development education helped adolescents with intellectual disabilities become more aware of their sexual arousal behaviors, contributing to their overall sexual development and well-being (Karaca & Çiçek, 2022).

In the present study, the independent variables predicting the KPD scale subdimension of adolescents with intellectual disability were mothers' educational status and children's diagnosis. As the mother's education level decreases, the need for information about development increases. Information is also needed according to the diagnosis of the disease received by the child. Öncü et al. (2019) stated that parents have the most significant responsibility for sexual education and the development of their children. Increasing aggression in children, self-care problems, and indulging in sex are the leading fears experienced by family members, especially those with a disabled child (Surekha et al., 2017). Therefore, families may need information about their children's physical and sexual development and disease diagnoses.

The degree of disability of adolescents with intellectual disability predicts the SSC variable. This situation suggests that those with severe disabilities cannot perform sexual self-care themselves. While children with typical development can perform sexual self-care by collecting information about self-care, it is often not possible for children with intellectual disability and severe disability to practice sexual self-care due to the limitations of their disabilities (Çifçi Tekinarslan & Eratay, 2013).

Limitations of the Study

This study had several limitations. First, self-report measuring instruments were used in this study, which may cause response bias. Second, the results cannot be generalized since this study was conducted in a province in Türkiye's Eastern Black Sea Region. Third, since the study was cross-sectional, causality could not be determined. Therefore, caution is advised when interpreting the study results. Despite these limitations, the study also has strengths. This study is valuable for evaluating the sexual development characteristics of adolescents with intellectual disability, which is an exceptional group, and for increasing parental awareness of this issue.

Conclusions

The present study revealed that the sexual development characteristics of adolescents with intellectual disability were affected by the educational status of the mother, the place of residence of the family, the help of the spouse with childcare, the gender of the child, the verbal communication status of the child, the degree of inadequacy of the child and the ability to meet the personal needs of the child. The sexual education that parents provide to their children with intellectual disability is one of the essential factors in shaping children's personalities, protecting family health and improving public health, and planning and implementing the necessary training to eliminate sexual problems, which can be achieved through multidisciplinary education. This team should include midwives, nurses, special education teachers, and other health professionals.

Each member contributing to education has different responsibilities in protecting and improving public health (McCann, 2003; Cangöl et al., 2013). The most significant responsibility of the midwives and nurses on this team is to provide training that improves sexual health. This education will be possible by promoting evidence-based practices in sex education and replicating research in different communities. In addition, midwives and nurses should actively plan and implement specialized educational and counseling interventions for parents. In this way, ensuring the healthy sexual development of adolescents with intellectual disability can affect public health.

Conflict Of Interest

No potential conflict of interest relevant to this article was reported.

Ethical considerations

This study was conducted with the approval of the Ethics Committee of Bayburt University with reference number (ACP-2023-164/8).

Author Contributions

Study Design: ZÖK; Data Collection: ZÖK, EOA; Statistical Analysis: ZÖK, EOA; Data Interpretation: ZÖK, EOA; Manuscript Preparation, ZÖK, EOA; Literature Search: ZÖK, EOA. All authors have read and agreed to the published version of the manuscript.

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RESEARCH ARTICLE

Intents and Actualities of Health Optimizing Physical Education (HOPE) Curriculum Implementation: A Sequential Exploratory

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Abstract

This study explores the implementation of the Health Optimizing Physical Education (HOPE) curriculum in senior high schools in Pasay City, Philippines. Utilizing an exploratory sequential mixed-method design, the research first employed validated questionnaires to quantitatively assess the implementation of HOPE 1, 2, 3, and 4. Subsequently, Focus Group Discussions (FGDs) with teachers provided qualitative insights into the challenges and experiences during the curriculum's initial three years. The study involved 428 private school students, 412 public school students, 27 private school teachers, and 38 public school teachers. Quantitative findings indicated a moderate to limited extent of curriculum implementation, with significant differences between public and private schools for HOPE 1 and 2, but not for HOPE 3 and 4. Qualitative data highlighted challenges related to curriculum content, facilities, equipment, and teacher training. Recommendations include targeted workshops, Learning Action Cell sessions, collaboration with community resources, and initiatives like the Family Activity Challenge. These interventions aim to enhance the curriculum's effectiveness, promoting physical activity and health literacy among students.

Keywords
Health Optimizing, Physical Education, Health Promotion, Physical Activity, Philippines

INTRODUCTION

In the realm of education and health promotion, there is a growing recognition of the pivotal role played by physical education programs in fostering holistic student development. Research indicates that students who engage in regular physical activity not only exhibit better physical fitness but also demonstrate improved academic performance and enhanced mental well-being. Physical education is crucial in promoting lifelong health, with physically active individuals experiencing reduced risks of chronic diseases such as obesity and cardiovascular disorders (Mather, 2023). Within the context of the Philippine education system, the implementation of the Health-Optimizing Physical Education (HOPE) curriculum holds significant promise.

Unlike traditional physical education programs, which often focus solely on physical fitness, the HOPE curriculum integrates evidence-based strategies that promote comprehensive health and well-being. This approach is particularly timely as it addresses the dual challenge of rising non-communicable diseases and the need for holistic education among Filipino youth. Despite these intentions, the effective implementation of the HOPE curriculum faces multifaceted challenges, ranging from resource constraints to varying levels of teacher preparedness and institutional support (Department of Education, 2020). The primary objective of this research is to explore the intents

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and actualities surrounding the implementation of the HOPE curriculum in senior high schools across Pasay City, Philippines. Specifically, it aims to identify the key factors influencing the successful integration of health-promoting strategies within the existing physical education framework. Through a sequential exploratory mixed-methods approach, this study seeks to uncover the lived experiences of teachers and students regarding the HOPE curriculum's implementation. By employing both qualitative data from focus group discussions and quantitative data from validated questionnaires, this research intends to provide a comprehensive understanding of the challenges and opportunities in enhancing health outcomes through physical education in Pasay City schools (Bezeau et al., 2023).

Furthermore, this study seeks to contribute to the broader educational discourse by offering empirical insights into the efficacy of HOPE curriculum implementation strategies. By identifying gaps and successes in current practices, this research aims to inform policy recommendations and educational reforms aimed at optimizing student health outcomes through evidence-based physical education interventions.

The rationale for conducting this study lies in its potential to inform evidence-based practices that can significantly impact the health and educational outcomes of students in Pasay City. By elucidating the factors that influence the implementation of the HOPE curriculum, this research not only aims to benefit educational institutions and policymakers but also holds personal significance for the author as a catalyst for positive change in educational practices and student well-being (Rudhumbu, 2021).

This study is guided by several key research questions: What are the intents of the HOPE curriculum? What are the actualities in the implementation of the HOPE curriculum as perceived by students and teachers in public schools in terms of Exercise for Fitness (HOPE 1), Sports (HOPE 2), Dance (HOPE 3), and Recreational Activities (HOPE 4)? Additionally, it seeks to understand the actualities in the implementation of the HOPE curriculum as perceived by students and teachers in private schools in terms of Exercise for Fitness (HOPE 1), Sports (HOPE 2), Dance (HOPE 3), and Recreational Activities (HOPE 4). The study also aims to determine if there is a significant difference in the actualities in the implementation of the HOPE curriculum between public and private schools as perceived by students and teachers in the same categories. Furthermore, based on the challenges experienced by HOPE teachers, the research seeks to recommend solutions to address their training needs in terms of curriculum content, facilities and equipment, instructional materials, and mode of delivery (pedagogical approaches). Finally, based on the study's findings, the research aims to recommend strategies to enhance the program and capacitate the teachers to achieve the goals and objectives of the HOPE curriculum. By addressing these research questions, the study aims to provide a detailed and nuanced understanding of the HOPE curriculum's implementation, its challenges, and potential areas for improvement.

MATERIALS AND METHODS

This study employs an exploratory sequential mixed-method design, beginning with a quantitative phase followed by a qualitative phase to comprehensively evaluate the implementation of the Health Optimizing Physical Education (HOPE) curriculum in Pasay City's senior high schools. The initial quantitative phase utilizes a researcher-made questionnaire, validated by field experts and aligned with the Department of Education's Senior High School HOPE curriculum guide. This phase aims to quantitatively assess the implementation of HOPE 1, 2, 3, and 4, identifying key strengths and weaknesses in curriculum delivery and teaching efficacy.

Following the quantitative assessment, a qualitative phase is conducted to delve deeper into the contextual factors influencing curriculum implementation. This phase involves Focus Group Discussions (FGDs) with randomly selected teachers, exploring their experiences and challenges during the initial three years of HOPE curriculum implementation. This mixed-method approach enables a thorough examination by first capturing quantitative data on curriculum implementation metrics and then gaining qualitative insights into educators' perspectives and experiences.

The study includes a diverse participant pool, comprising 428 private school students, 412 public school students, 27 private school teachers, and 38 public school teachers from Pasay City. This broad sample ensures the inclusion of varied institutional contexts, providing a robust dataset for analyzing the implementation of health-optimizing physical

education. The quantitative data are collected using validated questionnaires, while the qualitative data are gathered through open-ended interviews and FGDs with HOPE teachers.

Ethical considerations are meticulously addressed in this study. Permissions were obtained from the Department of Education Division of City Schools, Pasay, and private senior high schools. Written consent forms were provided to all participants, ensuring their right to withdraw from the study at any time. Additionally, informed consent was secured from the parents of participants under 17 years old. For teachers involved in the focus group discussions, both written and verbal consent were obtained. The ethical protocol ensures the protection of participants' rights and the integrity of the research process.

Statistical Analysis

Statistical analyses, including Weighted Mean, T-test for comparing responses from public and private school teachers, and Z-test for students' responses, are employed to rigorously evaluate curriculum implementation effectiveness. These analyses aim to identify trends, disparities, and areas for improvement in physical education practices across different educational settings within Pasay City.

RESULTS

This section contains reported data collected in terms of the following research questions:

1. What are the intents of the HOPE curriculum?
2. What are the actualities in the implementation of the HOPE curriculum as perceived by students and teachers in public and private schools?
3. Is there a significant difference in the actualities of the implementation of public and private schools as perceived by students and teachers?
4. Based on the challenges experienced by the HOPE teachers, what may be recommended to address their training needs in terms of curriculum content, facilities and equipment, instructional materials, and pedagogical approaches?
5. Based on the study's findings, what may be recommended to enhance the program and capacitate the teachers to achieve the goals and objectives of the HOPE curriculum?

The discussion of the results and their interpretation are presented according to the problems of the study.

The Intents of the HOPE Curriculum

Based on the HOPE Curriculum Guide (DepEd, 2019), the following intents are explicitly stated: Physical Education and Health offers experiential learning for learners to adopt an active life for fitness and lifelong health. The knowledge, skills, and understanding, which include physical and health literacy competencies, support them in accessing, synthesizing, and evaluating information; making informed decisions; and enhancing and advocating their own as well as others' fitness and health.

HOPE 1

Exercise for Fitness. This course intends to enable the learner to set goals, monitor one's participation in aerobic and muscle- and bone-strengthening activities, and constantly evaluate how well one has integrated this into one's lifestyle. It consists of an array of offerings which learners can choose from (Bharathiraja, 2018).

HOPE 2

Individual, Dual, and Team Sports in Competitive and Recreational Settings. The course consists of an array of offerings which learners can choose from. Demonstrates understanding of sports in optimizing one's health as a habit, as requisite for physical activity assessment performance, and as a career opportunity. The learner, leads sports events with proficiency and confidence resulting in independent pursuit and influencing others positively (Pharr et al., 2019).

HOPE 3

Dance. This course on dance includes rhythmical movement patterns, the promotion and appreciation of Philippine folk dance, indigenous and traditional dances as well as other dance forms. It consists of an array of offerings which learners can choose from. The students are expected to demonstrate an understanding of dance in optimizing one's health, as requisite for physical activity assessment performance, and as a career opportunity. As such, the students should be able to lead dance events with proficiency and confidence resulting in independent pursuit and influencing others positively (Lobo, 2022).

HOPE 4

Recreational Activities. The course on recreational activities is associated with outdoor, natural, or semi-natural settings; it enables learners to move safely and competently in these settings while making a positive relationship with natural environments and promoting their sustainable use.

It consists of an array of offerings which learners can choose from. Students are expected to demonstrate an understanding of recreation in optimizing one's health as a habit, as a requisite for physical activity assessment performance, and as a career opportunity. They should also be able to lead recreational events with proficiency and confidence resulting in independent pursuit and influencing others positively (Aquino, 2023).

The actualities in the implementation of the HOPE curriculum as perceived by students and teachers in public schools

Tables 1 and 2 summarize the extent of implementation of the HOPE curriculum. The general evaluation of teachers and students from both private and public-school institutions indicates that the curriculum has been implemented to a moderate to limited extent. This is reflected in the differences in evaluation ratings between private and public-school institutions, which are further discussed below.

The average distributions of ratings across respondents are as follows: Great Extent 28.05%, High Extent 24.93%, Moderate Extent 19.59%, and Limited Extent 27.44%. This shows that the HOPE curriculum was generally implemented between High to Great Extent at 52.98%. Limitations in its implementation cannot be ignored, thus the significance of this study is to be fully mostly implemented. Creating an enhanced program recognizes factors that limit its full implementation (Lalu et al., 2013).

However, despite a Moderate to High Extent of curricular implementation, some respondents perceived certain competencies have poor implementation:

Hope 1

Display initiative, responsibility, and leadership in fitness activities; and

Organize fitness events for a target health issue or concern.

Hope 2

Differentiates types of eating (fueling for performance, emotional eating, social eating, eating while watching TV or sports events).

Observe personal safety protocol to avoid dehydration, overexertion, hypo- and hyperthermia during MVPA participation; and

Identify school and community resources in case of an injury or emergency.

Table 1. Public schools

Students in Public Schools			Teachers in Public Schools		
	Overall Weighted Mean	Verbal Interpretation		Overall Weighted Mean	Verbal Interpretation
HOPE1	1.56	Limited Extent	HOPE1	3.27	High Extent
HOPE2	1.57	Limited Extent	HOPE2	2.46	Moderate Extent
HOPE3	2.37	Moderate Extent	HOPE3	2.13	Moderate Extent
HOPE4	2.38	Moderate Extent	HOPE4	2.23	Moderate Extent

Limited Extent 1-1.75, Moderate Extent-1.76-2.51, High Extent-2.52-3.27, Great Extent-3.28-4.00

Table 2. Private Schools

Students in Private Schools			Teachers in Private Schools		
	Overall Weighted Mean	Verbal Interpretation		Overall Weighted Mean	Verbal Interpretation
HOPE1	2.03	Moderate Extent	HOPE1	1.81	Moderate Extent
HOPE2	2.2	Moderate Extent	HOPE2	1.87	Moderate Extent
HOPE3	2.59	High Extent	HOPE3	2.46	Moderate Extent
HOPE4	2.32	Moderate Extent	HOPE4	1.82	Moderate Extent

Limited Extent 1-1.75, Moderate Extent-1.76-2.51, High Extent-2.52-3.27, Great Extent-3.28-4.00

Significant Differences in the Actualities in The İmplementation of The HOPE Curriculum of Public and Private Schools in Terms of The Students, Teachers, and Administrators

The test of significance results show that there is a significant difference in the implementation of HOPE 1 and 2 curricula between private and public-school institutions as perceived by both teachers and students. The results can be attributed to the difference in how each respondent from both institutions (private and public) evaluated the curriculum based on their perceptions. Public-school respondents tend to rate the curriculum's extent of implementation higher than private school respondents. These tendencies are observed when comparing the evaluation of both sets of respondents per curriculum learning competencies. The difference lies only in the rate that each respondent gave upon evaluation, but the average rate is the same across learning competencies. This tendency is due to an approximation of ratings brought about by the absence of specific guidelines or rubrics in marking evaluations (Belinda et al., 2020).

Teachers' evaluation on HOPE 1 and 2 curriculum implementation generally falls towards the Great Extent level from Private Schools and Moderate Level from Public Schools across learning competencies. Those of the student evaluators differ greatly between Limited Extent for Public Schools and Great and High Extent for Private Schools (Awuonda, 2023).

The results of the evaluation on the extent of implementation of the HOPE 3 and 4 curricula between private and public school institutions, however, show no significant difference. As noted above when comparing the evaluation across competencies, the average rate is generally rated Moderate Extent. However, the distribution of ratings in HOPE 3 and 4 greatly differs between students and teachers. Private School teachers rate at a High Extent in HOPE 3 while students rate at a Moderate extent. Public School HOPE 3 teachers rate at a Moderate extent while students mostly rate at a limited extent. The same can be seen with HOPE 4 respondents. Teachers in Public Schools were mostly rated at a Moderate extent while students rated at limited extent (Solihin et al., 2023).

Private School HOPE 4 respondents generally rated at Great Extent. Factors affecting perceptions in rating between private and public, and teachers and student ratings need to be studied to give better context towards leanings in ratings.

Despite Moderate to High Extent of implementation, some perceived poor implementation of competencies:

HOPE 4

Self-assess health-related fitness (HRF) status, barriers to physical activity assessment participation, and one's diet. Set FITT goals based on training principles to achieve and/or maintain HRF. Organize events for a target health issue or concern. However, these items received a general evaluation of Moderate Extent from questionnaire responses.

Challenges Experienced By the HOPE Teachers May Be Addressed Through Capacity-Building Training

During the Focus Group Discussion, HOPE teachers highlighted various challenges encountered during the implementation of the curriculum from 2016 to the present. Concerns regarding curriculum content were expressed, with participants noting misalignment between examination content and the curriculum guide, as well as issues with the assessment process, indicating a lack of proper implementation and a mismatch between content objectives and assessment methods. Specific components of the curriculum, such as HOPE 1, 2, and 4, were reported as not being fully implemented, citing examples like the failure to organize fitness events or to conduct personal safety protocols during physical activities. The inadequacy of facilities and equipment was also a significant issue raised by participants, impacting the effective delivery of the curriculum (Ampang, 2023).

Additionally, challenges related to instructional materials, such as the need for updates and the unavailability of books, were highlighted. Concerns were also raised regarding the mode of delivery, with suggestions for non-Physical Education (P.E) specialists to undergo training and for P.E teachers to receive adequate training to enhance their pedagogical approaches. Specific instances were mentioned where teachers felt ill-equipped to teach certain topics, such as mountaineering and aquatics, due to a lack of background knowledge, suggesting a need for alternative teaching approaches. Overall, these challenges underscored the complexities involved in effectively implementing the HOPE curriculum and highlighted areas for improvement in terms of

content alignment, resource availability, and teacher training (Esmilla, 2023).

Training Activities that may be Recommended in the Crafting of Capacity Building for Teachers and to Fully Attain the Goals and Objectives of the HOPE Curriculum

The recommendations stemming from the Focus Group Discussion included a call for targeted training activities to address the identified challenges. It was suggested that teachers be equipped with strategies tailored to the needs of contemporary learners and be proficient in their assigned topics. Additionally, emphasis was placed on the importance of conducting physical fitness tests properly and ensuring access to adequate instructional materials and facilities. Collaboration with publishing companies to develop learning materials and providing proper compensation for teachers involved in crafting such materials were also proposed. To address specific challenges related to equipment and facilities, recommendations included workshops on content updates and instructional material development, as well as modifications to equipment to suit the teaching of PE 2 and PE 4. Given the practical constraints faced, such as the lack of equipment for PE 2, alternative approaches were suggested, such as engaging students in activities using items they already possess (Kela & Zulu, 2023).

Furthermore, there was a consensus on the need for government support to provide essential facilities and equipment. Specifically, for the teaching of HOPE 2 and HOPE 4, a Learning Action Cell (LAC) session focusing on best practices in teaching, improvisation of equipment or activities, and utilizing available venues or remote learning environments was recommended to enhance the teaching and learning experience. These recommendations aimed to address the identified challenges and improve the overall implementation of the HOPE curriculum (Lugtu, 2023).

DISCUSSION

Based on the research questions, the study verified the hypotheses that there exists a significant difference in the implementation of HOPE 1 and 2 curricula between private and public-school institutions, but no significant differences in HOPE 3 and 4 as perceived by both teachers and students. Using a mixed-method approach, the study utilized questionnaires followed by Focus Group Discussions (FGD) with teachers to gather data. Various studies offer insights into the implementation and impact of the HOPE program, focusing on its four components: Exercise for Fitness (HOPE 1), Sports (HOPE 2), Dance (HOPE 3), and Recreational Activities (HOPE 4). For example, (Bharathiraja, 2018) examined a health-optimizing physical education-based school physical activity program (CSPAP) aligned with the HOPE curriculum at a middle school, exploring its impact on student physical activity levels and overall health (Hasson, 2023) reviewed literature on Quality Physical Education (QPE) and HOPE, comparing the two approaches and identifying similarities and differences. Cronin & Maher (2023) conducted a qualitative study exploring teachers' experiences implementing the HOPE curriculum, examining their perspectives on the curriculum's effectiveness, challenges faced, and strategies for successful implementation. These studies provide valuable insights into the development, implementation, and effectiveness of the HOPE curriculum in promoting physical activity and overall health in schools.

The results indicated that the HOPE curriculum has been implemented to a moderate to limited extent in both public and private schools. A significant difference exists in the implementation of HOPE 1 and 2 curricula between private and public-school institutions, but no significant differences were found in the implementation of HOPE 3 and 4 curricula. Despite the overall moderate to high extent of implementation, teachers and students reported challenges, including gaps in curriculum content, instructional materials, facilities, and equipment. To address these gaps, several broad recommendations have been made.

Firstly, workshops on content updates and instructional materials development are essential to address the gaps in curriculum content and instructional materials. These workshops will ensure that teachers are informed about the latest developments in physical education and equipped with the necessary resources to deliver the curriculum effectively. Implementing, monitoring, and evaluating these workshops will ensure the goals are achieved (Esmilla, 2023). For HOPE 2 (Sports) and HOPE 4 (Recreational Activities), Learning Action Cell (LAC) sessions on best practices for teaching these courses are recommended. These sessions will provide a

platform for teachers to share and learn best practices, focusing on the improvisation of equipment or activities and the use of available venues or remote learning environments. These sessions will help teachers enhance their teaching strategies and ensure more effective curriculum implementation (Kela & Zulu, 2023).

To address the inadequacy of facilities and equipment, it is recommended to establish linkages with barangay, community, and schools with public spaces for student use. This collaboration will provide students with the necessary environments to engage in physical activities, ensuring the curriculum's objectives are met (Ampang, 2023). Additionally, the Family Activity Challenge: "Outdoor Bonding with Family" is recommended. This initiative aims to promote physical activity beyond the school environment by encouraging students to participate in outdoor activities with their families and submit evidence in a portfolio. This recommendation aims to foster a culture of physical activity and health literacy within the family unit, enhancing students' engagement in physical activities and strengthening family bonds (Lugtu, 2023).

It is essential to ensure that the proposed training activities are not only implemented but also monitored and evaluated to achieve their intended goals. Continuous assessment is crucial to identify areas for improvement and make necessary adjustments to the training programs. To gain a deeper understanding of the implementation and effectiveness of the HOPE curriculum, it is recommended to conduct follow-up studies considering other variables. These studies can provide further insights into the challenges and successes of the curriculum, allowing for ongoing improvements and adaptations.

In summary, the study confirmed that the HOPE curriculum's implementation varies significantly between public and private schools for HOPE 1 and 2 but not for HOPE 3 and 4. The findings highlight the need for targeted interventions to address the gaps in curriculum content, instructional materials, and facilities. Implementing the recommended strategies can enhance the effectiveness of the HOPE curriculum, ultimately leading to the achievement of its goals and objectives in promoting physical activity and health literacy among students. These conclusions and recommendations provide a comprehensive framework for improving the implementation of the HOPE curriculum, ensuring that it effectively contributes to the physical and health literacy of students across both public and private schools.

Conflict of Interest

The authors have declared no conflicts of interest.

Ethics Committee

This study received permission from the Ethics Commission of the State University of Malang No. 223/KEPK/2024.

Author Contributions

Study design, JMG; Data Collection, JFC; Statistical Analysis, SFF; Manuscript preparation, JMG; Literature review, SFF. All authors have read and agreed to the published version of the Manuscript.

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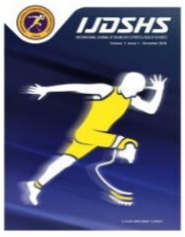

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RESEARCH ARTICLE

The Effect of Biomechanical and Viscoelastic Properties of Gastrocnemius (Lateral-Medial) Muscle and Achilles Tendon on Jumping Performance in Professional Soccer Players

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Abstract

Anaerobic performance (vertical jumps) is an important indicator in determining athletic performance in soccer. The aim of this study was to investigate the effects of biomechanical and viscoelastic properties of lateral and medial gastrocnemius (LG&MG) muscle and achilles tendon (AT) on jumping performance of professional soccer players. A total of 21 male professional soccer players with a mean age of 18.19±0.40 years, a mean height of 180.48±6.25 cm, a mean body weight of 70.71±7.82 kg, and a mean BMI of 21.66±1.65 kg/m² were included in this study. LG and MG muscle, as well as AT biomechanical and viscoelastic properties were evaluated with Myoton Pro device. Measurements were performed in the prone position of the soccer players, LG and MG at 50° plantar flexion, and AT at 0° (neutral position) at an angle of 4 cm above the calcaneal tubercle. Counter movement jump (CMJ) were recorded with the high-speed camera in the validated My Jump 2 application. A significant correlation was observed between the LG (F) tension value and CMJ (P) value and between the MG (R&C) values and the CMJ (F&P) value of professional soccer players ($p<0.05$). There was no significant relationship between AT values and CMJ values ($p>0.05$). It should not be forgotten that training coaches on this subject and applying this information to soccer players by conscious coaches will bring about increases in the athletic performance of soccer players, and all these performance characteristics can be achieved with planned and programmed training.

Keywords
Soccer, Achilles Tendon, CMJ

INTRODUCTION

Flexibility, i.e. increased range of motion (ROM), can be expressed as the ability of joints and series of joints to move at the maximum possible level (Bisanz & Gerisch, 1993). Flexibility; It is affected by factors such as "muscle strength, joint structures, muscle coordination, general body temperature, specific muscle temperature, fatigue, muscle tone, central nervous system functions, muscle contraction and relaxation ability, warm-up, training quality and intensity, injuries, time of exercise, age, climate and gender" (Corbin & Noble, 1986). Muscle elasticity, which is often confused with the concept of flexibility, can be defined as the ability of that object to return to its original state after the end of the application after the contraction in the muscle by applying an effective force to any object. It has been determined that the muscles of the athletes get tired faster as a result of the loss of muscle elasticity in the athletes due to factors that directly affect the performance of the athlete such as the lack of appropriate warm-up protocols, previous injury, poor and inadequate nutrition, and wrong training programming, and as a result, their contraction rates are limited (Gervasi et al., 2017; Masi & Hannon, 2008; Chuang et al., 2012).

Muscle stiffness, which adversely affects flexibility, is the resistance of the muscle against

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deforming forces (Masi & Hannon, 2008; Panjabi, 1992). In line with the efforts of the athletes in exhibiting their individual performances, the movements of the existing muscles participating in the work are likened to the resistance they show in practice. These muscles, that is, agonist muscles, need more energy to produce movement, causing more energy to be spent. This leads to muscle stiffness. It has been shown that differences in stiffness between the two legs, along with increased muscle stiffness, can lead to impaired coordination, one of the determinants of athletic performance of the athlete (Gapeyeva & Vain, 2008). In the literature, there are many different measurement applications such as vertical stiffness, tendon stiffness, muscle stiffness, joint stiffness and muscle joint stiffness (Brazier et al., 2014; Brughelli & Cronin, 2008; Butler et al., 2003). In terms of athlete performance, the presence of too much or too little stiffness in the muscle mass of athletes is a risk factor for injury (Butler et al., 2003). This is because muscle stiffness is vital in the body's load-bearing capacity and ability to perform work such as jumping (Lacroix et al., 2013).

It is known that, depending on lower extremity muscle stiffness, achilles tendon (AT) stiffness is exposed to 4 times more pressure than many other tendons, and therefore Achilles tendon health affects athletic performance in athletes (Kongsgaard et al., 2005; Usgu et al., 2020). Although the AT is the longest, thickest and strongest tendon of our body, this tendon forms an association with the lateral and medial gastrocnemius (LG & MG) muscles, one of the lower extremity muscles, and causes plantarflexion movement of the foot, especially in activities such as running, jumping and walking (O'Brien, 2005; Doral et al., 2010). AT stiffness may vary depending on age, training, neural, hormonal and biomechanical changes (Usgu et al., 2020; Kubo et al., 2001). Counter movement jump (CMJ) test, which is frequently used to measure the strength of lower extremity muscles, can provide information about the structure of athletes' AT. Considering that a large part of the movements applied in daily activities and training involve eccentric and concentric phases, jump tests to determine the athletic performance of athletes can determine the hardness of the AT and, accordingly, its functionality (Finnamore, 2018)

The aim of this study, which was carried out on the assumption that the strength of the lower extremity muscles and the optimal elasticity and stiffness of the AT structures can be effective in increasing the jumping performance (explosive force) of the soccer players, is to examine whether the LG and MG muscles, as well as the AT biomechanical and viscoelastic properties of professional soccer players, have effects on their jumping performance.

MATERIALS AND METHODS

Research Design

The research was carried out in the facilities of Gaziantep Soccer Club and the universe of the research consisted of the soccer players playing in Gaziantep Soccer Club, and the sample consisted of the soccer players who met the inclusion criteria. Ethical approval was obtained from Manisa Celal Bayar University Faculty of Medicine Health Sciences Ethics Committee with the date and number 24.04.2024/2393. Participant provided informed consent, with the volunteer form covering research details, risks, benefits, confidentiality, and participant rights. The research strictly adhered to the ethical principles of the Declaration of Helsinki, prioritizing participant's rights and well-being in design, procedures, and confidentiality measures.
The study included 21 elite soccer players between the ages of 18 and 40 who had no history of orthopedic injuries to the lower extremities in the last 12 months. Also athletes were excluded from the study if they had any back pain and attended any rehabilitation program. A descriptive evaluation form containing the demographic information of the athletes was used as a data collection tool. Individuals who agreed to participate in the study were made to sign an informed consent form. It was stated to the athletes that they should inform the researcher in case of any side effects during the evaluations and application. The evaluations lasted an average of 6 minutes for each soccer player.

Demographic and anthropometric measurements (gender, age, height, weight, body mass index (BMI) of the participants were recorded. The position in which he took part in training and the match and the dominant lower extremity were questioned. Evaluations were made on the dominant side. To ensure the accuracy of the measurements, participants were instructed to avoid strenuous activity five hours before the test and not to take any medication that would interfere with the test.

Sample and Data Collection

Achilles Tendon (AT)

AT viscoelastic properties were evaluated with a highly reliable MyotonPro device (Myoton AS, Estonia). The AT measurements of the participants were taken in the position where the athletes were lying face down with their ankles hanging from the table in a neutral position. Measurement; It is based on the free-swing technique after the excitation of the probe. AT measurement was performed 4 cm above this point after the distal insertion of the tendon (calcaneal tubercle) was determined (Liu et al., 2018). The myonometric measurement was repeated three times and the averages were recorded. Only measurements with a coefficient of variability of less than 3% were considered. Otherwise, the measurements were repeated. In determining the dominant side, the foot on which the athlete hit the ball was questioned.

Counter Movement Jump (CMJ)

Participants were given a standard 10-minute warm-up consisting of running, lower extremity dynamic warm-ups, and vertical jumps. Participants were asked to jump up with maximum force after making a rapid collapse motion from the knees down with the hands at the sides in the normal upright posture. Each participant recorded their vertical jumps using their Iphone 13 Pro (Apple Inc USA) phone with the high-speed camera in the validated My Jump 2 app (Balsalobre-Fernandez et al., 2015). Each participant was asked to make a vertical jump as high as possible 3 times. At the end of each jump, they were given a 2-minute passive rest period. From the video, the take-off and landing of the participants' feet were determined. He then calculated the jump distances using the equation (h= t2 x 1.22625) that determines the jump height. The best results were evaluated (Bosco et al., 1983).

Analyzing of Data

Statistical analyses were performed using SPSS v23 software. To determine the normality of the data, the Kolmogorov-Smirnov test was used. Mean and standard deviation values were taken to describe the data. Independent sample t-test was used to compare the groups. Pearson correlation analysis was used for the relationship between bounce CMJ performance and achilles tendon viscoelastic properties. The confidence interval was selected as 95% and values below <0.05 were considered statistically significant.

RESULTS

21 professional soccer players, all men, participated in the study. The mean age of the athletes was 18.19±0.40 years, the mean height was 180±6.25 cm, the mean body weight was 70.71±7.82 kg, and the mean BMI was 21.66±1.65 kg/m^2. The descriptive information of the soccer players is shown in table 1.

Table 1. Descriptive information

Professional Soccer Players (n=21)	Mean±Std
Age (years)	18.19±0.40
Height (cm)	180.48±6.25
Weight (kg)	70.71±7.82
BMI (kg/m^2)	21.66±1.65

kg: kilogram, m: metres, cm: centimeter, mean: average, std: standard deviation, BMI: body mass index, n: number of individuals

Table 2. Relationship between jump (CMJ) performance and lateral gastrocnemius (LG), tone, biomechanical and viscoelastic properties

CMJ Properties	F	S	D	R	C
JH	0.213	-0.025	-0.145	0.028	0.038
FT	0.215	-0.022	-0.159	0.023	0.031
F	0.324	-0.340	0.212	0.342	0.321
V	0.217	-0.024	-0.159	0.024	0.033
P	0.438*	-0.361	0.129	0.355	0.333

CMJ:Counter Movement Jump, LG: Lateral Gastroknemius, JH: Jump Height, FT: Flight Time, F: Force V: Velocity, P: Power, F:Tone [Hz], S: Dynamic Stiffness [N/m], D: Elasticity, R: Relaxation Time [m/s], C: Relaxation and Deformation Time, *p<.05.

A significant correlation was observed between the LG (F) voltage value and the CMJ (P) value ($p<0.05$). There was no significant relationship between LG other values and CMJ values.

Table 3. Relationship between jump (CMJ) performance and medial gastrocnemius (MG), tone, biomechanical and viscoelastic properties

CMJ Properties	F	S	D	R	C
JH	-0.088	-0.057	-0.073	-0.006	-0.007
FT	-0.078	-0.048	-0.067	-0.019	-0.021
F	-0.189	-0.393	-0.143	0.468*	0.489*
V	-0.078	-0.049	-0.068	-0.018	-0.020
P	-0.219	-0.415	-0.165	0.466*	0.486*

CMJ: Counter Movement Jump, MG: Medial Gastroknemius, JH: Jump Height, FT: Flight Time, F: Force V: Velocity, P: Power, F:Tone [Hz], S: Dynamic Stiffness [N/m], D: Elasticity, R: Relaxation Time [m/s], C: Relaxation and Deformation Time, *p<.05.

A significant relationship was observed between MG (R&C) values and CMJ (F&P) values ($p <0.05$). No significant relationship was observed between other MG values and CMJ values.

Table 4. Relationship between jump (CMJ) performance and achilles tendon (AT), tone, biomechanical and viscoelastic properties

CMJ:

CMJ Properties	F	S	D	R	C
JH	-0.129	-0.119	0.127	0.268	0.327
FT	-0.124	-0.115	0.131	0.269	0.330
F	0.214	0.071	0.021	-0.170	-0.163
V	-0.124	-0.115	0.131	0.268	0.329
P	0.200	0.043	0.064	-0.090	-0.063

Counter Movement Jump, AT: Achilles Tendon, JH: Jump Height, FT: Flight Time, F: Force V: Velocity, P: Power, F:Tone [Hz], S: Dynamic Stiffness [N/m], D: Elasticity, R: Relaxation Time [m/s], C: Relaxation and Deformation Time, *p<.05.

There was no significant relationship between AT values and CMJ values ($p>0.05$).

DISCUSSION

It is known that anaerobic performance (vertical jump) is an important feature in determining athletic performance in soccer, and in order to develop this feature, the strength of the lower extremity muscles and the optimal elasticity and rigidity of the AT structure are needed. For this reason, it is known that determining the individual AT structure can be effective in increasing the jumping performance (explosive force) of soccer players. Based on this, the aim of this study was to examine whether the biomechanical and viscoelastic properties of the LG and MG muscles and AT affect the jumping performance of professional soccer players.

In the study, which included 21 professional male soccer players, the mean age was 18.19±0.40 years, the mean height was 180.48±6.25 cm, the average body weight was 70.71±7.82 kg, and the mean BMI was 21.66±1.65 kg/m². It is known that the amount of fat tissue negatively affects the physical, physiological and psychological performance characteristics of the athlete. It can be thought that the muscle viscoelastic performance characteristics of soccer players may differ positively or negatively depending on their current physical and physiological characteristics. When the body mass indexes of the soccer players are examined, we can say that the fat tissue values are not high in the soccer players participating in the study, but the elasticity levels of the LG and MG muscles are not affected by this. In such studies, taking the fat percentages of athletes is likely to provide researchers with more accurate information in terms of understanding whether AT and fat tissue ratio are related. As a matter of fact, while it was argued that there was a negative relationship between fat layer and muscle hardness values in the study conducted on professional badminton athletes, other studies showed a low and moderate relationship (Bravo-Sánchez et al., 2019; Frohlich

et al., 2014; Agyapong-Badu et al., 2016). For adaptation to training, it is of great importance to know the lower extermite muscle strength output of soccer players, AT functionality and to determine these values. In line with the data obtained from our study, there was a significant relationship between the LG (F) voltage value and the CMJ (P) value and between the MG (R&C) values and the CMJ (F&P) value of professional soccer players ($p<0.05$). There was no significant relationship between AT values and CMJ values ($p>0.05$). Unlike our study in the literature, one study found that there is a relationship between strength output and AT hardness in athletes, which affects athletic performance (Bojsen-Moller et al. 2005). In another study, Wu et al., (2010) stated that AT hardness was associated with CMJ performance characteristics. In the posture position, which is the first stage of the jump, the LG and MG muscle provides the current power output to the extent that it can contract, while the AT creates the optimal jumping performance criterion by extending depending on its elasticity. Brughelli et al. Thought that high muscle stiffness values could be beneficial in terms of performance, as in soccer, which is one of the branches where eccentric and concentric phases are one after the other (Brughelli & Cronin, 2008).

There are many studies showing that explosive force performance values are at optimal values in athletes with high AT stiffness ratio. In studies that put forward this idea and examined the relationship between AT stiffness and jumping performance, it was argued that high AT stiffness values of athletes may be more beneficial in terms of athletic performance (Burgess et al., 2007; Kalkhoven & Watsford, 2018). In another study, Cristi-Sanchez et al., (2019) included 98 elite soccer players and showed that the AT stiffness of soccer players playing in different positions in the same team was similar, and the reason for this was that they did the same training. In another study conducted with athletes from different branches, it was emphasized that AT mechanical properties did not show a significant difference between athletes (Kurihara et al., 2012).

Conclusion

The biomechanical and viscoelastic properties of LG, MG and AT soccer players are very important for optimal jumping performance, which is one of the requirements of the branch. The fact that everyone in the team did the same training and that measurements were applied to soccer players with regionally similar body structure affected the characteristics of the data obtained. In this sense, it is thought that examining the Gastrocnemius-AT structures will contribute to changes in force output and prevention of injuries. It can be said that training coaches on this subject and applying this information to soccer players by conscious coaches will increase the athletic performance (jumping performance, strength, body structure, etc.) of soccer players.

Recommendations

In line with all this information, it should not be forgotten that the optimal performance characteristics that athletes will achieve can be realized through planned, programmed trainings and trainings.

Limitations

The higher number of soccer players involved in the study could have further increased the reliability of the data obtained from the study. At the same time, we do not have the device used for measurements, and we only used this device in a research project. Device support is needed for different studies.

Conflict of Interest

No conflict of interest is declared by the authors. In addition, no financial support wasreceived.

Ethics Statements

This study followed ethical standards and received approval was obtained from Manisa Celal Bayar University Faculty of Medicine Health Sciences Ethics Committee with the date and number 24.04.2024/2393.

Author Contributions

Study design, data collection, statistical analysis, data ınterpretation, article preparation, literature review processes were carried out by the author. The author has read and accepted the published version of the article.

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RESEARCH ARTICLE

Investigation of Burnout Levels of Special Education Teacher Candidates

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Abstract

The current research is to examine the burnout levels of special education teacher candidates. This study used a correlational survey design. 311 teacher candidates studying in the special education department in Turkiye in the 2023-2024 academic year participated in the research. The research data were collected through the Maslach Burnout Inventory-Student Form (MTE-Student Form). The analysis of the obtained data was carried out through the statistical package program. Independent groups t-test was used to reveal the differences in variables related to the gender of the teacher candidates, their satisfaction with the special education teaching department they studied in, and their interaction with individuals with special needs in the past. One-way analysis of variance ANOVA was used to determine the differentiation in terms of variables related to the grade level of education. In cases where differentiation was understood, the Tukey test was used to reveal the reason for the differentiation and to control the difference between the means. As a result of the research, it is revealed that there is a significant difference ($p<0.05$) between the gender, grade level, satisfaction with the special education department and interaction with individuals with special needs in the past and burnout levels of pre-service teachers. In order to reduce burnout in pre-service special education teachers, personal achievement and skills of these individuals should be developed, activities that encourage learning should be included and group work should be included.

Keywords
Burnout, Special Education, Teacher Candidates

INTRODUCTION

The excessive demands of daily life can lead individuals to delay or neglect daily tasks, or in some cases, completely forget about them. It is observed that individuals feel exhausted and inadequate in some situations in daily life. Individuals may constantly complain about such problems. This situation, which is frequently observed as a result of research, is defined as "burnout syndrome" (Özay-Köse et al. 2017). It can be seen that there are various definitions of burnout in the literature. The concept of burnout, defined as psychological and physical depletion of energy (Budak & Sürgevil, 2005), was first defined by Freudenberger (1974) as an occupational disorder seen among volunteer workers in a hospital where drug addicts were treated. Maslach (2003) defines burnout as a psychological condition that occurs as a reaction to stress-increasing factors in the workplace. It also defines burnout as the depletion of energy, strength or resources through excessive demands, fatigue and failure. Maslach et al. (1996) state that burnout is caused by various factors. Role conflict, role ambiguity, participation in decision-making, autonomy and social support are among these factors.

Burnout is a condition that can be seen in professional groups such as teachers, nurses, social workers, physicians, physiotherapists and psychologists who work in professions that require face-to-face interaction with people (Ünal et al. 2001). According to the first researchers who studied burnout, burnout is defined as the result of an attrition process in which highly motivated people lose their enthusiasm (Maslach, 1982;

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Freudenberger & Richelson, 1981). Therefore, it is observed that the described burnout situation is a situation that can also be experienced by university students (Schaufeli & Salanova, 2007). Burnout levels of university students are related to negative individual experiences (Dyrbye, et al. 2006), their level of interest in academic studies (Durán et al. 2006), anxiety about the future (Erturgut & Soyşekerci, 2010) and the individual's feeling of being ready for future professional life (Çavuşoğlu, 2009), results were obtained that it was associated with different variables. Because various behaviors such as meeting the academic challenges expected from them, studying for exams, and participating in classes are seen as students' jobs (Breso et al. 2007).

Burnout faced by teacher candidates; It is evaluated in three dimensions: emotional exhaustion, depersonalization and personal failure (Gmelch & Gates, 1998). Emotional exhaustion is the resistance of individuals to an existing negative situation (Dursun, 2000). For teachers, emotional exhaustion is among the first symptoms of burnout, and teachers often experience emotional exhaustion in the school environment. It is emphasized that emotional burnout can suddenly occur in teachers who start their work enthusiastically in the first years. Depersonalization is the state of protecting the individual from exhaustion and disappointment. Individuals experiencing apathy may experience significant deterioration in their health and effective work potential. In the case of personal failure, when individuals feel ineffective, they feel increasing inadequacy. This situation causes them to lose self-confidence (Maslach & Leiter, 1997).

School environments are considered one of the important educational environments for teacher candidates in terms of their personal, social and academic development (Duru, 2008). Education faculties have the responsibility of training teacher candidates as both good educators and individuals with personality traits that can cope with various difficulties (Çapan, 2012). During this period, teacher candidates may experience problems due to various situations such as various academic duties, exams and economic reasons (Şentürk, 2016; Abbey, 2002). In addition, due to the high expectations and varying concerns of teacher candidates, they may experience stress thinking that they will practice the teaching profession (Yücel, 2012).

Physical and mental symptoms have been observed, including negative attitudes towards work, life, and other people, which cause individuals to experience physical exhaustion, long-lasting fatigue, feelings of helplessness and hopelessness (Jia et al. 2009). When the current symptoms are examined, school burnout; It refers to the fact that the high expectations of university life and general education schools wear out students physically, mentally, psychologically and emotionally (Aypay & Eryılmaz, 2011). Considering Türkiye's education system; It is seen that exams are intense from basic education to high school and university, and a challenging competition is held for students, such as the public personnel selection exam. Therefore, it becomes very stressful for students to make career plans and focus on the education process during this education process (Çapri et al. 2011). In a study on student burnout, it is stated that students who are alienated from school distance themselves from school activities and lessons, and also avoid interacting with their peers at school and all school personnel (Tarquin & Cook-Cottone, 2008). Especially students who are alienated from school and their peers perceive their education and training experiences negatively. Such students may lose their sense of belonging to school and think that such environments are among the threatening places for them. Therefore, it can be said that school anger can be seen as a result of alienation from school (Civitci, 2011).

The high incidence of burnout among special education teachers causes students with special needs to benefit less from educational environments. For this reason, both time is lost during the activity process and the allocated resources are not utilized sufficiently. Additionally, children with special needs are deprived of effective educational practices. The satisfaction of special education teachers with their jobs is directly related to meeting their expectations and personal needs regarding that job. This is possible by ensuring the emotional satisfaction of special education teachers. (Akçamete et al. 2001; Ergin, 1997). Considering this situation experienced by special education teachers, it is important to understand the burnout status of special education teacher candidates (Gönültaş, 2017). Because knowing the burnout levels of teacher candidates is important for the development of the students they will educate and their interest and commitment to the profession (Akgün & Özgür, 2014).

It is emphasized that burnout, which is considered an important problem in teachers, is also likely to be experienced in teacher candidates, and that research should be conducted in this field (Fives et al. 2005; Çavuşoğlu, 2009; Balkıs et al. 2011). However, pre-school teaching (Kan, 2008; Adıgüzel, 2016; Mahmood & Sak, 2017), classroom teaching (Tümkaya & Uştu, 2016; Şencan, 2019; Elma & Ergen, 2019), science teaching (Yavuz & Akdeniz, 2019), mathematics teaching (Amasralı & Aslan, 2017), university senior teacher candidates studying in music, science, biology and preschool teaching programs (Önder et al. 2018; Dübastilar & Yildirim, 2015; Aktaç & Çetinkaya, 2019; Özay-Köse et al. 2017). Although research has been conducted on the burnout levels of teacher candidates (Çelik & Üstün, 2017), it appears that limited research has been conducted on the burnout levels of special education teacher candidates (Gönüldaş & Gümüşkaya, 2022). Therefore, the purpose of this research is to examine the burnout levels of special education teacher candidates. Within the framework of this main objective, the following sub-objectives have been tried to be achieved.

1. Burnout score averages of special education teacher candidates,
2. The difference between gender and burnout levels of special education teacher candidates,
3. The difference between special education teacher candidates' past interactions with individuals with special needs and their burnout levels,
4. The difference between special education teacher candidates' satisfaction with the department they study in and their burnout levels,
5. It is aimed to reveal the difference between the grade levels and burnout levels of special education teacher candidates.

With 311 participants from the special education department of state universities, this study provides valuable insights into the psychological and emotional challenges faced by future special educators. Utilizing the Maslach Burnout Inventory-Student Form (MTE-ÖF), adapted for Turkish by Çapri et al., (2011), the research identifies critical factors such as gender, satisfaction with their department, past interactions with individuals with special needs, and grade level as variables affecting burnout levels. The findings contribute to a deeper understanding of the burnout phenomenon within a specific educational context, highlighting the need for tailored support systems for teacher candidates. By identifying the variables that significantly influence burnout levels, this study underscores the importance of addressing the emotional and psychological well-being of future special education teachers. This research not only contributes to conclusions regarding teacher burnout, but also paves the way for interventions aimed at reducing burnout and enhancing the educational experience for both teachers and students with special needs.

MATERIALS AND METHODS

Model of the Research

Since this study aimed to examine the burnout levels of special education teacher candidates, the relational scanning model, one of the descriptive scanning models, was used. Because screening models describe a past or present situation as it is. Relational screening models, on the other hand, enable understanding the amount of change between two or more variables (Karasar, 2006).

Research Group

311 undergraduate students studying in the special education teaching department of the faculty of education at state universities in Türkiye, participated in the research. 134 (43.08%) of the students are male and 177 (56.9%) are female. 86 (27.65%) of the participants are 1st year students, 86 (27.65%) are 2nd year students, 59 (18.9%) are 3rd year students and 80 (25.7%) are 4 year old students. He is studying in class. Demographic information of the participants is included in the table below.

Ethics

This study was conducted in accordance with the ethical standards and ethical approval was obtained from the Inonu University Social and Human Sciences Research Ethics Committee in Turkey, with reference number [2022/18-6]. The participants signed informed consent document through a volunteer form that outlines the research procedures, risks, benefits, confidentiality, and participant rights. The current research strictly adhered to the ethical principles of the Declaration of Helsinki, prioritizing the rights and welfare of the participant in its design, procedures, and confidentiality measures.

Table 1. Demographic information of teacher candidates participating in the research

		Gender					
		Male		Female		Total	
		N	%	N	%	N	%
Grade Level	1st Grade	32	37,2%	54	62,8%	86	100%
	2nd Grade	36	41,9%	50	58,1%	86	100%
	3rd Grade	17	28,8%	42	71,2%	59	100%
	4th Grade	49	61,2%	31	38,8%	80	100%
	Total	134		177		311	

Data Collection Tool

Maslach Burnout Inventory-Student Form (MTE-ÖF), developed by Schaufeli et al., (2002) and adapted to Turkish by Çapri et al., (2011), was used in the study. Maslach and Jackson's burnout model, which is the most widely used in research and is the subject of this research; Today, it is one of the most important theories accepted in the field of burnout. Maslach and Jackson accept burnout as emotional exhaustion, depersonalization and lack of personal accomplishment (Maslach & Jackson, 1981). As a result of the confirmatory factor analysis conducted by Çapri et al., (2011) for the construct validity of the scale, a 3-factor structure consisting of 13 items was obtained. In the criterion-related validity study of the Maslach Burnout Inventory-Student Form, the Burnout Scale Short Version (TÖ-KV) was applied and the correlations between the total score of this scale and the sub-factors of MTE-ÖF were calculated, respectively. It was found to be 51, .45 and -.38. The Cronbach Alpha internal consistency coefficient calculated to determine the reliability of the scale was found to be .76, .82 and .61, respectively, while the test-retest reliability results were found to be .76, .74 and .73, respectively. Therefore, it was understood that the Turkish adaptation of the scale was usable. Ergin (1992), who adapted the Maslach Burnout Inventory (MTE), which was previously developed by Maslach & Jackson (1981) for professionals working face to face with people, into Turkish, stated that the 7-point rating format is not suitable for Turkish culture. For this reason, the scale adapted to Turkish by Çapri et al., (2011) was prepared in the form of a 5-point rating (never, sometimes, usually, most of the time).

Data Analysis

The data obtained in the study was analyzed using a statistical package program. Independent groups t-test was used to understand the differences in teacher candidates' gender, previous interaction with individuals with special needs, and satisfaction with the special education teaching undergraduate program they studied. One-way analysis of variance (ANOVA) was used to understand the differentiation of teacher candidates in terms of variables related to grade level. In cases where differentiation was understood, Tukey test was performed to control the difference between the means in order to find the reason for the differentiation.

RESULTS

In this part of the research; Descriptive analyzes for the burnout score averages of special education teacher candidates, independent t-test results to understand the relationship between participants' gender, past interaction with individuals with special needs, and satisfaction with the special education department they study in, and burnout levels, and the relationship between teacher candidates' grade levels and burnout levels. For understanding, one-way analysis of variance (ANOVA) results are included.

Table 2. Descriptive analyzes for teacher candidates' burnout score averages

	$\overline{X}$	Sd	Skewness	Kurtosis
Depersonalization	1,79	,81	,925	,947
Emotional Exhaustion	2,18	,82	,972	,696
Competence	3,31	,84	,918	,970
Total	2,41	,49	,971	,920

*N=311

Table 2 includes descriptive analyzes regarding the burnout average scores of teacher candidates studying in the special education department. The mean scores of the burnout scale dimensions were = 1.79 in the depersonalization sub-dimension, = 2.18 in the emotional exhaustion sub-dimension and = 3.31 in the competence sub-dimension, respectively. It is seen that teacher candidates have very low average scores in the depersonalization dimension, low average scores in the emotional exhaustion dimension, and medium score averages in the competence dimension. The central tendency measures (mean, median and peak value) were examined to determine whether the data met the normality conditions and it was understood that they were close to each other. Additionally, the kurtosis and skewness coefficients of the data group to be tested for normality were examined, and since these values were between +1 and -1, it was assumed that they were normally distributed (Hair et al. 2006; George & Mallery, 2012).

Table 3. Independent t test results for the relationship between participants' gender status and burnout levels

	Gender	N	$\bar{X}$	Ss	t	p
Emotional Exhaustion	Male	134	11,35	4,377	1,62	,105
	Female	177	10,59	3,883		
Depersonalization	Male	134	7,83	3,479	3,18	**,002**
	Female	177	6,66	2,982		
Competence	Male	134	13,02	4,139	-1,04	,295
	Female	177	13,42	2,687		

*p<0,05

Table 3 compares the gender status of teacher candidates with the emotional exhaustion dimension, depersonalization dimension and competence dimension. Considering the averages in Table 3, in the emotional exhaustion sub-dimension, males =11.35, females =10.59; In the depersonalization subscale, males = 7.83, females = 6.66; In the competence sub-dimension, males = 13.02 and females = 13.42. It was examined whether there was a significant difference between the sub-dimensions of emotional exhaustion, depersonalization and competence levels, whether the teacher candidates were male or female. It was revealed that there was no significant relationship between emotional exhaustion and competence levels and the gender of the teacher candidates (p>0.05), but there was a significant difference between the gender of the teacher candidates with the depersonalization sub-dimension (p<0.05) and the significant difference was in favor of the male teacher candidates.

Table 4. Independent t-test results regarding participants' interaction with individuals with special needs in the past

	Interaction	N	$\bar{X}$	Ss	t	P
Emotional Exhaustion	Yes	236	11,28	4,219	2,80	**,005**
	No	75	9,77	3,551		
Depersonalization	Yes	236	7,58	3,433	4,12	**,000**
	No	75	5,85	2,135		
Competence	Yes	236	13,25	3,560	,041	,967
	No	75	13,24	2,808		

p<0,05

In Table 4, the emotional exhaustion, depersonalization and competence sub-dimensions of teacher candidates' interactions with individuals with special needs in the past are compared. Considering the averages in Table 4; In the emotional exhaustion sub-dimension, those who interacted = 11.28, those who did not interact = 9.77; In the depersonalization sub-dimension, those who interact =7.58, those who do not interact =5.85; In the competence sub-dimension, those who interact are =13.25, and those who do not interact are =13.24. It was examined whether there was a

significant difference between the teacher candidates' interactions with individuals with special needs in the past and the sub-dimensions of emotional exhaustion, depersonalization and competence. There is no significant difference between the competence sub-dimension and the situations in which teachers have interacted with individuals with special needs in the past (p>0.05), but there is a significant difference between the emotional exhaustion and depersonalization sub-dimensions and the situations in which they have interacted with individuals with special needs in the past (p<0.05). It was revealed that the difference was in favor of the teacher candidates who interacted.

Table 5. Independent t test results regarding the participants' satisfaction with the special education teaching department where they study

	Satisfaction	N	$\bar{X}$	Ss	t	p
Emotional Exhaustion	Yes	298	10,65	3,923	-5,711	**,000**
	No	13	17	3,807		
Depersonalization	Yes	298	6,97	3,142	-5,145	**,000**
	No	13	11,53	2,696		
Competence	Yes	298	13,38	3,314	3,338	**,001**
	No	13	10,23	3,833		

p<0,05

Table 5 compares the satisfaction levels of prospective teachers with the special education teaching department in which they study with the sub-dimensions of emotional exhaustion, depersonalization and competence. Considering the averages in Table 5, those who are satisfied in the emotional exhaustion sub-dimension =10.65, those who are not =17; In the depersonalization sub-dimension, those who are satisfied =6.97, those who are not =11.53; In the competence sub-dimension, those who are satisfied is =13.38, and those who are not are =10.23. It was examined whether there was a significant difference between the teacher candidates' satisfaction with the special education teaching department in which they studied and the burnout, depersonalization and competence sub-dimensions. It was observed that there was a significant difference (p<0.05) between emotional exhaustion, depersonalization and competence sub-dimensions and satisfaction with the special education teaching department. It was observed that the significant difference was in favor of those who were dissatisfied in the depersonalization and emotional exhaustion sub-dimensions, but in favor of those who were satisfied in the competence sub-dimension.

Table 6. One-way ANOVA results regarding the grade level of education

		N	$\bar{X}$	Ss	F	p	Direction of Difference
Depersonalization	1stGrade	86	5,27	1,838	33,690	**,000**	1stGrade- 3rdGrade
	2ndGrade	E86	6,39	2,498			1stGrade-4thGrade
	3rdgrade	59	7,96	3,183			2ndgrade -3rd Grade
	4thGrade	80	9,45	3,666			2ndGrade -4thGrade
	Total	311	7,17	3,252			3rdGrade -4thGrade
Competency	1st Grade	86	13,93	2,806	1,945	,122	
	2ndGrad e	86	13,26	2,817			
	3rd Grade	59	12,69	2,966			
	4th Grade	80	12,92	4,558			
	Total	311	13,25	3,390			
Emotional Exhaustion	1stGrade	86	8,63	2,934	16,176	**,000**	1stGrade -2ndGrade
	2nd Grade	86	11,25	3,887			1stGrade -3rdGrade
	3rdGrade	59	11,38	3,837			1stGrade-4thGrade
	4th Grade	80	12,67	4,586			
	Total	311	10,92	4,114			

***p<0,05**

When Table 6 is examined, the sub-dimensions of depersonalization, competence and emotional exhaustion are compared with the undergraduate grade levels in which the teacher candidates studied. Considering the averages, in the depersonalization sub-dimension, 1st grade students = 5.27, 2nd grade students = 6.39, 3rd grade students = 7.96, 4th grade students = 9.45; In the competence sub-dimension, those studying in the 1st grade =13.93, those studying in the 2nd grade =13.26, those studying in the 3rd grade =12.69, those studying in the 4th grade =12.92; In the emotional burnout sub-dimension, the scores for those studying in the 1st grade = 8.63, those studying in the 2nd grade = 11.25, those studying in the 3rd grade = 11.38, and those studying in the 4th grade = 12.67. It was examined whether there was a significant difference between the undergraduate grade levels of the teacher candidates and the emotional exhaustion, competence and depersonalization sub-dimensions.

It was observed that there was no significant difference between the grade levels of the prospective teachers and the competence sub-dimension ($p>0.05$), but there was a significant difference between the grade levels of the prospective teachers with the sub-dimensions of depersonalization $F=33.690$ ($p<0.001$) and burnout $F=16.176$. Tukey test, one of the Post Hoc tests, was used to test the source of the difference. The direction of the difference is 1 class-3 in the depersonalization sub-dimension. Among the classes, 3rd Class is in favor, 1st Class-4th. It is between the classes, in favor of the 4th Class, 2nd Class-3rd Class. Between Classes and in favor of 3rd Class, between 2nd Class and 4th Class and in favor of 4th Class, between 3rd Class and 4th Class. It was found in favor of the 4th Class. In the emotional exhaustion sub-dimension; 1st Grade-2nd It is between the classes and in favor of the 2nd Class, 1st Class-3rd Class. It is between the classes and in favor of the 3rd Class, 1st Class-4. It was found in favor of the 4th Class.

DISCUSSION

As a result of the research, it is seen that special education teacher candidates have very low average scores in the depersonalization dimension, low average scores in the emotional burnout dimension, and medium score averages in the competence dimension. Considering the burnout scale score averages, it can be said that special education teacher candidates do not feel burnt out. The results of some research conducted in the past have revealed that teacher candidates studying in different branches have high burnout levels due to their concerns about the Public Personnel Selection Examination (KPSS) and finding a job (Repetowski, 1989; Özay-Köse et al. 2017), but special education teachers can easily work in Türkiye. The fact that they can have a profession and start working as teachers easily after the Public Personnel Selection Examinations can be stated as the reasons why they do not experience burnout. Again, special education teacher candidates do not experience burnout; It is stated that it is related to different variables such as attitude towards the profession (Çağlar, 2013), having a happy past life and being satisfied with the department studied (Duru, 1995).

As a result of the research, it was revealed that there was no significant difference between the gender status of the teacher candidates and the competence and emotional exhaustion dimensions of the burnout dimensions, but there was a significant difference between the depersonalization sub-dimension and the gender of the teacher candidates in favor of male teacher candidates. It appears that similar results have been achieved in past research (Aydın et al. 2022). As a result of the research conducted by Ören & Türkoğlu (2006), it was revealed that male teacher candidates showed more burnout in the depersonalization dimension than female teacher candidates. In another study conducted with 469 teachers, a significant difference was found between gender and depersonalization. It has been revealed that male teachers have higher student burnout than female teachers (Schwab & Iwanicki, 1982). Research on the relationship between burnout and gender gives different results (Belkıs et al, 2011; Seçer, 2015; Tansel, 2015). However, there are also research results showing that burnout occurs more in female teachers (Çankaya et al. 2012; Tümkaya, 1996). Studies have also shown that there is no significant difference between teacher candidates' burnout and gender (Özipek-Karabıyık, 2006; Çavuşoğlu, 2005). As a result of this research, it was revealed that there was no difference in the emotional exhaustion and competence sub-dimensions, which are among the burnout sub-dimensions. These contradictory findings show that the gender variable of teacher

candidates alone is not sufficient to explain their burnout status and that it should be examined together with different variables.

As a result of the research, it was revealed that there was no significant difference between the competence sub-dimension and the situations in which teachers interacted with individuals with special needs in the past. Studies have shown (Çikili & Karaca, 2019; Karaca et al. 2020) that teacher candidates' interaction with individuals with special needs does not cause any difference in their perceptions. In this case, it can be stated that especially competence, which is among the sub-dimensions of burnout, may arise from emotional, perceptual and personality characteristics rather than environmental factors (Çankaya et al. 2012). Again, as a result of the research, it was revealed that there was a significant difference between the burnout and depersonalization sub-dimensions and the situations of interacting with individuals with special needs in the past, in favor of the teacher candidates who interacted.

As a result of the research, it was seen that there was a significant difference in the satisfaction of the teacher candidates towards the special education teaching department in which they studied, in favor of those who were dissatisfied in the depersonalization and emotional exhaustion sub-dimensions, but there was a differentiation in favor of those who were satisfied in the competence sub-dimension. Therefore, it was revealed that teacher candidates who were satisfied with the special education department they studied experienced less burnout than teacher candidates who were dissatisfied. In the findings of the research conducted by Cemaloğlu & Erdemoğlu-Şahin (2007), it is seen that there is a significant difference between the satisfaction level and burnout levels of teachers. When the average scores of depersonalization and emotional exhaustion levels of teachers who were dissatisfied with the environment they worked in were examined, it was seen that they experienced more burnout. It has been stated that this situation is due to them not being comfortable in their school environment, feeling that they are constantly being observed, experiencing conflicts within themselves, being tense and being in a stressful environment. Again, in many studies, it is stated that there is a relationship between satisfaction status and burnout and that satisfaction status is a factor affecting burnout (Kırılmaz et al. 2000; Dolunay, 2001; Çam, 1992).

As a result of the research, it was seen that there was no significant difference between the grade levels of the teacher candidates and the competence sub-dimension, but there was a significant difference between the depersonalization and emotional burnout sub-dimensions and the class levels of the teacher candidates in favor of the upper grades. In their research, Gündüz et al., (2012) draw attention to the increase in burnout levels of prospective teachers as their grade levels increase. In their research, Ören & Türkoğlu (2006) state that teacher candidates' burnout increases as their age group increases. As a result of this research, the increase in burnout in favor of upper grades can be considered as a situation related to student age groups. According to the findings obtained in another study, a positive relationship was observed between burnout and the level of anxiety towards the Public Personnel Selection Examination (KPSS) (Özçelik, 2009; Çapulcuoğlu & Gündüz, 2013), which can be explained as a reason why burnout increased in teacher candidates as their grade levels increased. The fact that teacher candidates see themselves as exhausted towards the pre-professional period, even if at a low level, is a result that should be considered. In this respect, the school administration needs to understand the personality and interests of teacher candidates. In addition, orientation studies (Çankaya et al. 2012; Yıldız & Ünlü, 2021) should be included for teacher candidates before they enter their professional life.

It is emphasized that burnout should be reduced in teacher candidates preparing for the teaching profession, the personal success and abilities of these individuals should be developed, activities that encourage learning should be included and group work should be included (Arıcan, 2009) Because considering that burnout covers a process; The fact that the causes of burnout in teachers are seen only as a result of factors encountered after starting the profession prevents the existing problems from being seen as a whole. For this reason, the burnout levels of teacher candidates in the pre-teaching period should be understood and evaluated (Çankaya et al. 2012). Therefore, it is recommended that future studies be conducted to examine the burnout status of special education teacher candidates in different countries.

The limitations of this research are centered around its specific focus and methodology. Firstly, it relies on self-reported data from the Maslach Burnout Inventory-Student Form, which could introduce bias based on individual perceptions and the accuracy of self-assessment. Secondly, the sample is confined to undergraduates from state universities, excluding those from private institutions or those already working in the field, which might offer different insights into burnout levels. Additionally, the research design is cross-sectional, providing a snapshot in time without capturing changes over the course of study or into the early years of teaching.

Conflict of Interest

The research was completed with a single author.

Ethics Committee

Inonu University Social and Human Sciences Scientific Research Ethics Committee decided on the ethical suitability of this research with the decision number 2022/18-6, dated 29.09.2022, session number 18.

Author Contributions

A single author carried out all stages of the research.

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RESEARCH ARTICLE

The Preventive Efficacy of Selenium Supplements on Muscle Soreness Post Heavy Eccentric Exercise

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Abstract

Delayed Onset Muscle Soreness (DOMS) is the muscle pain and stiffness following unaccustomed or strenuous physical activity that initially appears 8–20 h after exercise, peaks at 24–48 h after exercise and persists for several days and affect performance. The aim of the present study was to examine the physiological effects of selenium supplementation on delayed-onset muscle soreness and muscle damage. Thirty-two recreational male students of Sports Science Department, Universitas Negeri Surabaya were randomly and double-blindly assigned to either a selenium supplementation group (n=16) or a Placebo group (n=16) and were directed to take either a selenium capsule or a placebo for a period of 3-weeks. Following the 3-weeks supplementation period, both groups underwent a 10-set x 10-rep countermovement jump (1-min recovery between sets) as an eccentric exercise protocol. Pain of DOMS and CK level were measured prior to the eccentric exercise 1-hr before, 24-hr and 48-hr after eccentric exercise. the result of this study showed that both groups experienced Delayed Onset Muscle Soreness (DOMS) and increased total CK serum within 24 to 48 hours post heavy eccentric exercise. The results indicated that the selenium-supplemented group had a significantly greater reduction in plasma DOMS and total CK serum compared to the Placebo group ($p<0.05$). In summary, selenium supplementation might lower the risk of muscle injury after heavy eccentric exercise, as it effectively reduces plasma DOMS and CK levels in the bloodstream

Keywords
Exercise, Pain, Muscle Damage, Public Health, Supplements

INTRODUCTION

Delayed Onset Muscle Soreness (DOMS) is the muscle pain or tenderness that occurs after unfamiliar exercise (Sulistyarto et al., 2022), Different from acute injuries, DOMS initially appears 8–20 h after exercise, peaks at 24–78 h after exercise (Fleckenstein et al., 2021), and dramatically subsides within 96 hours (Irawan et al., 2022; Şentürk & Göbel, 2022).

This soreness is a natural response of the body to muscle damage and inflammation, as it tries to repair and adapt to the new level of exertion. In relation to DOMS, there are several accompanying symptoms. These include localized muscle weakness, increased swelling, decreased range of motion, and a rise in the blood level of creatine kinase (Lamb et al., 2019).

DOMS is commonly caused by exercises that involve predominantly eccentric movements which are unfamiliar to the body. Eccentric (lengthening) muscle contraction associated with microtrauma to connective and/or contractile tissue (Wiecha et al., 2021). The intensity of injury or damage related to DOMS is often influenced by the muscle's training level. At its core, this injury is a mechanical disruption within the sarcomeres, which are the basic functional units of muscle fibers (Doma et al., 2021). Delayed Onset Muscle Soreness (DOMS), which appears after unaccustomed or high-intensity eccentric exercise, can cause discomfort and anxiety among athletes. Although not classified as

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a disease or disorder, it can also attenuate exercise performance.

Delayed Onset Muscle Soreness (DOMS) occurs due to minor injuries within the muscle fibers, initiating an inflammatory reaction in the body. Athletes often experience pain associated with these micro-damages in their muscle fibers, enables the discharge of certain cellular contents, such as the enzyme creatine kinase (CK) (Ali et al., 2023). Numerous hypotheses have been suggested to explain the cause of Delayed Onset Muscle Soreness (DOMS), such as lactic acid accumulation (Harahap et al., 2023), muscle contractions, injury to connective tissues, muscle damage, and inflammation (Hanon et al., 2024; Keriven et al., 2023).

Numerous studies have identified the release of reactive oxygen species (ROS) due to oxidative stress as a significant contributor to Delayed Onset Muscle Soreness (DOMS) following exercise (Amalraj et al., 2020; Tanabe et al., 2021). Eccentric exercises, in particular, often lead to heightened muscle soreness, as they intensify oxidative stress levels beyond the body's antioxidant capabilities (Barker et al., 2023; Konrad et al., 2022). Moreover, the risk of cellular damage from free radicals can be lessened by the actions of skeletal muscle antioxidant enzymes, such as GPx, GR, SOD, and CAT (MS et al., 2020).

To address this issue, several studies have concentrated on the utilization of dietary supplementation with antioxidants. These substances are renowned for their capability to neutralize free radicals and alleviate the consequences of oxidative stress within the body, which could potentially lead to DOMS and inflammation. Numerous dietary interventions have been investigated for their potential to minimize damage or lessen inflammation following heavy eccentric exercise exercise, some of these include Branched-Chain Amino Acid (BCAA) (Cosentino et al., 2021), Omega-3 Fatty Acid (Mesta & Medithi, 2023), tart cherry Juice (Lamb et al., 2019), Astaxanthine (Barker et al., 2023), and Vitamins C and E (Konrad et al., 2022).

Selenium (Se), an essential trace element, has antioxidant and immune functions. It is an important component of selenoproteins, which play important roles in redox catalytic activity, structural function, and transport processes (Saito, 2022). The effects of Selenium (Se) are linked to providing antioxidant defense, supporting thyroid hormone production, regulating testosterone metabolism, preserving DNA structure, modulating vitamin E (alpha-tocopherol), promoting anti-cancer mechanisms, and improving muscle performance (Kuršvietienė et al., 2020).

Previous studies have shown that increased serum levels of Selenium and selenoenzymes (such as GPx and Se protein) have been noted in the early phase of serious diseases characterized by inflammation and oxidative stress (Hariharan & Dharmaraj, 2020). Therefore, further research is needed to confirm the potential benefits of Selenium, especially to reduce the risk of DOMS and muscle damage after eccentric exercise.

The aim of the present study was to examine the physiological effects of 3-week period of selenium supplementation on delayed onset muscle soreness and muscle damage.

MATERIALS AND METHODS

Participant

This study was a randomized, double-blind, placebo-controlled experiment. Thirty-two recreational male students of Sports Science Department, Universitas Negeri Surabaya were randomly and double-blindly assigned to either a selenium supplementation group (n=16) or a Placebo group (n=16). To ensure a fair comparison, all participants met specific criteria, including being healthy, having a normal Body Mass Index, and not being smokers or on any medications or supplements. Both group was low risk of bias.

All participants had not engaged in heavy or strenous exercise within the past 1 months, nor experienced from any pain. They were instructed to abstain from using any medications or therapies during the study duration. Additionally, throughout the 4-week study duration, participants were directed to refrain from participating in intense physical activities not only during the study but also for 48 hours after the experiment.

Before the study commenced, all anthropometric measurements were consistent across the groups. The research team provided a detailed explanation of the study's objectives and protocols to the participants, who subsequently gave their informed consent.

Prior to enrolling in the study, participants verified their absence of pain or injury through the Physical Activity Readiness Questionnaire (PAR-Q) pre-exercise screening. This Physical Activity

Readiness Questionnaire (PAR-Q) is a standardized tool used to assess an individual's readiness for physical activity to identify the participants who may be at risk of experiencing adverse health consequences due to physical activity (Varanoske et al., 2021). When completing the PAR-Q, participants are accompanied by a Fitness Expert from the Faculty of Sports and Health Sciences. This questionnaire consists of seven questions that inquire about the individual's medical history, symptoms, and physical limitations.

This study followed ethical standards and received approval from the Health Research Ethics Committee, Faculty of Public Health, Airlangga University, and has been deemed ethically acceptable with the identity number: 104/EA/KEPK/2023

Experimental Procedures

The aim of this study was to evaluate the efficacy of 200µg Selenium capsule supplementation over a 3-week period in reducing Delayed Onset Muscle Soreness (DOMS) and Creatine Kinase (CK) levels as indicators of muscle damage after eccentric exercise.

The research spanned a month, commencing with an initial assessment visit. Both the Selenium group and the Placebo group documented their baseline information, which included body weight, height, fat percentage, physical activity level, and VO2Max, to ensure comparable attributes between the groups. In this study, the Multistage Fitness Test (MFT) was used to determine VO2Max of the participants (Kristi et al., 2023). Prior to this, informed consent was obtained following a comprehensive explanation of the study.

Within this study, the Selenium group (n=16) administered capsules, each containing 200µg of selenium (commercially available products), and Placebo group (n=16) received placebo capsules containing 100mg of corn starch, both gruops consumed the capsules one per day after breakfast for 3-week period. Following the 3-weeks supplementation period (22nd day), the participants performed an exercise-induced muscle damage protocol based on 10 sets x 10 with 1-min recovery between sets of repetitions repeated countermovement jumps RCJ), to induce DOMS (Wolska et al., 2023). This protocol has been proven to cause pain sensation (DOMS) in the rectus femoris, tibialis anterior, and fibula muscles of the leg that underwent eccentric exercise (Figure1).

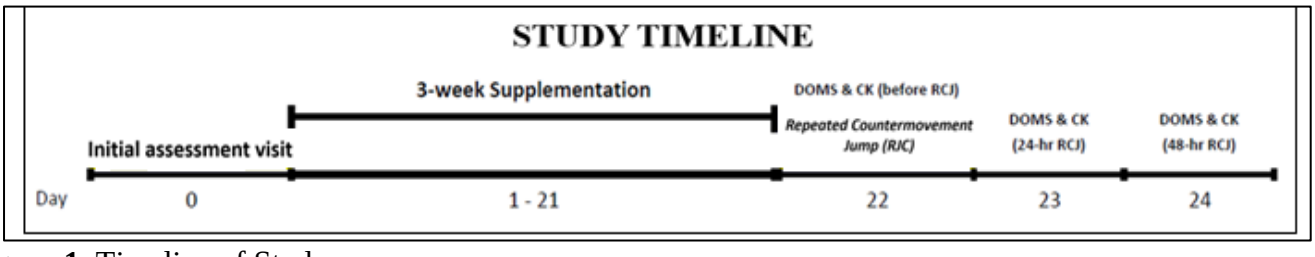

Figure 1. Timeline of Study

Data Collection Tools

Assessment of Muscle Soreness

Visual Analog Scale (VAS) of a 100mm range was used to assess soreness (0mm = no soreness, 100mm = unbearable soreness) before damaging protocol, 24-hr and 48-hr after damaging protocol. Subjects rated DOMS in the lower extremity, which involves three muscles (rectus femoris, tibialis anterior, and fibula muscles of the leg).

Assessment of Creatine Kinase

Blood samples was drawn from the elbow's cubital vein before damaging protocol, 24-hr and 48-hr after damaging protocol. The blood samples were preserved with EDTA to evaluate the total CK (Creatine Kinase) levels. After centrifuging samples at 3000 rotations per minute for 15 minutes, the obtained serum was refrigerated at 20°C in a freezer until further analysis.

Total CK is determined spectrophotometrically, at 30°C, using a commercially available kit (CK-MB Glory Diagnostics). The assessment of CK serum was conducted at the Inregrated Laboratory, Airlangga University Indonesia, to obtain the total CK serum data.

Statistical Analysis

Repeated measures ANOVA was used to analyze mean DOMS (2 x 3), serum CK (2 x 3) scores. Then, a Tukey post-hoc test was used to test the significant effects. The significance level was set at $p < 0.05$, and the value was reported as M ± SD.

RESULTS

Subjects

A total of 32 recreational male students of the Sports Science Department, Universitas Negeri Surabaya students, with an average age of 19.56 years (±0.89) and a mean BMI of 20.93 (±1.14), participated in this study. All participants willingly agreed to become respondents, providing informed consent. The participants were then randomly divided into two groups, Selenium group and Placebo group.

The mean age of the Selenium group (n = 16) was 19.69 (±0.87), while the mean age of the Placebo group (n = 16) group was 19.44 (SD ±0.89). The study presents the physical characteristics, including age, height, weight, BMI, fat percentage, IPAQ, and VO2Max, for both the Selenium group and Placebo group, with p-values greater than 0.05 ($p > 0.05$) to gain the homogeneity variables of both groups (Selenium group and Placebo group). The physical characteristics of both groups (Selenium group and Placebo group) are shown in Table 1.

Table 1. Physical characteristic

Variables	Physical Characteristic				
	Selenium group (M ± SD)		Placebo group (M ± SD)		*P-values*
Age (years)	19.69	±.87	19.44	±.89	.429
Height (cm)	167.63	±5.49	168.06	±2.98	.781
Weight (kg)	59.06	±5.23	58.88	±3.90	.909
BMI	20.99	±1.17	20.84	±1.14	.707
Fat Percentage (%)	12.95	±1.19	12.75	±0.97	.605
Physical Activity Level (MET)	1247.88	±229.03	1271.19	±125.30	.723
Maximum Oxygen Intake (mL/(kg·min))	37.13	±2.54	35.61	±2.60	.105

Muscle Soreness

Post-hoc testing revealed that soreness scores were significantly (P <.05) elevated over baseline in both groups. Selenium group soreness scores at 24 hours were 3.97 (±.62), and significantly decreased at 48 hours 2.5 (±.61) after exercise. Placebo group soreness at 24 hours was 4.05 (±.71), then significantly decreased at 48 hours 4.09 (±.80) after exercise. However, the soreness score in the Selenium group rose less than in the Placebo group (P <.05), this suggests that selenium supplementation may result in a more significant decrease in DOMS than the placebo

Creatine Kinase

Post-hoc testing revealed that Creatine Kinase serum was significantly (P <.05) elevated over baseline in both group. Selenium group Creatine Kinase at baseline was 92.42 (±11.81), then at 24-hours was 110.84 (±13.10) and at 48 hours 104.47 (±8.44) after exercise. Placebo group Creatine Kinase at baseline was 94.48 (±11.81), then at 24-hours was 110.84 (±13.10) and at 48 hours 104.47 (±8.44) after exercise. However, the soreness score in the Selenium group rose less than in the Placebo group (P <.05), which suggests that selenium supplementation may result in a more significant decrease in DOMS than the placebo

Table 2. Time after exercise, in hours

	Groups	Pre	24-Hr	48-Hr
DOMS	Selenium	1.00 ± .00	3.97 ±0.62	2.50 ±0.61
	Placebo	1.00 ± .00	4.50 ±0.71	4.09 ±0.80
Creatine Kinase	Selenium	92.42 ±11.81	110.84 ±13.10	104.47 ±8.44
	Placebo	94.50 ±13.03	131.04 ±13.31	139.62 ±13.49

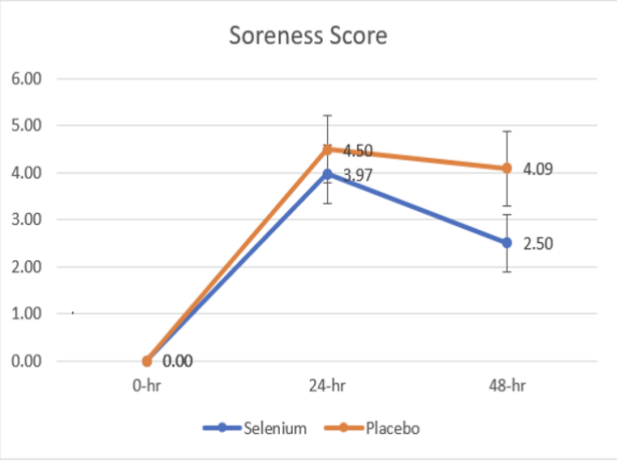

Figure 2.Soreness ratings *(M± SD)* for selenium group and placebo group subjects across time

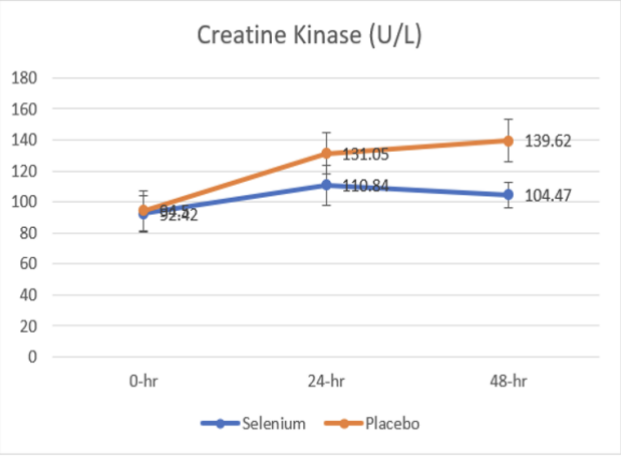

Figure 3. Creatine kinase ratings (M± SD) for selenium group and placebo group subjects across time

DISCUSSION

The aim of the present study was to examine the physiological effects of a 3-week period of selenium supplementation on delayed onset muscle soreness (DOMS) and Creatine Kinase (CK) serum as muscle damage marker. The result of this study indicated that there were increased DOMS and CK in both groups (Selenium group and Placebo group) which peaked at 24-hr after heavy eccentric exercise. The main finding of this study was selenium-supplemented group had a significantly greater reduction in plasma DOMS and total CK serum compared to the Placebo group ($p<0.05$) (see figure 2 and 3). The pain experienced 24-hr after heavy eccentric exercise in the Selenium group decreased significantly 24-hr after heavy eccentric exercise in contrast to the Placebo group. This indicates that selenium supplementation has a positive effect on pain reduction and perceived muscle soreness 24 to 48 h after the heavy eccentric exercise.

The symptoms of pain typically appear after exercise hours or days later, known as delayed onset muscle soreness (DOMS). DOMS initially appears 8–20 h after exercise, peaks at 24–78 h after exercise, and lasts for five-to-seven days (Angelopoulos et al., 2022). The main consequences of DOMS include increased muscle stiffness, loss of strength development and decreased exercise performance (Boukhris et al., 2020; Hotfiel et al., 2019) and muscle protein elevations in blood creatine kinase (CK) (Marathamuthu et al., 2022).

While the occurrence of Delayed Onset Muscle Soreness (DOMS) is well-known, there remains a lack of consensus among experts regarding the exact underlying cause (Sonkodi, 2021). Several studies have proposed that the cause of DOMS is attributed to the development of an acute-phase inflammatory response, stemming from metabolic, mechanical, and oxidative stress (Yoon et al., 2020). It has been shown that high intensity exericse leads to an increase in reactive oxygen species (ROS) production, which is linked to skeletal muscle damage and a decline in physical performance (Tokinoya et al., 2020). There is mounting evidence suggesting that ROS play a role in the muscle injury observed after demanding or unaccustomed exercise (Supruniuk et al., 2023).

Eccentric exercise may lead to heightened levels of ROS, which are a result of oxidative stress. This oxidative stress can trigger a range of systemic and local inflammatory responses, as demonstrated in a study by Zhang et al., (2020). In the context of this specific research, inflammatory responses were associated with increased muscle cell damage indicated by CK release and pain sensation, and in a delayed manner which is characteristic of muscle damage due to heavy eccentric exercise (Tanabe et al., 2021; Wolska et al., 2023).

Selenium (Se), a essential trace element, plays significant roles in antioxidant and immune systems. As a vital component of selenoproteins, it participates in redox catalysis, structure, and transportation tasks. Selenium's functions involve antioxidant defense, thyroid hormone synthesis, testosterone metabolism, maintaining DNA integrity, modulating vitamin E (alpha-tocopherol),

combating cancer, and enhancing muscle performance (Wesolowski et al., 2022; Zhao et al., 2021).

Several studies reported that Selenium supplementation increased the activity of plasma Gluthatine Peroxidase (GPx) (Ringuet et al., 2021; S. Wang et al., 2022), a highly efficient antioxidant enzyme, is significantly dependent on the presence of Se (Shen et al., 2022). This implies that the connection between GPx and Se might be vital for the antioxidant GPx defense, which helps neutralize an excess of ROS (Reactive Oxygen Species). The formation of radicals and other ROS during exercise in muscle, and the antioxidant defense provided by Se, may form a reciprocal relationship, in which they may play a key role of the mineral trace element Se in exercise performance (Ammar et al., 2020).

Furthermore, this study showed that supplementation with selenium significantly reduced the increase in creatine kinase (CK) serum levels as a marker of muscle damage triggered by heavy eccentric exercise. The decrease in CK serum levels in this study was attributed to Selenium supplementation's capacity to restrain the NF-kappa B pathway by adjusting the expression of selenoprotein genes (Wang et al., 2022) This is believed to be due to the fact that by inhibiting the NF-kappa B pathway, the production of inflammatory markers decreases. Selenium seems to lessen nitric oxide (NO) production by regulating the expression of nitric oxide synthase (NOS) and inducible NOS (iNOS) genes (Zachariah et al., 2021).

Conclussion

In summary, we found that Se supplementation could contribute to reducing the increase in DOMS levels and serum CK levels caused by vigorous eccentric exercise. This was suggested to be probably due to the high efficiency of the Se-dependent enzyme GPx, which increased during the supplementation period. Consequently, Selenium supplementation could potentially serve as an enhancer of antioxidant potential for physically active individuals

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Conflict of Interest

All authors have no conflict of interest regarding this article. This research was funded by the Faculty of Sports Science through the Policy Research grant program of the Faculty of Sports Science, Surabaya State University in 2024

Ethical Clearence

This study followed ethical standards and received approval from the Health Research Ethics Committee, Faculty of Public Health, Airlangga University, and has been deemed ethically acceptable with the identity number: 104/EA/KEPK/2023. Participants provided informed consent, with the volunteer form covering research details, risks, benefits, confidentiality, and participant rights. The research strictly adhered to the ethical principles of the Declaration of Helsinki, prioritizing participants' rights and well-being in design, procedures, and confidentiality measures.

Author Contributions

Study design, AS; Data Collection, RJI; Statistical Analysis, AS, RJI; Manuscript preparation, AS, RJI; Literature review, AS, RJI. All authors have read and agreed to the published version of the Manuscript.

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RESEARCH ARTICLE

Effect of Ergonomic Training and Exercise in Esports Players: A Randomized Controlled Trial

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Abstract

This study aimed to investigate the effectiveness of exercises given with ergonomics training on sleep, neck, and upper extremity functions in esports players. Fifty professional or amateur esports players were randomly divided into two groups: an exercise group that received exercise and ergonomics training and a control group that received only ergonomics training. The exercise program was applied three days a week for eight weeks. Before and following the study, the participants were evaluated using the Disabilities of the Arm, Shoulder, and Hand Questionnaire (DASH), the Neck Disability Questionnaire (NDI), the Rapid Upper Extremity Assessment (RULA), and the Pittsburgh Sleep Quality Index (PSQI). Following the implementation of an intervention, there were notable declines in both the NDI and RULA scores in both groups. Conversely, while a reduction in the DASH and PSQI scores was observed in the exercise group, this was not evident in the control group. The decline in NDI and DASH scores in the exercise group following the intervention period was found to be statistically significant when compared to the control group ($p < 0.01$). The application of physical exercise improving thoracic and shoulder mobility, nerve stretching, and hand/wrist strength and mobility, along with ergonomics training, has been shown to have a positive impact on the neck, upper extremity functions, and sleep quality of the esports players.

Keywords
Ergonomics, Exercise, Esports, Neck pain, Sleep

INTRODUCTION

Electronic sports (esports) emerged as a popular phenomenon within the gaming community during the early 2000s, attracting an estimated audience of 395 million individuals globally by 2018 (Giakoni-Ramírez et al., 2022). Esports is characterized by its reliance on computer games and has been referred to by various terms in literature, such as computer games, electronic games, cyber games, online games, video games, and virtual games (Macey & Hamari, 2018). It can be described as a sport where players compete on digital platforms, often within multiplayer online games (Peter et al., 2019). The proficiencies essential for esports are similar to those demanded in traditional sports, including traits like astute decision-making, imaginative reasoning, and a comprehensive grasp of the game (Pedraza-Ramirez et al., 2020).

Furthermore, esports aim to enhance mental and physical abilities that are closely linked to information and communication technology (Wagner, 2006). It has been shown that participation in esports can enhance cognitive abilities, such as improved thinking, reaction time, and hand-eye coordination skills, while also fostering a sense of teamwork (Dongsheng et al., 2011). Similar to modern sports, electronic sports involve matches and tournaments, each game requiring its own distinct strategy, tactics, and individual or team motivation. Therefore, a high level of physical fitness in esports players can confer a competitive edge in this field (Bányai,

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Griffiths, Király, & Demetrovics, 2019; Yükçü & Kaplanoğlu, 2018).

However, since esports players often engage in prolonged periods of sedentary activity, there is a risk of adverse effects on their physical health (Giakoni-Ramírez et al., 2022). Due to the prolonged periods of sedentary behavior commonly observed in esports players, there exists a potential risk of detrimental effects on their physical well-being (Borbély & Achermann, 1999). In addition, the physical and environmental conditions of the workspace may also play a role in the onset of such health issues (Pandey et al., 2020). Ergonomics assumes a pivotal role in the genesis of musculoskeletal disorders, underscoring the significance of comprehending ergonomic principles to avert such occurrences (Babak Vahdatpour, 2015; Pandey et al., 2020). Several studies highlighted the importance of ergonomics training to protect desk workers from musculoskeletal diseases and to prevent such occupational diseases (Hoe et al., 2018; Mahmud et al., 2011). Previously, physical exercise has been suggested for the prevention and treatment of musculoskeletal complaints (De la Corte-Rodriguez et al., 2024). Several studies have drawn attention to the correlation between computer-related tasks and musculoskeletal discomfort, highlighting the beneficial influence of physical activity on both physical and mental health (Dockrell et al., 2015; Kaliniene et al., 2013). Nonetheless, the scarcity of empirical investigations into the efficacy of ergonomic training and physical exercise interventions for esports players is noteworthy.

In view of these revelations, the aim of this study was to explore the impact of ergonomics training and physical exercise on postural alignment, quality of sleep, as well as dysfunctions in the neck, arms, shoulders, and hands among esports players.

MATERIALS AND METHODS

Study Design

This study followed ethical standards and received approval from the Üsküdar University Non-Interventional Research Ethics Committee (reference number 61351342/September 2023-20). Participants provided informed consent, with the volunteer form covering research details, risks, benefits, confidentiality, and participant rights. The research strictly adhered to the ethical principles of the Declaration of Helsinki, prioritizing participant's rights and well-being in design, procedures, and confidentiality measures.

Determination of Sample Size

The G*Power 3.1.9.7 program was employed to determine the requisite sample size for the study. The minimum sample size necessary to achieve a statistical power of 0.80 and alpha level of 0.05 in 2 groups and 2 repeated measurement designs with an effect size of 0.50 was calculated as 50 individuals (25 in each group). The study population consisted of 50 licensed players who participated in professional and amateur esports organizations or tournaments of the related games. The research was conducted as a single-blind, randomized controlled study, adhering to the ethical principles outlined in the Declaration of Helsinki and approved by the ethics committee.

Randomization

The research was carried out following established research design principles as a single-blind randomized controlled trial. The assessor assessed the investigation as single-blinded. Fifty individuals were randomly assigned to either the exercise group (n:25) or the control group (n:25). Randomization was achieved through the utilization of sealed envelopes. To ensure unbiased randomization, the names of eligible participants were written on paper and placed in a container. A random selection process was then used by an evaluator to create different groups. Initially, 57 participants underwent assessments by a medical specialist to determine their eligibility for the trial. The trial ultimately involved 50 participants. The flow of participants through the study is depicted in Fig. 1.

The inclusion criteria included individuals who had actively participated in esports organizations and tournaments in the preceding six months (Tang et al., 2023), were free from chronic conditions affecting the musculoskeletal system, had not experienced any health issues that precluded exercise and had not undergone a surgical procedure within the previous six months.

The exclusion criteria were defined as being under the age of 18 years, not having participated in esports organizations or tournaments in the previous six months, having a chronic disease that would affect the musculoskeletal system, and having undergone a surgical operation that would preclude interest in esports games over the previous six months.

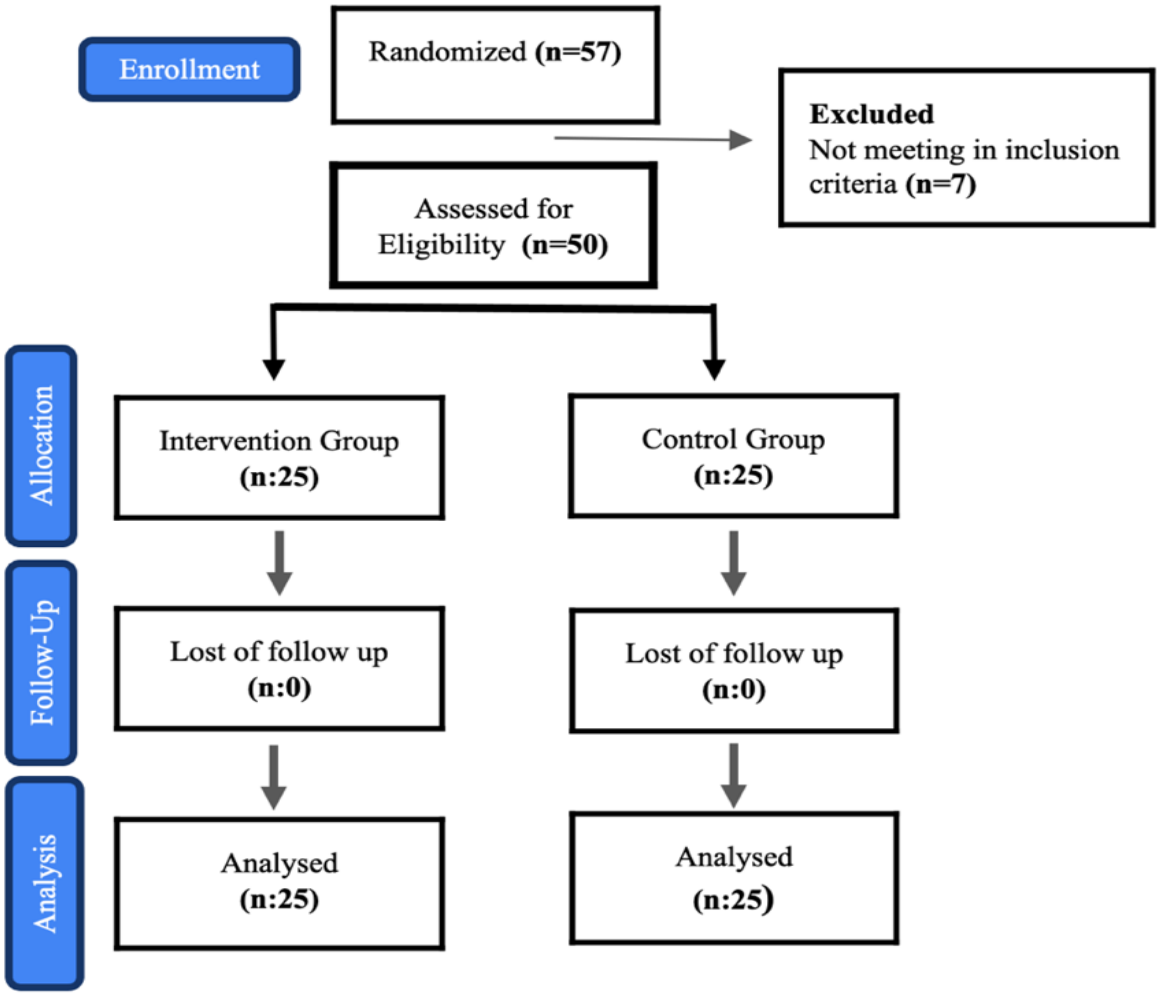

Figure 1. CONSORT flowchart

Intervention and procedure

Once the individuals to be included in the study had been informed in detail about the study, they were asked to sign an informed consent form, indicating their voluntary agreement to participate. Participants were divided into the control group and the exercise group. All participants received ergonomics training. The exercise group was additionally given an exercise program for eight weeks, three days a week, and 45 minutes a day.

Ergonomic Training

All participants in the study underwent ergonomic training. This training encompassed the following elements: the definition, importance, purpose, and risk factors for musculoskeletal disorders that can be seen in esports players, ergonomic arrangements that can be made in the working environment, and methods of protection from musculoskeletal injuries, posture disorders, and various ergonomic arrangements that can be made for posture disorders, chair selection, screen selection, rest breaks. The participants were trained on two occasions: on the first day of the study and at the end of the fourth week. The training was conducted interactively, with the use of videos and visual aids. The training sessions were conducted individually and lasted approximately two hours.

Exercise Training

The exercise training program was conducted three days a week for eight weeks, with an average duration of 45 minutes. Before the commencement of the exercise training program, all participants were informed about the exercises that would be performed. The exercise protocol was designed in three parts, comprising a warm-up, exercise, and cool-down. Stretching exercises, mobility exercises, and strength exercises were performed. Rest time was 30-45 seconds between sets and 2-3

minutes between exercises. The participants were instructed in the performance of dynamic and static stretches, nerve stretches, postural strength, and functional exercises for the upper extremity. The related movements were modified according to the exercise capacity of the participants. The exercise content also included median, ulnar, and radial nerve stretching, neck and thoracic mobility exercises, and functional strength exercises for the shoulder, arm, hand, and wrist. Regular online interviews were conducted to monitor the exercise follow-up.

Outcome Measurements

The sociodemographic information form, the Disabilities of the Arm, Shoulder and Hand Questionnaire (DASH), the Neck Disability Index (NDI), the Rapid Upper Limb Assessment (RULA) and the Pittsburgh Sleep Quality Index (PSQI) were used to obtain data from the players.

Disabilities of the Arm, Shoulder, and Hand Questionnaire

The Disabilities of the Arm, Shoulder, and Hand Questionnaire (DASH) is a region-specific self-administered assessment tool that is used to evaluate self-reported levels of upper-extremity disability and symptoms. It consists of three sections that scored 0 (no disability) to 100. The initial part of the questionnaire is focused on assessing the patient's function/symptom (DASH-FS) score. This section includes 30 questions, with 21 questions dedicated to evaluating the patient's strain during daily activities, 5 questions examining symptoms such as pain, activity-related pain, tingling, stiffness, and weakness, and the remaining 4 questions assessing social function, work, sleep, and self-confidence individually. The working model (DASH-W) encompasses an additional four questions beyond the initial 30 questions to gauge the individual's disability in the workplace. The Sports-Musicians Model (DASH-SM), which also contains four questions and demands high performance, determines the extent of disability in patients engaged in sports or music. A Turkish validity and reliability study of the questionnaire was conducted (Tülin Düger, 2006; Hudak, 1996).

Neck Disability Index

The Neck Disability Index (NDI) is used to evaluate neck pain severity, self-care, lifting, reading, headache, concentration, work, driving, sleep, and leisure activities. Each parameter is rated on a scale from 0 to 5, with 0 indicating no pain or functional limitation and 5 representing the most significant pain and limitation. Participants were required to choose the most suitable option for each parameter. Subsequently, the scores for each selected option were tallied to calculate the total score. In the NDI, scores of 35 points or higher were categorized as complete disability, 25 to 34 points as severe disability, 15 to 24 points as moderate disability, 5 to 14 points as mild disability, and 0 to 4 points as no disability. The validity and reliability of the Turkish version of the questionnaire were assessed by Aslan et al. (Aslan et al., 2008; Vernon H., 1991).

Rapid Upper Limb Assessment

The RULA (Rapid Upper Limb Assessment) is used to identify and interpret inappropriate working postures and to inform the implementation of corrective measures. It is typically employed by employees engaged in desk-based or seated work. In the observational approach, individuals are directly observed while working and the body postures they adopt during the work are recorded by a physiotherapist. The method comprises two main components. In the initial phase of the assessment, the arm, forearm, and wrist are evaluated. Subsequently, the neck, trunk, and lower extremities are assessed. In the sagittal plane, additional points are awarded if there is a rotation, lateral flexion, shoulder abduction and elevation, and wrist deviation accompanying the aforementioned body parts. The main sections under evaluation are static or intermittent loading, static posture, or repetitive movements lasting longer than 10 minutes. Points are increased according to the severity of the condition. The total RULA score is between 1 and 7, with an increase in score indicating a worsening of the working posture. The total RULA score allows for the identification of four distinct categories, each accompanied by a corresponding action level. RULA-1 (1-2 points) indicates that the current working posture is acceptable if it is not maintained or repeated for an extended period. RULA-2 (3-4 points) indicates that further research is necessary and changes may be required. RULA-3 (5-6 points) indicates that research and changes should be conducted without delay. Finally, RULA-4 (7 points and above) indicates that research and changes are required immediately (McAtamney & Nigel Corlett, 1993).

Pittsburgh Sleep Quality Index

The PSQI is a questionnaire that assesses sleep quality through a series of questions grouped into seven main categories: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disorders, sleep medication use, and daytime functioning. The responses to each question are scored on a scale of 0 to 3, with higher scores indicating poorer sleep quality. Each of the seven main topics is first evaluated independently, and then the scores for the seven components are summed. A total score of 5 or above indicates impaired sleep quality. The validity and reliability study of the PSQI in Turkey was conducted by Ağargün et al. (Ağargün MY, 1996; Buysse, D, 1989).

Data Analysis

A statistical analysis was conducted using the IBM SPSS 24.0 package program. Descriptive statistics were employed to express categorical data as frequency (%), numerical data as mean ± standard deviation. The compliance of the data with normal distribution was determined by the Kolmogorov-Smirnov test, skewness and kurtosis values, and histogram graphs. In intergroup comparisons, the Mann-Whitney U test was employed for non-normally distributed parameters, whereas the independent sample t-test was used for normally distributed parameters. Statistical significance was accepted at the $p < 0.05$ level.

RESULTS

Table 1 presents the demographic characteristics of the participants. A total of fifty esports players participated in the study.

The average age of the participants in the exercise and control groups was 23-24 years. At the same time, approximately 60-70% of the participants were male within the groups. Participants with different levels of education were approximately homogeneously distributed in the groups.

Table 1. Demographic information of the participants

Variable	Group	Exercise Group n(%)	Control Group n(%)
Age (X±SD)		23.48±4.33	24.24±4.23
Gender	Female	10(40)	8(32)
	Male	15(60)	17(68)
Education Level	High School	11(44)	7(28)
	University	13(52)	17(68)
	Master	1(4)	1(4)
Game	Valorant	8(32)	8(32)
	League of Legends	7(28)	6(24)
	Rise Online World	8(32)	4(16)
	FIFA	2(8)	2(8)
	Counter Strike	0(0)	5(20)

ANOVA; p: Chi-square test. p<0.05 was considered significant. SD: Standard Deviation; X: mean

Table 2 shows the NDI, DASH, PSQI, and RULA scores before and after the intervention in the exercise and treatment groups. NDI, DASH, and RULA scores decreased significantly in the control group after treatment ($p < 0.05$). However, no significant difference was observed in the PSQI score in the control group ($p > 0.05$). In the exercise group, NDI, DASH, PSQI, and RULA scores decreased after treatment ($p < 0.001$).

Table 2. Within-group comparisons before and after the interventions

Group	Assessment	Before X±SD	After X±SD	t	p
Control	NDI	14.44±4.77	9.04±4.13	7.030	.000***
	DASH	8.26±6.38	7.56±5.55	2.355	0.027*
	PSQI	6.88±1.64	6.44±1.60	1.901	0.069
	RULA	3.28±1.27	2.16±0.68	5.527	.000***
Exercise	NDI	20.92±6.45	8.52±3.46	11.242	.000***
	DASH	10.80±6.87	8.51±4.99	4.612	.000***
	PSQI	7.16±1.99	6.12±1.53	4.578	.000***
	RULA	3.4±1.44	2.56±1.12	4.257	.000***

*p<0.05, **p<0.01, ***p<0.001, DASH: Disabilities of the Arm, Shoulder, and Hand Questionnaire, RULA: Rapid Upper Limb Assessment, NDI: Neck Disability Index, PSQI: Pittsburgh Sleep Quality Index, X: Mean, SD: Standard Deviation.

Table 3 shows the comparison of changes in NDI, DASH, PSQI, and RULA scores among the groups. Following the intervention, there was no notable distinction was detected in PSQI and RULA scores in the exercise group compared to the control group. Conversely, a substantial reduction was noted in NDI and DASH scores within the exercise group compared to the control group ($p < 0.001$).

Table 3. Between-group comparison of differences in NDI, DASH, PSQI, and RULA scores

Variable	Control Group X±SD	Exercise Group X±SD	t	p
NDI	5.40±3.84	12.40±5.51	-5.208	0.000***
DASH	0.69±1.48	2.28±2.47	-2.750	0.008**
PSQI	0.44±1.15	1.04±1.13	-1.850	0.070
RULA	1.12±1.01	0.84±0.98	0.990	0.327

**p<0.01, ***p<0.001, DASH: Disabilities of the Arm, Shoulder, and Hand Questionnaire, RULA: Rapid Upper Limb Assessment, NDI: Neck Disability Index, PSQI: Pittsburgh Sleep Quality Index, X: Mean, SD: Standard Deviation.

DISCUSSION

This study aimed to investigate the efficacy of ergonomics training and physical exercise on posture alignment, sleep quality, and physical disabilities related to the neck, arms, shoulders, and hands in esports players. The results of our study indicated that exercise programs integrated with ergonomics training were associated with a reduction in musculoskeletal pain and functional limitations in esports players.

This study showed that a physical exercise program applied with ergonomics training was more effective than ergonomics training alone in reducing upper-extremity disability and symptoms (including the neck, arm, shoulder, and hand) in e-athletes. Previous research suggests that individuals involved in esports typically exhibit sedentary behaviors for approximately 4.2 hours daily (Kari & Karhulahti, 2016). The prolonged periods of sitting among esports participants may lead to adverse effects, including a higher likelihood of injuries and chronic ailments like upper extremity dysfunction, metabolic imbalances, sleep pattern disturbances, and neck/back issues (Zwibel et al., 2019). The studies point out that esports players who deliberately adhered to the proper sitting positions showed a notably reduced probability of encountering discomfort or tension in the upper and lower back. Likewise, individuals who integrated short breaks into their extended gaming sessions exhibited a notably diminished experience of neck discomfort (Tang et al., 2023). Poor posture worsens improper positioning and contributes to various symptoms that may result in postural disorders, muscle imbalances from overuse, nerve

compressions, and other conditions. Seated positions that are deemed suboptimal can exert pressure exceeding 150% of the body weight on the spinal column (Quka et al., 2015). When considering posture in the context of esports, ergonomics can provide posture efficiency to enhance performance and mitigate the risk of repetitive strain injuries as seen in this study. Although a control group without any intervention was not considered, upper extremity injuries and symptoms in e-athletes decreased with ergonomics training, indicating that the effect of ergonomics on physical health protection should not be ignored. Several studies in the literature corroborate the findings of the present study. Emara et al. examined the ergonomic considerations for keyboard sensitivity to prevent repetitive strain disorders like back pain, carpal tunnel syndrome, and tendinopathies (Emara et al., 2020). Recently, it was reported that ergonomic training in esports players was effective in protecting body health in athletes (Nicholas Nalic Pierides JR., 2023). Similarly, Robertson et al. observed a notable enhancement in the level of ergonomic knowledge and awareness among individuals following training on office ergonomics (Robertson et al., 2009). Previously, office workers demonstrated a significant decrease in RULA scores following the training which demonstrates the impact of ergonomic regulations in the workplace on the reduction of musculoskeletal complaints (Murat Dalkılınç, 2011).

These results highlight the significance of ergonomic considerations in competitive gaming, as they play a role in the overall health and wellness of gamers. The American College of Sports Medicine (ACSM) stated that "Exercise is a Medicine," to incorporate exercise therapy as an integral part of maintaining healthcare (The American College of Sports Medicine, 2024). This study is the first to address integrated ergonomics training and physical exercise in e-athletes. Prior research exists in the literature that employs exercise regimens similar to our investigation. A study incorporating stretching routines as part of exercise protocols found that such exercises served as a preventive measure against work-related musculoskeletal disorders (da Costa & Vieira, 2008). Another study has demonstrated a negative correlation between the increase in regular physical activity and the incidence of work-related musculoskeletal diseases (Sharma & Golchha, 2011). Therefore, we suggest physical exercise combined with ergonomics training to maintain the physical health of e-athletes.

Sleep is crucial for learning and memory consolidation, as well as attention renewal (Lowe et al., 2017). Poor sleep quality can lead to memory and attention issues, increasing the risk of accidents (Fullagar et al., 2015). However, there is limited research on the sleep quality of esports players. Esports players who incorporate physical exercises into their routines have been shown to enhance gameplay and cope with stress (Guillen Pereira et al., 2017). Nevertheless, only a small percentage of esports athletes, ranging from 6% to 9%, report exercising for performance-related advantages, while a larger portion, between 32% and 47%, engage in physical activities primarily for general health benefits (Kari & Karhulahti, 2016). Studies have shown that sleep quality decreases in esports players (Sanz-Milone et al., 2021). Several factors can affect sleep patterns directly in adolescents, including a delay in melatonin secretion and high exposure to electronic devices (Sanz-Milone et al., 2021). Research has revealed an association between television watching and diminished sleep quality. Similarly, computer game playing has been linked to an increased likelihood of sleeping later and experiencing shorter sleep durations (Harbard et al., 2016). In this study, the PSQI demonstrated that esports players who implement ergonomic training and physical exercise exhibited a high subjective sleep quality post-intervention. These findings are consistent with those reported in the literature. It has been demonstrated that participation in an exercise training program has a positive effect on sleep quality in middle-aged and older adults (Yang et al., 2012). It may be concluded that physical exercise and ergonomic training could be an alternative or complementary approach to maintaining the well-being of esports athletes. However, the inclusion of exercise in ergonomics training did not make any difference, so an analysis of the sleep-wake cycle would be useful to improve the results found in this study. Additionally, it would be advantageous to evaluate the population of esports players in terms of their sleep parameters, with different screening procedures for different game categories.

Like traditional sports, esports have a physical impact (Sánchez et al., 2019). Research in this field shows that esports athletes require not only tactical analysis or the ability to respond to

something that appears on the screen but also endurance to perform these activities over long periods of time. In this study, we investigated the contribution of ergonomic training and physical exercise to the physical health of esports athletes. The findings have significant implications for promoting a more objective understanding and appreciation of esports and the sustainable development of esports players. Also, further research is necessary to explore potential causal relationships between esports participation and health outcomes and to develop a healthier sports practice modality from a sports science perspective. It was observed that the severity of pain, fatigue, and functionality decreased in e-athletes to whom ergonomic training and an exercise program were applied. It was determined that there was no significant difference in the findings regarding sleep quality. It was observed that thoracic mobility, shoulder mobility exercises, nerve stretching exercises, strength and mobility exercises for the hand and wrist, and ergonomics training applied to the exercise group were effective in the arm, shoulder, hand, neck, and upper extremities. Therefore, regular exercise and ergonomics positively affect the musculoskeletal system of esports players. An interprofessional medical team would represent the final step in the future. However, for the present, it is essential to invest more research and time into the various factors that influence the performance of an esports athlete, including the technical skill required for each game, physical health, nutrition, mental health, and ergonomics.

Conflict of interest

The authors declare no conflict of interest. Also, no financial support was received.

Ethics Committee

The approval was taken from the Üsküdar University Non-Interventional Research Ethics Committee (reference number 61351342/September 2023-20).

Author Contributions

The authors accomplished this study by making significant contributions including designing the study according to the formulation of its objectives. AG and ÖŞ performed on conception and design of the study. AG collected the data. ÖŞ performed data analysis and interpretation. All authors were contributors and responsible for the manuscript's content and approved the version submitted for publication.

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RESEARCH ARTICLE

Effects of Tapering of Three Different Percentages on Physiological Variables Among Futsal Players

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Abstract

The purpose: this study aimed to determine the effect of a two-week tapering period on physiological variables by reducing three different percentages of volume (30%, 50%, 70%) while maintaining high training intensity on young futsal players. Method: An experimental design was used. The research sample was chosen from players of the talent school in Nineveh Governorate for the year 2023-2024, totaling 18 players (6 players per group). A paired student's t-test was used to process the interaction effect between pre- and post-training, and an ANCOVA test was used to determine the differences between the three groups. Results: Tapering with a 50% reduction rate led to the development of all physiological variables of performance in the Bruce test ($p<0.005$), aerobic ($p<0.025$) and anaerobic work ($p<0.018$), VO2max ($p<0.028$), and blood Lactate ($p<0.031$). while tapering with a 30% reduction rate led to the development of aerobic work ($p<0.33$) and VO2max ($p<0.044$). Tapering with a 70% reduction rate led to the development of achievement in the Bruce test($p<0.01$), anaerobic work ($p<0.046$), and LA ($p<0.030$). While there were no significant differences among the three groups in physiological variables of performance in the Bruce test ($p<0.151$), aerobic ($p<0.085$) and anaerobic work ($p<0.343$), VO2max ($p<0.181$), and LA ($p<0.166$). Conclusions: the tapering by 50%, showed a more balanced development in aerobic and anaerobic work, VO2max, and LA compared to to the tapering by 30% reduction, which developed only aerobic work and VO2max, and to the tapering 70% reduction, which developed anaerobic work and LA.

Keywords
Tapering, Futsal, Functional Variables, Bruce, Aerobic, Anaerobic

INTRODUCTION

Futsal has become a fertile field for researchers and coaches to conduct research, studies, and training programs that can contribute to the development of the training process to participate in many tournaments and sports competitions in a single season. Futsal is a high-intensity intermittent non-aerobic game. Naser (2017) indicates that the work-to-rest ratio in futsal is 1:1, and players exert low effort every 14 seconds, moderate effort every 37 seconds, high-intensity effort every 43 seconds, and maximal effort every 56 seconds, with changes in motor activities every 3.3 seconds. From these results, it can be concluded that futsal is a high-intensity non-aerobic activity (Naser et al, 2017).

The intensity and duration of training throughout the preparatory and competitive seasons can lead to severe fatigue among futsal players. Maintaining this high training workload throughout the season may lead to excessive fatigue and performance decline. Therefore, (Coutts et al. 2008) recommend using a tapering strategy between training cycles and implementing short-term reductions at the end of each Mesocycle. Training volume is an important component that can be manipulated during the tapering period to alleviate physical, psychological, and physiological stress on the body's systems.

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This helps in reducing fatigue and muscle soreness, aiding in glycogen replenishment, and tissue repair, and reducing the risk of injury to reach peak performance. Many researchers have described different strategies to improve tapering, but the common approach is to reduce training load by decreasing volume and repetitions while maintaining high training intensity, ensuring high-intensity intermittent training in team sports (Bosquet et al., 2007; Mujika, et al, 2004).

Researchers have tried to answer many questions regarding the tapering period in training loads through the results of experiments, research, and studies conducted in individual and team sports. In individual sports, several studies have been conducted, such as a study by Van Handel PJ et al. on elite swimmers, using a high training workload for 60 days followed by a gradual tapering period for 20 days, reducing the training workload from 10,000-20,000 meters of swimming to 2000-3000 meters while maintaining training intensity (Van Handel et al., 1988).

In another study, Smyth B & Lawlor A aimed to analyze tapering strategies for recreational runners to determine the most suitable strategy for the race day performance. The study analyzed 158,000 marathon runners to determine the appropriate tapering period based on different reductions in training volume and a mix of tapering durations ranging from 1-4 weeks (Smyth & Lawlor, 2021).

Another study by (Karimi) aimed to understand the effects of two types of tapering on plasma levels and the performance of elite male wrestlers. Thirty elite wrestlers participated in four weeks of high-intensity wrestling training during the competition period. The sample was then divided into three equal groups for one week of training: the first group reduced the training workload by 50%, the second group by 75%, and the control group trained with the same workload without reduction (Karimi, 2017).

In a study by Souhail HermassiI et al. on handball players in the premier league, a sample of 20 left-handed players in the wing and pivot positions was used. The first group performed weight training followed by tapering for two weeks, while the second group (control) followed the coach's training program (HermassiI et al., 2019).

In a study by Ameen Khazal Abe comparing three tapering methods (vertical, horizontal, and progressive) on futsal players, 18 players were divided into three groups (6 players per group) (Abe, 2015). Leonardo et al. aimed to analyze the effect of tapering on maximal oxygen consumption (VO2max) in young futsal players, showing that tapering in the final weeks of training increases maximum oxygen consumption efficiency (Leonardo et al., 2015).

In a study by Hugo Augusto on male youth basketball players, the effect of tapering type on anaerobic endurance was examined. The sample of 47 players was divided into three groups: the first group used linear tapering, the second group used step tapering, and the third group served as the control (Hugo Augusto, 2017).

In a study by Mohammed et al. to compare the impact of reducing training workload during tapering weeks on physical match activities among 19 professional futsal players over a 17-week high-load season and 7 weeks of load reduction, match activities were measured using a computerized match analysis system and compared between standard training and tapering weeks (Fessi et al., 2016).

These studies and research differ in the approach to tapering regarding how to control intensity and volume components to achieve the desired goal mentioned above. Some studies compared intensity and volume, while others compared methods of reducing workload (linear, progressive, and step). Some studies compared different percentages of training volume reduction. However, there has been no study to determine the appropriate training percentages for training volume reduction during the tapering period in futsal. It is important to note that there is variability in the percentage of tapering in training volume to prepare futsal players physically, skillfully, psychologically, and functionally for sports competitions at their best level, following a proposed training program consisting of general, specific, and competitive preparation stages.

The importance of this research lies in supporting sources and research that have addressed tapering in team sports and how to regulate training load through training workload components (intensity, volume, and rest). It also provides theoretical and practical solutions to detect fatigue and stress that may affect players before the most important competitions and how to deal with it. This study aims to provide a specific training program for the tapering period and determine the optimal training

workload reduction percentages that are compatible with the specificity of futsal.

MATERIALS AND METHODS

Research Methodology

The experimental method was used since it suited the nature of the study, The original research sample consisted of 22 players , 4 players was excluded due to injuries or non-compliance with the training dose, The remaining 18 players were divided into three equal sections based on their anthropometric measurements (age, training age, height, and mass) and their results on the Bruce test, The division into three equal sections was based on Levene's test, which is a statistical test used to assess the equality of variances in different samples.

Ethical Approval

This study followed ethical standards and received approval from the College of Physical Education and Sports Sciences at the University of Mosul/Iraq with reference number [22/11/2022-3035]. Informed consent was obtained from the participants, with a volunteer form covering the details of the study, the risks and potential benefits to the participants, and the confidentiality and rights of each participant. Throughout the study process, the ethical principles of the Declaration of Helsinki were strictly adhered to, prioritizing the rights of participants in design, procedures, and confidentiality measures.

Research Sample

The research sample consisted of {18} players from the youth futsal team at the Talent School affiliated with the Ministry of Youth and Sports in Nineveh Governorate. The sample was then divided into three experimental groups as follows:

The first group: consisted of 6 players who used a 30% reduction in workload volume.

The second group: consisted of 6 players who used a 50% reduction in workload volume.

The third group: consisted of 6 players who used a 70% reduction in workload volume.

Devices And Tools Used

An Electronic device for measuring mass and length, type (Detecto™). A Treadmill device, type (tmx425 trackmaster 2004™). K5™ device for measuring functional variables. Electronic timing watches for measuring time in tests, type (Kenko™).

A 30-meter measuring tape, 15 plastic cones,12 legal futsal balls, 2 ladders for conducting agility exercises, Special obstacles used in exercises, 2 passing zones were used in the skill test.

Data Collection Methods

Functional Variable Measurement

After analyzing the content of literature, the protocol of graded exercise test on treadmill by Bruce was adopted to measure the following physiological variables (Adams, 2002):

The Key Points Regarding The Measurement Of Physiological Variables Are

The Bruce Protocol Treadmill Test was used to measure the following functional variables: (Test time, Aerobic work time, Anaerobic work time, Maximum oxygen consumption (VO2 max), Lactate accumulation)

The functional variables (VO2 max, METs, HR) were measured directly using the K5 device during the graded physical effort of the Bruce test.

Following Precautions were taken:

No training for at least 12 hours before the tes

No consumption of liquids or food for 4 hours before the test

Removal of jewelry or metal items

Aerobic and anaerobic work were determined based on the metabolic factor RQ (respiratory quotient)

RQ of 0.7 indicates reliance on fats, increasing to 1.0 indicates reliance on glycogen

Aerobic work time was determined from the start until RQ reached 1.0

Anaerobic work time was determined from RQ reaching 1.0 until the end of the test (Brown et al, 2006)

The highest VO2 max value was recorded during the graded Bruce test.

Blood lactate was measured 5 minutes after completing the Bruce test using the Lacta-Pro device

Training Program

The training curriculum was designed with:

7 weeks of preparation

4 weeks of competitions

4 training units per week during both the preparation and competition periods,

This was followed directly by a 2-week Tapering curriculum, also with 4 training units per week

During The Tapering Curriculum

Group 1 reduced their training volume by 30%
Group 2 reduced their training volume by 50%
Group 3 reduced their training volume by 70%

All 3 groups underwent training with similar intensity. At the end of tapering period, all 3 groups underwent posttests.

There were no changes made to the warm-up and cool-down periods

An additional "fast exponential decay" type of tapering was also used Our study procedures were agreed with (Hovanlo et al, 2012; Fortes et al, 2016; Karimi, 2007).

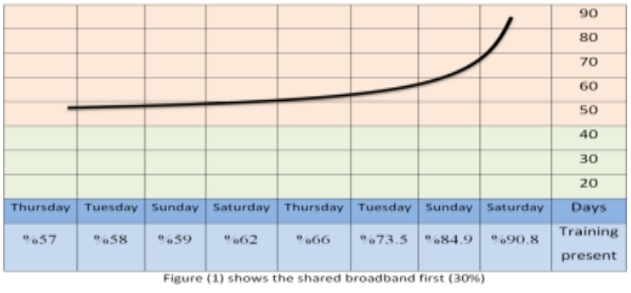

Figure (1) shows the shared broadband first (30%)

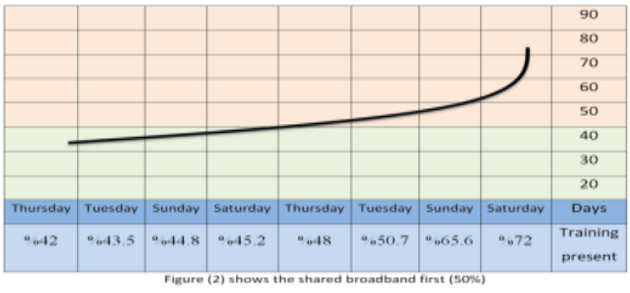

Figure (2) shows the shared broadband first (50%)

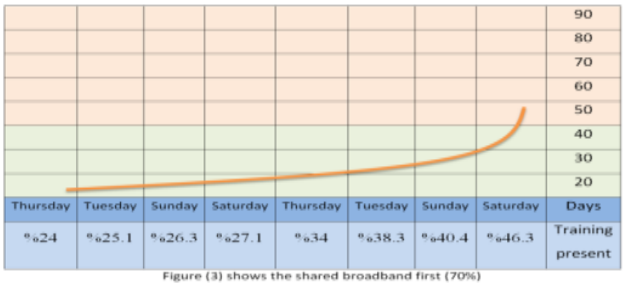

Figure (3) shows the shared broadband first (70%)

Figure 1,2,3. details the reduction in training workload for the three training groups.

Primary Research Procedures

Pre-Measurements

Pre-measurements of physiological variables were conducted. To achieve the study objectives, Bruce treadmill test conducted on all study sample members from January 31, 2024, to February 1, 2024.The measurement steps were taken as follows:

The Experiment was Conducted As Follows

The participants prepared for the test by wearing pants and sports shoes. The Warm-up was performed by giving the examiner (7-10) minutes at a speed of (5-7) km/h and an incline of (4-6) degrees on the treadmill. The rest period between warm-up and the start of the test was (5-7 minutes) to restore physiological variables to their normal state. A mask of the K5™ device was placed, and then the participant sat on a chair to take the pre-measurements of the physiological variables, and the device was worn on the participant's empty loop. The examiner started the Bruce test. The test continued with increasing speed and incline until the participant reached exhaustion. The test was stopped by pressing the stop button. The data were stored automatically.

Application of the Gradual Decrease Training Program

The gradual decrease training program was applied for two weeks, with 4 training sessions per week on Saturdays, Sundays, Tuesdays, and Thursdays for the three experimental groups.

Post-Measurements

Post-measurements were conducted, after completing the application of the training program for the three experimental groups, similar to the pre-test procedures, with the assistance of the same team under the same conditions as the pre-tests

Statistical Means

The data analysis was done in SPSS V. 26 package program. In this research, descriptive statistics (mean and standard deviation) was used to describe the data, To compare the changes in (Levene's test, t-test, Ancova test). The significance level of $p<0.05$ was determined in all of the statistical procedures.

RESULTS

Table 2. It shows the arithmetic mean, standard deviations, calculated T-values, and the degree of significance between the pre- and post-tests for the first experimental group, which reduced the training volume by (30 %).

The first group (30% reduction)						
Variables	**Pre-test**		**Post test**			
	Mean	SD	Mean	SD	T	Sig
Achievements in testing Bruce (min)	17.7533	1.36286	18.1900	0.97824	1.421	0.214
Aerobic work in Bruce test (min)	13.5633	.46753	13.9367	.71068	2.926	0.033
Anaerobic work in Bruce test(min)	3.9233	1.08354	4.0533	.75179	0.461	0.664
(VO2max).(ml/min)	4451.27	477.26	4715.97	412.89	2.669	0.044
(LA max) (mlg)	13.8167	2.74694	14.5167	1.79044	1.206	0.282

Table 3. It shows the arithmetic mean, standard deviations, calculated T-values, and the degree of significance between the pre- and post-tests for the second experimental group, which reduced the training volume by (50%).

The first group (50% reduction)						
Variables	**Pre-test**		**Post test**			
	Mean	SD	Mean	SD	T	Sig
Achievements in testing Bruce (min)	17.6450	1.32319	18.7500	1.26529	4.748	0.005
Aerobic work in Bruce test (min)	13.6833	2.12809	14.2400	1.90486	3.154	0.025
Anaerobic work in Bruce test(min)	3.7617	1.32034	4.3083	1.14922	3.475	0.018
(VO2max).(ml/min)	4411.76	654.39	4701.36	750.31	3.064	0.028
(LA max) (mlg)	14.1833	2.24893	16.6717	3.52800	2.969	0.031

Table 4. It shows the arithmetic mean, standard deviations, calculated T-values, and the degree of significance between the pre- and post-tests for the third experimental group, which reduced the training volume by 70%.

The first group (70% reduction)						
Variables	**Pre-test**		**Post test**			
	Mean	SD	Mean	SD	T	Sig
Achievements in testing Bruce (min)	18.0050	1.03940	18.7533	1.20199	6.929	0.001
Aerobic work in Bruce test (min)	14.2967	1.07897	14.2917	1.06099	.0600	0.954
Anaerobic work in Bruce test(min)	3.5750	1.37551	4.1283	1.17196	2.648	0.046
(VO2max).(ml/min)	4544.51	196.37	4569.87	125.22	0.407	0.701
(LA max) (mlg)	14.5167	2.03707	15.2667	1.93976	3.000	0.030

Through Table (2,3,4), it is evident that there are significant differences in aerobic work ($p<0.033$), (VO2max) ($p<0.044$), between the first and second post-tests for the second experimental group that implemented the gradual decrease (Tapering) program by 70% of the volume. While there were significant differences in Bruce test performance ($p<0.005$), aerobic work($p<0.025$), anaerobic work($p<0.018$), VO2max($p<0.028$), and blood LA max($p<0.031$), there were also significant differences in Bruce test performance($p<0.001$), anaerobic work($p<0.046$), and LA max ($p<0.030$).

Table 5. It shows the arithmetic mean, standard deviations, calculated (f) values, and the degree of significance after post tests for the tests of the three experimental groups for the functional variables.

Variables	The first group (30%)		The first group (50%)		The first group (70%)			
	Mean	Chang %	Mean	Chang %	Mean	Chang %	F	Sig
Achievements in testing Bruce (min)	18.229[a]	2.46	18.879[a]	6.26	18.585[a]	4.24	2.173	0.151
Aerobic work in Bruce test (min)	14.195[a]	2.75	14.38p[a]	4.07	13.917[a]	0.081	2.947	0.085
Anaerobic work in Bruce test(min)	3.930[a]	3.31	4.302[a]	14.53	4.224[a]	15.48	1.155	0.343
(VO2max).(ml/min)	4732.835[a]	5.95	4755.417a	6.56	4498.953a	0.56	2.499	0.118
(LA max) (mlg)	15.231[a]	5.07	16.662[a]	17.54	14.862[a]	5.166	2.050	0.166

In table 5, the significance value was greater than 0.05, indicating no significant differences in physiological variables among the three groups.

DISCUSSION

Pre and Post-Test Results for physiological Variables

Tables (2,3,4) comparing pre and post-tests in the three gradual decrease groups (30%, 50%, and 70%) respectively show improvements in physiological variables but at different levels. The 30% gradual decrease group showed a significant improvement in aerobic work time from the graded exercise test, maximal oxygen consumption, and maximal metabolic equivalents. On the other hand, the 70% gradual decrease group showed a significant improvement in performance and in the anaerobic phase, as well as in the maximum heart rate and maximum blood lactate accumulation in the blood. As for the remaining variables, they improved but did not reach a significant level in both the 30% and 70% gradual decrease groups. The 50% gradual decrease group showed a significant improvement in all physiological variables.

The developments in the above variables, for all three research groups, were attributed to external training workload factors, including the gradual decrease, and internal training load factors (physiological).

Regarding the gradual decrease in training workload, the three experimental groups followed a training plan for two weeks that included reducing the training volume using a rapid exponential tapering method while maintaining high training intensity. This facilitated the process of super-compensation and reaching peak performance or performance. Such an approach allowed for gradual adaptations of physiological systems, including improvements in VO2max, blood lactate accumulation, and maximum heart rate.

Researchers such as Mujika et al., (2009), Bosquet et al., (2007), Bomba, (2015), Shepley, (1992) and Houmard et al., (1992) suggest that a two-week period of gradual decrease, achieved by progressively reducing the training volume while maintaining high training intensity, allows for the necessary recovery for players and provides positive results in physical, physiological, and performance aspects in team and individual sports.

As for internal training workload factors (physiological), the overall development in the three groups and specifically in the 50% gradual decrease group in the post-test can be discussed as follows: In the graded exercise test, the gradual decrease by 50% and 70% allowed for recovery from accumulated fatigue while maintaining the acquired fitness levels from previous training. Studies like the one conducted by Neary on cyclists for a distance of 20 km showed a 5.4% improvement in performance for the experimental group that used a gradual decrease for 7 days with a 50% reduction in training volume while maintaining 85% training intensity, compared to no improvement in the groups that reduced training volume by 30% and 80% while maintaining high training intensity. Similarly, a study by Karimi on football players showed that a gradual decrease for a week with a 50% and 75% reduction in training volume would reflect the fatigue and exhaustion that primarily affected players, while improving their performance compared to the group that continued training with the same volume, and there

were no differences between the reduction strategies (50%, 70%) (Mohammad, 2017).

Regarding the improvements in aerobic work and anaerobic threshold in the graded exercise test, they were attributed to the gradual decrease of 50% and 70% for two weeks, allowing for some physiological adaptations such as effort economy, increased mitochondrial density, and improved aerobic enzyme activity, leading to improved aerobic endurance and anaerobic threshold. Studies like that by Houmard et al., which evaluated energy expenditures in 18 middle-distance runners after a gradual decrease for 7 days, reported a 7% decrease (0.9 kcal/min) in energy expenditures at 80% of VO2peak on a treadmill. The researchers suggested that the reason for the oxygen consumption economy is the increase in muscle mitochondria capacity, in addition to neural, structural, and mechanical factors (Houmard et al., 1994).

Bomba mentions that the possibility of improving maximum oxygen consumption is attributed to the increased formation of red blood cells during the gradual decrease period (Bomba,2015). Iaia et al., (2009) also noted a 6-8% decrease in VO2 at sub-maximal running speeds, while maintaining muscle oxidative capacity, capillary density, and running performance for a 10-kilometer distance. Regarding improvements in anaerobic work and anaerobic threshold in the graded exercise test, the researcher attributes them to the gradual decrease of 50% and 30% for two weeks, allowing for some physiological adaptations such as increased lactate tolerance in the blood and improved anaerobic enzyme activity. Studies like Hugo et al. on basketball players assessed the effect of two types of gradual decrease (linear, and stepwise) on the anaerobic capacity of basketball players, with a 50% reduction in volume in the stepwise gradual decrease and reductions of 80%, 60%, 40% in the linear gradual decrease while maintaining high training intensity, found that both strategies were effective in improving anaerobic endurance, although the linear reduction strategy was more effective than the stepwise reduction (Hugo et al , 2017) , In a study by McArdle et al., it is mentioned that for the cell to be able to produce energy, oxidative enzymes must be present in sufficient concentrations to make reactions start and function properly and that these enzymes (CK) and (ATPase) tend to decrease with high training loads but increase with gradual decrease (McArdle et al., 2006).

In a study conducted by Mujika et al., (2002) on middle-distance runners, the improvement in competitive performance in the 800-meter race after the gradual decrease phase is positively correlated with the change in peak blood lactate concentration after the race, where an increase in peak blood lactate concentration by 7.6% was observed, and this increase is closely related to running performance.

Regarding the maximum oxygen consumption VO2max, this variable is a key factor in endurance capacity. The gradual decrease of 50% and 30% allowed for reducing fatigue while maintaining or even enhancing aerobic fitness levels, as was observed in the current study. The aim of the gradual decrease in the current study was to enhance the efficiency of oxygen utilization within muscle tissues, thereby improving aerobic capacity and endurance. This efficiency can be achieved through various physiological adaptations, including increased blood vessel density, enhanced mitochondrial density, and improved oxygen extraction by muscle fibers. This aligns with a study by Fortes et al., which found that the tapering strategy leads to an increase in VO2max while maintaining high training loads did not alter the maximum oxygen consumption VO2max. The researchers mentioned that the reason for this is the increase in mitochondrial density in muscles, which enhances fat and glucose oxidation, leading to improved aerobic energy production. Additionally, arterial-venous oxygen differences can also improve VO2max. Therefore, muscle tissues increase their ability to extract oxygen (Fortes et al., 2016).

This study also agrees with a study by Neary et al., which showed a 2.4% increase in VO2max for seven male endurance cyclists who maintained training intensity (85-90% maximum heart rate) while reducing training duration over 7 days (Neary et al., 2003**)** , In the same study, it was also found that a 17% increase in muscle glycogen stores after 4 days of gradual decrease and a 25% increase after 8 days of gradual decrease. This study also agrees with Leonardo's study on futsal players, where the tapering strategy increased VO2max while maintaining training loads did not change VO2max. This is attributed to the increase in mitochondrial density, which helps in fat and glycogen oxidation in muscles, leading to improved aerobic energy production and improving the muscles' ability to extract oxygen **(**Leonardo, 2016**)**. As for maximum

blood lactate accumulation, gradual decrease will reduce its accumulation during exercise below maximum effort by allowing for muscle glycogen replenishment, which enhances lactate removal rates. However, the results of the current study showed an increase between the pre-test and post-test by 2.5 mg/dL in the 50% and 70% decrease groups, which are attributed to the nature of the graded exercise, characterized by maximum physical effort. This study agrees with Ameen's study, which used three different methods of reducing training load (linear, step, and stepwise) on futsal players, where the amount of accumulated lactate increased in the post-test for all three groups (Ameen, 2015; Abe, 2015).

Mujika also notes that an increase in blood lactate concentrations after a gradual decrease is associated with enhancing maximal performance capacities in swimming, running, cycling, and rowing. Conversely, no change or a decrease in blood lactate concentrations during sub-maximal exercise intensity is expected after an effective gradual decrease (Mujika, 2009) .

If we delve further into the underlying mechanisms behind the effect of gradual decrease on physiological variables under this study, we will find that gradual decrease allows for the replenishment of muscle glycogen stores, which are essential for high-intensity exercise performance. In a study by Neary et al., a 17% increase in muscle glycogen stores after 4 days of gradual decrease and a 25% increase after 8 days of gradual decrease were reported (Neary et al ,1992). Spurway and MacLaren also mentioned a 15% increase in muscle glycogen stores in a group of highly trained middle-distance runners after 7 days of high-intensity gradual decrease (Spurway & MacLaren, 2006). In Table 2, the significance value was greater than 0.05, indicating no significant differences in physiological variables among the three groups. However, by observing the development ratio, we notice the superiority of the second experimental group that reduced the volume by 50% in most functional variables, as it was more comprehensive in developing all physiological variables and with a higher development ratio than the others.

There were no significant differences between the post-tests of the three research groups in the variables (Bruce test performance, aerobic work, anaerobic work, VO2max, max blood Lactate). However, when we observe the development ratio, we find that the 50% reduction group showed the highest development ratio in all variables. This group is considered the most balanced compared to the first group (30%) and the third group (70%) in developing functional variables.

Between Three Groups

Tables (5) comparing post-tests in the three groups decrease (30%, 50%, and 70%) , if There were no significant differences between the post-tests of the three research groups in the variables (Bruce test performance, aerobic work, anaerobic work, VO2max, max blood Lactate). However, when we observe the development ratio, we find that the 50% reduction group showed the highest development ratio in all variables. This group is considered the most balanced compared to the first group (30%) and the third group (70%) in developing functional variables.

Conclusion

The tapering program has a positive effect on all physiological variables according to the three percentages used in the research (30%, 50%, 70%). They also found that a 50% reduction in tapering showed a significant improvement in functional variables of (Bruce test performance, aerobic work, anaerobic work, VO2 MAX, LA), while a 30% reduction showed improvement in aerobic work and VO2max. A 70% reduction showed improvement in Bruce test performance, anaerobic work, and LA. Based on these results, the researchers concluded that a 30% reduction in tapering tends to improve aerobic work, while a 50% reduction is the best as it balances the improvement in aerobic and anaerobic work. A 70% reduction tends to improve anaerobic work.

It is recommended to use a 50% reduction when using tapering with futsal players due to its balanced training program.

Conflict Of Interest

This research no conflict of interest. No financial support was received.

Ethics Statement

This study followed ethical standards and received approval from the College of Physical Education and Sports Sciences at the University of Mosul/Iraq with reference number [22/11/2022-3035]

Author Contributions

Planned by the authors: Study Design, MYS, AMA; Data Collection, MYS, AAT; Statistical Analysis, AAT; Data Interpretation, MYS, AMA; Manuscript Preparation, MYS, AAT; Literature Research, AMA The published version of th

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RESEARCH ARTICLE

The Relationship Between Some Anthropometric Measurements and Pulmonary Volumes to the Numerical Achievement of 800-Meter Event Runners in Palestine

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Abstract

The study aimed to identify the contribution of some anthropometric measurements and pulmonary volumes to the Numerical Achievement of runners in the 800-meter running event at Palestine. The study was conducted on a purposely-designed sample of (17) runners in Palestine, aged between (18-22) years. The researchers used the descriptive analytical approach because it suits the nature of the study. Anthropometric measurements were performed related to (age, body mass, height, arm length, leg length, thigh length, lower leg length, instep length, chest circumference, chest circumference with inspiration, abdominal circumference, thigh circumference, and Leg calf, upper arm circumference, and related Pulmonary volume measurements. Related Pulmonary volume measurements were performed (VC, FVC, FEV1, FWV1/FVC%, MVV, TV, RV), and after the data was collected, it was processed statistically using SPSS. The results of the study showed that the anthropometric measurement that have the most contribution In the Numerical Achievement of 800 meters running event runners in Palestine was Height, which contributed to explaining (43.1 %) of the finishing time. The study also found that Pulmonary volume measurements contributed most to the Numerical Achievement For runners of the 800- meter running event in Palestine, was Vital Capacity (VC)which explained (39.1%) of the time Achievement. Researchers recommend that the predictive equations that have been developed should be used as predictors for the numerical achievement of the 800-meter running event.

Keywords
Anthropometric Measurements, Pulmonary Volumes, Numerical Achievement, Runners, Vital Capacity

INTRODUCTION

The 800-meter running competition is one of the middle-distance competitions that is closely linked to the endurance element, and that is why it is called (an endurance race), as the runner in this competition goes through four curved sections and four straights, so it is classified alongside the 400-meter running competition as one of the fiercest, most exciting and thrilling track competitions. This is indicated by the name given to them which "the killers of men or the graveyard of runners". The reason behind this name is the pain and fatigue that the runners of these competitions feel during the race resulting from the accumulation of large amounts of lactic acid because of the incomplete burning of glycogen, which is used as energy fuel in the race by the anaerobic system. Therefore, cyclic respiratory endurance, speed endurance, strength endurance, and performance endurance are considered the most important physical elements for success and achievement in this competition (Salama & Khalifa, 2018). Achieving high in this competition depends greatly on what the runners

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possess. From anthropometric and physiological specifications at the level of the heart muscle, Pulmonary, nervous and muscular systems, in addition to height, leg length, and a muscular body free of fat (Salameh, 2018), as (Zar et al, 2008; Mande, 2016) to the importance these specifications are by saying that understanding the anthropometric, physical and physiological specifications for each sporting activity is an important and influential factor in sporting achievement, as each sporting activity has its own anthropometric, physical and physiological requirements that pave the way for the player who possesses these requirements to achieve achievement.

He added (Gursavek & Mishra, 2012) that it is no less important than the technique used by an athlete in any game, and this requires attention to it by coaches and teachers when selecting players. Parseh & Hassan, (2015) also indicated that the medals obtained by Eastern European players In 1972, and in 1976, attention was paid to the anthropometric, physical, and physiological requirements when selecting talented athletes, according to the requirements of each game, and this was confirmed by many studies that dealt with studying the relationship between anthropometric and physiological measurements with athletic achievement, such as the study (Salama & Khalifa, 2018), which It showed that abdominal circumference and instep length were the most contributing anthropometric measurements to the level of Numerical Achievement for the 800m running event, as they contributed to explaining (13.8%) of the completion time , and a study (Mishra & Rathore, 2016) that found a significant relationship statistically between height, body mass, leg length, and thigh circumference with the 50-yard speed test, and a study (Singh & Malik, 2015) that showed a statistically significant relationship between height, leg length, shoulder circumference, hip circumference, shoulder diameter, and Elbow, thigh skin thickness, skin thickness of the biceps brachii muscle, 100-meter sprint completion, and a study (Singh & Malik, 2015) that showed a statistically significant relationship between height, leg length, shoulder circumference, hip circumference, shoulder diameter, and elbow diameter, The skin thickness of the thigh, the skin thickness of the biceps brachii muscle, the completion of a 400-meter run, and a study (Omelchenko et al, 2023), the results of which revealed a positive and direct relationship between height and body mass with measurements of pulmonary volumes related to (VT, FEV1, FVC, MV, ERV, IRV, VC, MVV) , and the study (Salameh et al, 2020) which showed that the Pulmonary volume measurements most capable of predicting physical efficiency were (FEV1 , FVC), which respectively contributed to explaining (73.5, 78.3%) of the efficiency index. Physical fitness, a study (Mazic et al, 2014) showed that there was a statistically significant relationship between the (VC) measurement and players who played boxing and rugby.

It also showed that there was a relationship between the (FVC) measurement and players who played Cycling, football, boating, as well as a relationship between measuring (FEV1) And boxing and water polo players, and a study (Yasuaki et al, 2006) which showed that high school football players in Yanazaki Prefecture in Japan are characterized by high levels of Pulmonary volume measurements related to (TLC, VC), and a study (Cheng et al, 2003) Which concluded that people who practice sports activities are characterized by high levels of pulmonary volume measurements (FVC, FEV1, FEV1/FVC%).

Given the importance of anthropometric measurements and pulmonary volumes among runners of the 800-meter running event, this study came as a practical scientific attempt by the researchers to determine the most contributing of these measurements to the Numerical Achievement of the 800-meter running, even in light of the unsatisfactory results achieved by a runner in competition at the national level from here it appears the study problem for the researchers.

MATERIALS AND METHODS

The study was conducted on a purposive sample of (17) elite 800-meter runners. The study was approved and supervised by the departmental research committee, Palestine Technical University - kadoorie (Ref: 2024/32 Date: 20. May. 2024). Also the current study involving human participants was approved and obtained ethical permission from them, and Table No. (1) shows the characteristics of the study sample.

Table 1. Characteristics of the study sample (N = 17)

Variables	Measuring unit	Minimum	Maximum	Mean	SD	Skewness coefficient
Age	Year	19.00	21.00	20.05	.820	-0.117
Body mass	Kg	60.00	74.00	66.20	4.68	.2030
Height	Cm	160.00	183.00	171.23	5.836	.3430

It is clear from the results of Table (1) that the values of the Skewness coefficient are between (± 3) and this indicates that the study sample is subject to the normal distribution.

Study procedures

Anthropometric measurements were performed related to age, body mass, height, the lengths of (arm, leg, thigh, instep) and the circumferences of (chest, chest with inspiration, abdominal, thigh, calf, and upper arm) using a measuring tape.-Measurements of Pulmonary volumes (VC, FVC, FEV1, FWV1/FVC%, MVV, TV, RV, TLC) were performed using a spirometer. A Numerical Achievement measurement was conducted for the 800-meter running event on the track at Palestine Technical University -Kadoori. The study was conducted in the time period 11-8/ 20-8-2023.

The following is an explanation of the study procedures:

Anthropometric Measurements

First

Height and body mass (body weight): To measure height, the researcher used a rectameter device, which is a stand installed vertically on a wooden edge, its length 250cm, the zero is at the level of the wooden base. There is also a stand installed horizontally on the stand so that it can be moved down and up"

The test subject stands on the wooden base with his back facing the stand so that it touches it at three points: the area between the two boards, the furthest point of the pelvis from the back, and the farthest point of the calves of the legs. Care must be taken to pull the body up and look forward, and the stand is lowered until it touches the upper edge of the skull so that the number facing the stand expresses the length.

Second

The Lengths of The Limbs Include

Arm Length

A measuring tape in centimeters is used to measure the arm from lateral edge of acromial process to the end of middle finger when it is straight.

Leg length

The length of the lower limb is measured using a measuring tape from the greater trochanter of the upper head of the hip joint to the floor.

Femoral length

Femoral length is measured using a tape measure from the greater trochanter of the superior head of the femur to the lateral edge of the middle of the knee.

Leg Length

Leg length is measured using a measuring tape from the medial edge of the middle of the knee joint to the medial prominence of the heel.

Instep length

The instep length is measured using a tape measure from the end of the heel bone to the tip of the big toe.

Third

The Circumferences Include

Chest Circumference in the Normal Position

The chest circumference is taken at a level exactly above the nipple and the average circumference of the maximum inhalation and the minimum circumference during maximum exhalation are calculated.

Chest Circumference During Inhalation

The chest circumference is taken as in the previous method, but after the tester takes the maximum breath (inhalation) and holds it until the chest circumference is read.

Upper Arm Circumference During Diastole

The largest circumference during contraction and relaxation.

Abdominal circumference: the smallest circumference of the abdomen above the navel 2-3cm.

Thigh Circumference

The largest circumference of the thigh directly below the buttocks .

Calf circumference

The largest circumference in the calf (Salama, 2018; Hanon et al, 2024)

Pulmonary Function Measurements

The researchers used an electronic spirometer, type of Astra Touch, American made

and manufactured by a company SDI Diagnostics. It is considered one of the modern and accurate devices that measures more than 40 measurements.

Measurement Instructions And Instructions T he measurements were carried out at 10-12 am, at a temperature of 27 degrees Celsius. Students who smoke and students who have respiratory diseases were excluded. Students were told to eat breakfast at least two hours before the test. The students were informed not to engage in any sporting activity before the measurement.

Measurement Mechanism Measurements were performed according to the guidelines of the American Thoracic Society and the European Respiratory Society (ATS/ERS) according to the following steps: was explained to all players before starting the measurement, with a sample performance for each test. Measurements were taken from a sitting position on a chair. Close the nose with plastic forceps designated for this purpose. Players take tests with three attempts for each test, with the best one being recorded. (FVC, FEV1) were measured FEVI/FVC%) by the player taking the maximum inhalation and then following it with the maximum exhalation. VC was measured by the player breathing three times as a normal breath in the spirometer. On the fourth time, the player took the maximum inhalation followed by the maximum exhalation, so we obtained measurements (ERV, IRV, SVC, TV). (MVV) was measured by performing a breathing maneuver with the maximum possible inhalation and exhalation for (12) seconds (ATS, 2001). The Numerical Achievement measurement for the 800-meter running event on the Olympic track was taken at Palestine Technical University –Kadoorie.

Statistical analysis

The authors used IBM SPSS version 26 to analyze data by using means, standard deviations, skewness, Pearson correlation coefficient and Stepwise Multiple liner Regression.

RESULTS

Results related to the first study question, which states

What are the most anthropometric measurements contribute to the Numerical Achievement of 800-meter event runners in Palestine?. To answer this question, firstly, the researchers found the values of the Pearson correlation coefficient between anthropometric measurements and the Numerical Achievement of 800-meter event runners in Palestine, and Table (2) shows that.

Table 2. Pearson correlation coefficient between some anthropometric measurements the numerical achievement of 800-meter event runners in Palestine (N= 17)

Anthropometric Measurements	Measuring Unit	Mean	SD	R-value*
Age	Year	20.05	.820	0.195
Body Mass	Kg	66.20	4.68	-0.607
Height	Cm	171.23	5.836	*-0.657
Arm Length	Cm	73.53	3.18	-0.172
Leg Length	Cm	90.41	4.98	-0.383
Thigh Length	Cm	47.59	4.84	*-0.613
Lower Leg Length	Cm	42.88	2.47	0.373
Instep Length	Cm	26.65	1.58	0.126
Chest Circumference	Cm	84.41	4.43	-0.431
Chest Circumference With Inspiration	Cm	87.82	4.23	-0.352
Abdominal Circumference	Cm	74.24	4.18	0.066
Thigh Circumference	Cm	49.18	2.88	-0.294
Calf (Gastrocnemius) Muscle Circumference	Cm	34.71	2.64	-0.247
Upper Arm Circumference	Cm	28.47	2.62	0.215

From the results of Table (2), it is clear that there is no a statistically significant relationship at the level of significance ($\alpha \leq 0.05$) between some measurements of anthropometric related to measurements: (age, body mass, arm length, leg length, thigh length, lower leg length, instep length,

abdominal circumference, upper arm circumference), and the Numerical Achievement of 800-meter event runners, while there is statistically significant relationship with height, thigh length. In order to determine the contribution of height, thigh length measurements, linear stepwise regression analysis was applied to identify the possibility of developing a predictive equation from some anthropometric measurements height, thigh length as an independent variables with the Numerical Achievement of 800-meter event runners as a dependent variable, and Table (3) shows this.

Table 3. Results of a one-way analysis of variance to identify the regression coefficient for the predictive equation for Numerical Achievement for 800-meter event runners in Palestine (N=17)

Model	Source of variance	Sum of Squares	df	Mean Square	F	Sig.	R^2
Height	Regression	0.066	1	0.066	11.383	*0.004	.0431
	Residual	0.087	15	0.006			
	Total	0.153	16				

*Significance level ($\alpha \leq 0.05$)

It is clear from the results of Table (3) that anthropometric measurements contribute most In the numerical achievement for the 800 meter event runners , it was height where the value of (r^2) reached it has (0.431), and to identify the equation of the regression line, the t-test and the beta coefficient were used, and the results of table (4) show this.

Table 4. Results of the t-test and the beta coefficient of the regression line equation for the contribution of some anthropometric measurements to the numerical achievement of 800-meter event runners (N=17)

Model	Value	Standard Error	Beta	T	Sig.	R^2
Constant	4.149	0.560		7.413	*0.000	
Height	-0.011	0.003	-0.657	-3.374	*0.004	0.431

*Significance level ($\alpha \leq 0.05$)

It is clear from the results of Table No. (4) that the value of (t) was statistically significant at the significance level ($\alpha \leq 0.05$), where the measurement contributed Height In interpreting (43.1)% of the numerical achievement of the 800-meter event runners , the proposed equation becomes as follows:

Numerical Achievement for running 800 meters = 4.149 - ((Height (cm) × 0.011))

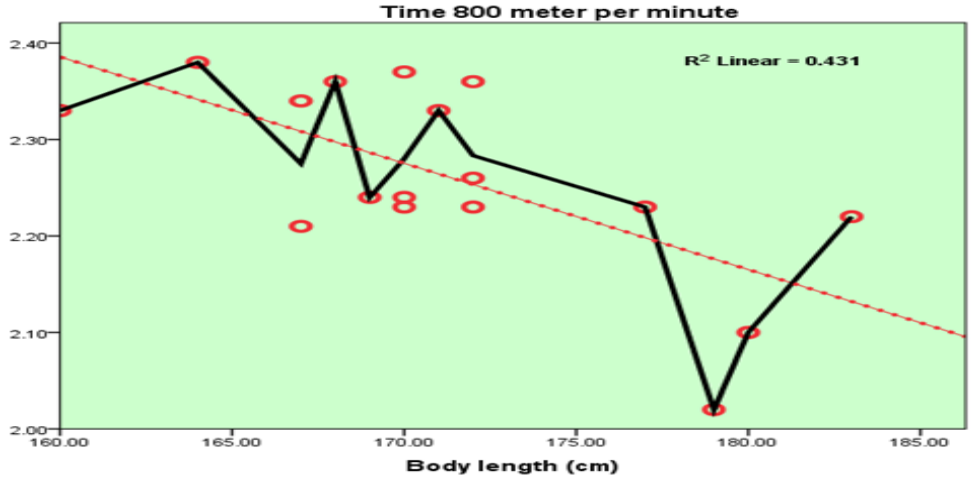

Figure 1. Height measurement as a predictive in the numerical achievement for the 800 meter event runners.

Results Related to the Second Study Question, Which State

What are the most Pulmonary volume measurements contribute to the numerical achievement of 800-meter event runners in Palestine?. To answer this question, firstly, the researchers found the values of the Pearson correlation coefficient between pulmonary volume measurements and the numerical achievement of 800-meter event runners in Palestine, and Table (5) shows that.

Table 5. Pearson correlation coefficient between pulmonary volume measurements and the numerical achievement of 800-meter event runners (N= 17)

Pulmonary volumes measurements	Measuring unit	Mean	SD	R-value*
VC	L / min	4.36	0.48	*-0.625
FVC	L / sec	4.22	0.46	*-0.555
FEV1	L / min	4.06	0.46	*0.288
FEV1/FVC%	%	95.52	4.70	0.429
MVV	L / min	164.38	18.92	0.168
TV	L / min	1.45	0.59	0.007
IRV	L / min	1.50	0.46	-0.276
ERV	L / min	1.49	0.65	-0.299
IC	L / min	3.20	0.62	-0.245
RV	L / min	1.06	.110	*-0.496

* Significance level ($\alpha \leq 0.05$), Standard Deviation (SD)

From the results of Table (5), it is clear that there is no a statistically significant relationship at the level of significance ($\alpha \leq 0.05$) between measurements of pulmonary volumes related to measurements: (FWV1/FVC%, MVV, TV, IRV, IC, ERV) and the numerical achievement of 800-meter event runners, while there is statistically significant relationship with (VC, FVC, FEV1, RV) and the numerical achievement of 800-meter event runners. In order to determine the contribution of (VC, FVC, FEV1, RV) measurements, linear stepwise regression analysis was applied to identify the possibility of developing a predictive equation from some Pulmonary volumes measurements (VC, FVC, FEV1, RV) as an independent variables with the numerical achievement of 800-meter event runners as a dependent variable, and Table (6) shows this.

Table 6. Results of one-way analysis of variance to identify the regression coefficient for the predictive equation for Numerical Achievement for 800-meter event runners in

Model	Source of variance	Sum of Squares	df	Mean Square	F	Sig.	R^2
VC	Regression	0.060	1	0.060	9.632	*0.007	.0391
	Residual	0.093	15	0.006			
	Total	0.153	16				

*Significance level ($\alpha \leq 0.05$).

It is clear from the results of Table (6) that Pulmonary volume measurements contribute most In the Numerical Achievement of runners in the 800-meter running event in Palestine She was VC The value of (R^2) reached (0.391), and to identify the equation of the regression line, the t-test and the beta coefficient were used, and the results of table (7) show this.

Table 7. Results of the t-test and the beta coefficient of the regression line equation for the contribution of some Pulmonary volume measurements to the Numerical Achievement of 800-meter event runners (n=17)

Model	Value	Standard Error	Beta	T	Sig.	R^2
Constant	2.819	0.181		15.615	*0.000	
VC	-0.128	0.041	-0.625	-3.10	*0.007	0.391

*Significance level ($\alpha \leq 0.05$).

It is clear from the results of Table No. (5) that the value of (t) was statistically significant at the significance level ($\alpha \leq 0.05$), where the measurement contributed VC explains (39.1)% of the Numerical Achievement of runners in the 800-meter running event , and therefore the proposed equation becomes as follows: Numerical Achievement for running 800 meters = 2.819 - ((VC (unit of measurement) × 0.12)).

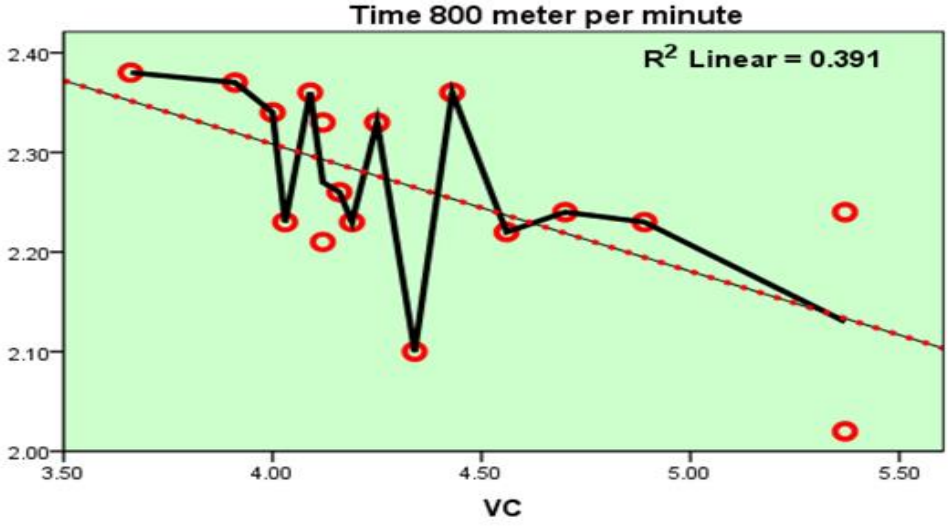

Figure 2. VC measurement as a predictive in the Numerical Achievement of running 800 meters

DISCUSSION

Discussing the Results Related to the First Question

It is clear from the results of Tables (2-4) that anthropometric measurements have the most contribution The Numerical Achievement for the 800-meter running competition among elite runners in Palestine was Height It contributed to explaining (43.1%) of the numerical achievement of runners in the 800-meter running event in Palestine. This result is consistent with the study (Sekarbabu et al, 2021), which showed that height contributed to explaining (31%) of the completion time of the 800-meter competition, and a study (Salameh, 2017), which found that height contributed to explaining (46.3%) of the performance distance in javelin throwing, and the study (Ali and Nasser, 2016), which proved that height contributed to explaining (35%) of the numerical achievement of my test. The broad and vertical jump from stability, among basketball players, and the study of Hanoun (2016) which proved that height was one of the most important anthropometric measurements for predicting the Numerical Achievement of some athletics events, as it contributed to explaining (49%) of the high jump completion distance, (49.2%) of the distance for completing the long jump, and (18.9%) the time for completing the 100-meter sprint, and the study (Mishra & Rathore, 2016) which showed that height is one of the most important anthropometric measurements related to speed, as well as the study of Singh & Malik (2015) which proved the existence of a positive relationship between height and Numerical Achievement in the effectiveness of the 100-meter sprint, and the researchers attribute this to the distinction of the tall athlete. Step length during fast running, as step length is one of kinematic variables that plays an important role in running speed and thus finishing the race distance in a small number of steps compared to short stature. Also, the muscular strength of the legs increases as their length increases, thus increasing the length and breadth of the step, and this is what was confirmed. It contains the results of a study (Pourrahim et al, 2021), which found that there is a significant and positive relationship between leg length with the time of running 400 meters, 800 meters, 1500 meters, and a test of the muscular strength of the legs.

Results Related to the Second Study Question, Which States

It is clear from the results of Tables (5-7) that Pulmonary volume measurements that contribute most in the Numerical Achievement of the runners of the 800-meter running event in Palestine was Vital Capacity (VC), which contributed to the interpretation of (39.1%) of the Numerical

Achievement of runners in the 800-meter running event in Palestine. The researcher attributes this to the importance of the Vital Capacity (VC) for 800-meter runners because it reflects the true adaptation that has occurred in Pulmonary efficiency and volume as a result of regular training, and improving this measurement means improving the rest of the Pulmonary volume measurements associated with it, which are (ERV, IRV, SVC, TV, ERV, IRV, TV, ERV, IRV, TV, FEV1, FVC, FEVI/FVC) which is obtained by the player breathing three times normally in a spirometer , and on the fourth time taking the maximum inhalation followed by the maximum exhalation. The Vital Capacity (VC) measurement is one of the measurements that is very closely related to training. Endurance, and in view of the importance of this physical element for 800 meter event runners, this contribution appeared, as he pointed out as (Salama, 2018) pointed out that the nature of the physical requirements for the 800 meter running event are closely related to the endurance element, and that is why they are called (endurance races), and cyclic respiratory endurance is considered, Endurance and speed, and speed is the most important of these elements for players, so this type of activity depends on the aerobic and anaerobic energy production system, and with a slightly greater percentage on the anaerobic system (lactic acid system), as (Mohamed, 2015) indicated that the approximate percentage of the contribution of energy sources The aerobic and anaerobic components in the 800 meter running event are approximately (60 %) anaerobic, and approximately (4.0 %) aerobic, and this develops the strength and efficiency of the breathing muscles (the diaphragm muscle, the intercostal muscles, the external intercostal muscle, the sternocleidomastoid muscle, and the spinal cord). Which increases the flexibility and expansion of the rib cage during the breathing process, and this allows for better performance of respiratory processes in runners during physical exertion. The density of the surrounding blood capillaries in the alveoli of the lungs also increases as a result of the opening of a number of closed or dormant capillaries or the generation of new capillaries under the influence of Continuous repetitions of performing physical effort, and this leads to an increase in the surface area over which gases are exchanged between the capillaries and pulmonary alveoli, not to mention an increase in the elasticity of the lungs and their ability to expand and contract to perform strong and deep breathing movements, and thus the efficiency of Pulmonary volumes, both static and dynamic, is improved, the most important of which is measuring vital capacity (VC). Which is considered one of the most important functional indicators of lungs and thus an increase in the volume of inspiratory reserve over expiratory reserve in runners as a result of speed endurance training. In general, the results of the current study were consistent with the studies of (Ja'afar et al, 2023; Nehe, et al, 2023; Megahed, et al, 2023; Abu Seman, et al, 2022; Drobnicc et al, 2021; Salameh et al, 2020; Kocahan et al, 2017; Akhade & Muniyappanavar, 2017; Akhade, V., Bhatt et al, 2015; & Muniyappanavar, 2014) which proved three basic and established facts, which are that Pulmonary volume measurements are positively affected by Height and mass, age, and practicing sports activities and competitions that require an element of respiratory cyclic endurance, speed endurance, force endurance, and performance endurance, such as middle- and long-distance running, and football. Basketball, handball, rowing, swimming, boxing, and snowboarding.

Conclusion

It is clear from the results of the study that anthropometric measurements, as well as pulmonary volume, can be used to predict measurements of achievement in the 800-meter running competition.

Conflict Of Interest

No potential conflict of interest relevant to this article was re reported.

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Ethics Statement

The study was approved and supervised by the departmental research committee, Palestine Technical University-kadoorie (Ref: 2024/32 Date: 20. May. 2024). Also the current study involving human participants was approved and obtained ethical permission from them.

Author Contributions

Study Design, KQ and HS; Data Collection, KQ, HS and AQ; Statistical Analysis, KQ and MA; Data Interpretation, KQ, AQ and LH; Manuscript Preparation, AQ, LH and RK; Literature Search,

KQ, HS, AQ, MA, LH and RK. All authors have read and agreed to the published version of the manuscript.

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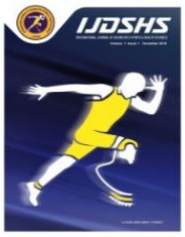

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RESEARCH ARTICLE

Athletes' Sleep Quality: Performance Study in Football Clubs Aged 13-15 Years

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Abstract

The athlete's stamina supports sports performance, but stamina is supported by various things, one of which is the quality of the athlete's sleep during recovery. This study aims to determine the effect of sleep quality on football performance. The method used in this research is descriptive quantitative with a correlational approach. The sampling technique used was purposive sampling with several considerations, including football school students aged 13-15 years actively participating in football school activities and students are permitted to take part in research from a total population of 10 students consisting of 2 students aged 13 years, six students aged 14 years and two students aged 15 years. The research instruments are PSQI to determine sleep quality and GPAI to assess performance. Based on calculations and data analysis, an average PSQI score of 4.1 was obtained, and the average GPAI score for the criteria included SE 3.4, DM 3.1, and SP 3.6. Based on the correlation value calculation, it was found that there was a negative correlation with a moderate strength of -0.502 for PSQI and SE. In contrast, the correlation value between PSQI, DM, and SP had weak strength and was also harmful to SE at -0.305 but positive for SP, namely 0.255. Conclusion: The influence of sleep quality on football performance has a significant relationship, but the level of influence is at a medium or even low level.

Keywords
Sleep Quality, Performance, Football, Young Athletes

INTRODUCTION

Various factors influence athletes' performance, i.e., 1). Exercise. One of the exercises that influences performance is intensive Training. Intensive Training, including high-intensity aerobic sessions and speed endurance, improves competition performance and benefits athletes in team sports such as football and basketball (Bangsbo, 2015). 2). Elite athletes' performance may be slightly but maybe significantly impacted by nutrition, nutrients, and dietary supplements (Maughan et al., 2018). Nutritional interventions such as carbohydrates, tryptophan, valerian, and melatonin can influence the quality and quantity of sleep in elite athletes, potentially improving their performance (Halson, 2014). 3). Genetics, cognitive abilities influenced by genetic polymorphisms, have been shown to influence competitive performance in athletes, indicating a relationship between cognitive function and athletic success (Gineviciene et al., 2022). Genetic variants can influence mental and emotional processes, particularly serotonergic pathways and athletic performance tendencies (Peplonska et al., 2019). Mental health symptoms and disorders in elite athletes impair performance (Reardon et al., 2019). Mental health is the leading resource for athletes regarding their performance and development, so interventions are needed to monitor and maintain athletes' mental health (Schinke et al., 2018). Sleep deprivation negatively impacts athletic performance, whereas extended sleep time improves athlete performance, with effects

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dependent on the local timing of performance (Thun et al., 2015).

Decision-making, task execution speed, and accuracy are all impacted by poor sleep quality (Troynikov et al., 2018). Sleep quality improves mental health (Scott et al., 2021), and good mental health influences performance and development (Schinke et al., 2018). Sleep quality reflects a person's satisfaction with their sleep time so that the individual does not show signs of fatigue but remains fresh and relaxed. This matter is characterized by the absence of restlessness, lethargy, and apathy, as well as the absence of dark circles around the eyes, swelling of the eyelids, eyes that do not feel sore, optimal concentration, freedom from headaches, and a lack of habit of yawning or feeling sleepy constantly continuously (Tentero et al., 2016). Sleep quality is also essential for healthy sleep and has been proven to affect health. People who sleep poorly tend to experience worse mental, cognitive, or physical health problems. Sleep quality can be even more important than sleep duration in some aspects of health, such as overall health, emotional distress, and risk of hypertension. The National Sleep Foundation Scientific Advisory Council recommends 8–10 hours of adolescent sleep (Surani et al., 2015). Quality sleep is considered essential for adequate exercise performance. Although the beneficial effects of sleep on recovery and athletic performance have been proven, many athletes do not have good quality sleep (García Castrejón, 2015). Sleep parameters correlate with the performance of Australian Football League athletes (Facer-Childs et al., 2020). Performance is a person's success in completing a task. The success of young athletes is greatly influenced by adequate quantity and quality of sleep. Today's young athletes have significant time responsibilities for school activities and homework, practice schedules, social interactions with friends, and sometimes part-time jobs. For this reason, sleep is often neglected in favor of other activities (Riederer, 2020).

Many studies have proven and strengthened the relationship between sleep quality, mood, and exercise performance (Andrade et al., 2016). Poor sleep quality in elite athletes, such as soccer players, can reduce athletic performance (Jorquera-Aguilera et al., 2021). Sleep deprivation negatively impacts athletic performance, neurocognitive function, and physical health (Simpson et al., 2017). In this study, the sample used was football school students aged 13-15 years because this age is early maturity and has better anthropometric and physical performance than players with late and average maturity (Yang & Chen, 2022). Besides, this age is the most senior. At football school Baraccuda, if the results of this research are significant, then it can serve as an example for juniors.

Not many studies have researched the influence of sleep quality on football performance, especially for ages 13-15 years—meanwhile, a study conducted by (Penggalih et al., 2021) correlated sleep quality with the performance of football athletes. The performance referred to in this study was fitness performance. In contrast, the study conducted by the author correlated sleep quality with appearance performance using the GPAI instrument to determine whether there was an effect. Indeed, an athlete has to maintain physical and mental fitness by having good quality sleep, as in the studies mentioned above. However, apart from that, the author often finds that many football athletes, even professional football athletes, often smoke and drink, but when in competitions, their performance is good even though, according to (Leonel et al., 2020), smokers have twice the risk of experiencing sleep disorders, including insomnia, and are more dissatisfied with the quality of their sleep. According to (He et al., 2019), alcohol use is associated with low sleep quality but not with sleep duration in life Daily.

MATERIALS AND METHODS

Participant

The research design used is quantitative research, which involves collecting and analyzing numerical data (Sharma et al., 2023). The approach used in this research is a correlation approach. The correlation approach is research that studies the relationship between two or more variables (Lestari et al., 2023). Participants in this research were football school Baraccuda students aged 13-15 years who actively participated in football school activities and received permission from the trainer to take part in the research, a total of 10 samples consisting of 2 students aged 13 years, six students aged 14 years and two students aged 15 years old. Purposive sampling is the sample strategy employed. Purposeful sampling is "a technique for

determining research samples with certain considerations with the aim of making the data obtained more representative" (Delta Septya Rahayu dan Nurul Iman, 2022). Some considerations include 1) age 13-15 years, 2) actively participating in football school activities, and 3) getting permission from the trainer to participate in research.

Before the research, the author prepared what was needed, such as a research permit, PSQI, and GPAI instruments. The author interviewed his football school advisor regarding his profile and achievements during the research. The author coordinated with the trainer to select samples using purposive sampling techniques, including students who actively participated in football school activities and students aged 13-15 years whom the trainer permitted to participate. As a result, research showed that the samples obtained were around 10. Then, the sample was conditioned by the author to fill out the PSQI questionnaire, after which the author prepared a 2x2 goal and a 30x15 field for the implementation of GPAI, assisted by one of the football school coaches. After completing the research, the author processed the data by finding the average of the PSQI and GPAI results; then, the author correlated the PSQI and GPAI data.

This study followed ethical standards and received approval from the Institute for Research and Community Service, Universitas Pendidikan Indonesia, with Letter Number B-298/UN40.D/PT.01.02/2024. Participant provided informed consent, with the volunteer form covering research details, risks, benefits, confidentiality, and participant rights. The research strictly adhered to the ethical principles of the Declaration of Helsinki, prioritizing participant's rights and well-being in design, procedures, and confidentiality measures.

Research Instruments

The instruments used in this research were PSQI and GPAI. The instruments used in this research were PSQI and GPAI. PSQI (Pittsburgh Sleep Quality Index) is a questionnaire with 18 questions to determine your sleep patterns and quality during the last month (Deng et al., 2020). The components of the PSQI are seven items, including subjective sleep quality, sleep latency, sleep duration, efficiency of sleep habits, sleep disorders, use of sleeping pills, and daytime dysfunction. Component scores range from 0 (no difficulties) to 3 (severe difficulties), and when summed, produce a global score that ranges from 0 to 21. A score>5 indicates significant sleep disturbance (Dietch et al., 2016). GPAI (Game Performance Assessment Instrument) aims to assist teachers and coaches in observing and recording players' performance behavior during the game. Four game types can use this instrument, which identifies observable components of game performance: invasion sports, net and wall, target games, and field and hitter (González-Víllora et al., 2015). Researchers modified the soccer game from (González-Víllora et al., 2015). Four against 4, without a goalkeeper, the field measures 30 × 15 m and uses a small goal. The goal used is 2x2, and no one is allowed to guard the goal. Playing time is two halves of 4 minutes with 3-minute intervals. The assessment criteria for this research in include the following:

a. Execution skill: Students pass the ball accurately until it reaches the intended recipient.
b. Decision-making: Students make the right decision when passing (i.e., passing to an unmarked teammate to create a goal-scoring opportunity).
c. Support: The student attempts to move into position to receive a pass from a teammate (i.e., looking for space to create a chance).

The assessment technique used is the scoring technique, where this scoring technique is on a scale from 1-5; the criteria include 5 = very effective performance (always), 4 = effective performance (usually), 3 = quite effective performance (sometimes), 2 = weak performance (rarely), 1 = feeble performance (never).

Statistical Analysis

Meanwhile, the data analysis used was IBM SPSS series 26 to find out the average PSQI and GPAI criteria scores and whether there was a correlation between PSQI and GPAI criteria scores. Correlation analysis uses Pearson correlation because Pearson correlation is more appropriate for analyzing the correlation between variables. The level of correlation between PSQI and GPAI in this study is -0.3, which means it is at a moderate level; this is to the table contained in (Shariff, 2019):

Table 1. Correlation Score Criteria

Correlation coefficient	Strength Level
1	Perfect
0.7<r<1 or -0.7<r<1	Strong
0.3<r<0.7 or -0.3<r<0.7	Currently
0<r<0.3 or 0<r<-0.3	Weak
0	Very weak

RESULTS

Data Descriptions

The first step in this research data analysis was to look for statistical descriptions in the form of average values and standard deviations from the PSQI and GPAI test instruments. A complete explanation can be seen in table 1 below:

Tabel 2. Statistical description of research instruments

PSQI	M	SD	ICC	95%CI
Subjective sleep quality	4.76	1.20	.821	.819-.882
Sleep latency	3,33	1.57	.843	.801-.899
Sleep duration	4.82	1.70	.807	.789-.877
Efficiency of sleep habits	2,67	1.50	.825	.779-.886
Sleep disorders	3.44	1.92	.860	.817-.912
Use of sleeping pills	3.59	1.35	.835	.782-.920
Daytime dysfunction	3.80	1.62	.827	.790-.873
GPAI	M	SD	ICC	95%CI
Skill execution	3.44	1.32	.865	.794-.829
Decision making	3.19	1.24	.858	.786-.944
Support	3.63	1.47	.843	.725-.938
Total PSQI	26.41	10.86	.805	.795-.956
Total GPAI	10.01	4.03	.814	.785-.896

Notes: CI = confidence interval; ICC = intraclass correlations; M = mean; SD = standard deviation;

Based on the calculation results in Table 2 above, the PSQI average is 26.41, the standard deviation is 10.86, and the intraclass correlation is 0.805, with a confidence interval range of 0.795-0.956. For GPAI, the total mean is 10.01, the standard deviation is 4.03, and the intraclass correlation is 0.814, with a confidence interval range of 0.785-0.896.

Data Normality Test

The normality test determines the next testing stage. If the data is average, then the linearity test is required for the Pearson Correlation test. The Shapiro-Wilk normality test was run using SPSS 26 for Windows. Table 2 displays the data for the normality test in question

Table 3. Normality test

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Group	Statistic	df	Sig.	Statistic	df	Sig.
PSQI	Group A	.233	5	.200*	.884	5	,329
	Group B	.300	5	.161	.833	5	,146
GPAI	Group A	.231	5	.200*	.943	5	,685
	Group B	.213	5	.200*	963	5	,826

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Based on Asymp.Sig for the Shapiro Wilk test results shown in Table 2 above with values much more significant than 0.05, further analysis is possible because the data is usually distributed.

Results of Hypothesis Testing

Based on the data normality test results, the next step is the ANOVA test, which is required for the next Pearson correlation test. Table 3 below presents the data in question:

Table 4. PSQI and GPAI between groups ANOVA test

ANOVA Table							
			Sum of Squares	df	Mean Square	F	Sig.
PSQI * GPAI	Between Groups	(Combined)	17.733	4	4.433	1.157	.428
		Linearity	4.417	1	4.417	1.152	.332
		Deviation from Linearity	13.317	3	4.439	1.158	.412
	Within Groups		19.167	5	3.833		
	Total		36.900	9			

Based on the results of the sig value. From the deviation from linearity, the result is 0.412, which means the value is >0.05, which means the relationship between the two variables is considered linear

Table 5. Mean and Correlation Pearson

Correlations			
		PSQI	**GPAI**
PSQI	Pearson Correlation	1	-.346
	Sig. (2-tailed)		.327
	N	10	10
GPAI	Pearson Correlation	-.346	1
	Sig. (2-tailed)	.327	
	N	10	10

The correlation value between PSQI and GPAI is -0.3, where this value is negative, which means that the greater the value of variable Y, the smaller the value of variable year. There is no significant relationship because the sig value of these two variables is 0.3, which is a value greater than 0.05 Based on the research results, it is known that the average PSQI score is 4.1, which means <5; if the PSQI value is <5, it means that the average sleep quality of the sample is good, while the average GPA score for the criteria is at a sufficient number, namely is at number 3. The Pearson correlation data processing results between PSQI and GPAI per criteria have a sig output. (2-tailed) <0.5, which means it is significant. The Pearson correlation value between PSQI SE (Skill Execution) and DM (Decision Making) has a negative coefficient value, namely -0.502 and -0.305, which means that the higher the PSQI score, the lower the execution and decision-making skills. Meanwhile, the person correlation coefficient value between PSQI and support is positive, namely 0.255, which means that the higher the PSQI score, the better the support. According to (Deng et al., 2020), an ICC (Intraclass Coefficient Correlation) value of less than 0.5 denotes low reliability, a value in the range of 0.5 to 0.75 indicates moderate reliability, a value in the range of 0.75 to 0.9 indicates good reliability, and values above 0.90 denote exceptional reliability.

For greater clarity, Figure 1 below shows a description of the correlation coefficient between variables as a Scatter Plot Graph.

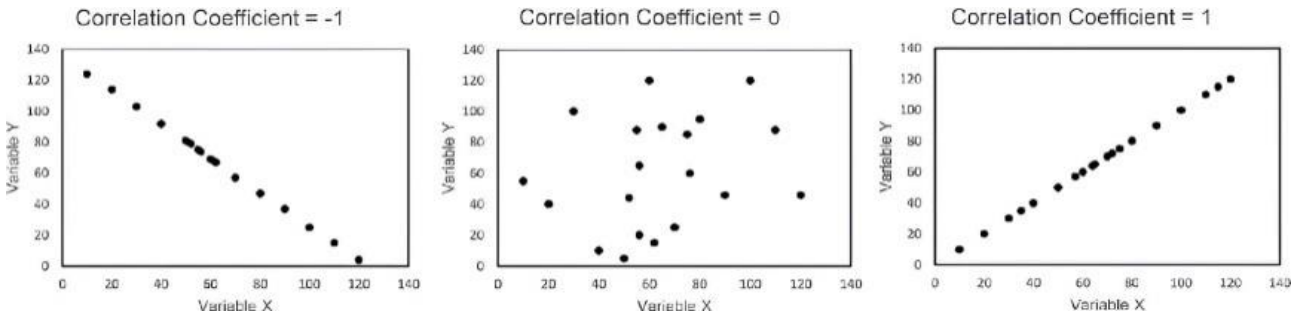

Figure 1. Correlation Coefficient PSQI and GPAI

DISCUSSION

Based on research results, the average PSQI score and GPAI score of football school students are at a good number; this is in line with research conducted by (Troynikov et al., 2018) that poor sleep quality can interfere with decision-making and accuracy in carrying out tasks and vice versa. Then, decision-making and accuracy of task implementation will also be good. The results of the study show that there is a significant relationship between sleep quality and football performance, but the level of correlation does not show a high level of correlation; the level of correlation between sleep quality and execution skills is medium, the level of correlation between sleep quality and decision making is low and the level of correlation between sleep quality and low-value support. This matter is based on the author's hypothesis that an athlete must maintain physical and mental fitness by getting good quality sleep every day to maintain his performance (Lengkana et al., 2020; Subarna et al., 2021). However, some athletes often smoke and even drink alcohol, which, according to (He et al., 2019; Leonel et al., 2020) interferes with sleep quality, but when playing on the field, the performance is good. Physical fatigue can hurt the technical and physical performance of soccer players. This condition can decrease technical skills such as passing, receiving the ball, shooting, and dribbling due to decreased motor coordination and increased mental fatigue. Fatigue can also reduce running speed, reaction, and physical endurance, increasing the risk of injury and disrupting mental concentration.

An athlete's performance is determined by intense physical training good technique, and the body's ability to recover effectively. Rest is a critical factor in an athlete's physical and mental recovery after training or competition. In achieving optimal performance, a deep understanding of the importance of rest in athlete recovery is very relevant (Hidayat et al., 2023; Mulya et al., 2021). Physical recovery involves healing muscles, connective tissue, and the nervous system after experiencing stress and fatigue during sports activities. Rest gives the body time to repair and regenerate, crucial for preventing ongoing injuries. The scientific literature highlights the critical role of rest in injury management and prevention of overtraining in athletes. In addition to recovering from physical damage, rest is also crucial in restoring energy and glycogen. Intense training can deplete energy and glycogen reserves in an athlete's muscles. Research by (Lengkana et al., 2024) shows that adequate rest allows the body to renew these energy reserves, essential for maintaining endurance and high performance. Athletes' recovery is not only related to physical aspects but also mental recovery. Fatigue conditions can affect concentration, focus, and decision-making. A literature review highlights that adequate rest plays a crucial role in recovering athletes' cognitive functions and mental aspects, ensuring optimal mental readiness for the next performance.

Rest also includes aspects of athletes' sleep patterns (Hidayat et al., 2022). Good recovery involves getting enough quality sleep. Lack of sleep can disrupt physical and mental recovery, potentially increasing the risk of injury. In this perspective, understanding the importance of rest includes knowing the benefits of adequate sleep for athlete recovery. Through this literature review, it is hoped that comprehensive insight can be obtained regarding the importance of rest in the athlete's recovery process. Physical and mental aspects in the context of athlete recovery are the main focus to improve understanding and optimize overall athlete performance (Razali et al., 2023). In an athlete's physical recovery, rest plays a central role. Physical recovery involves repairing muscles, connective tissue, and the nervous system after intensive sports

activities. Rest provides the necessary time to regenerate. They prevent excessive fatigue and support optimal physical recovery (Mulya et al., 2023). The importance of rest in injury management and prevention of overtraining was revealed in the research of (Weil et al., 2023). Adequate rest can facilitate injury healing and optimize recovery time, maintaining athlete health and preventing potential risks of overtraining. Rest provides time for the body to renew energy reserves depleted during sporting activities, ensuring the availability of sufficient energy to support the athlete's performance—the importance of rest in athletes' mental recovery. Mental fatigue can affect concentration, focus, and cognitive function. Rest provides an opportunity for mental recovery, maintaining the athlete's mental readiness for the next task and competition. Research by (Solet, 2018) confirms the role of good sleep as an integral part of rest. An adequate sleep pattern supports physical and mental recovery, strengthens the immune system, and increases endurance in athletes. Break time management and the influence of external variables, such as travel and time zone differences, are also deepened in the study (Gilley, 2023; Helvig et al., 2016). Awareness of this variability allows for appropriate rest timing, essential in optimizing athlete recovery in different situations. The results of this discussion underline the urgency of rest in athlete recovery from various perspectives. Implications include designing exercise programs that address rest time management, understanding the importance of sleep, and considering external variability. Practical recommendations include the coach's role in Developing a training schedule that aligns rest with training intensity, paying particular attention to injury management, and paying attention to the athlete's individual needs for optimal recovery. Overall, a deep understanding of the importance of rest can help achieve the balance necessary for consistent and optimal athlete performance. Therefore, effective fatigue management is critical to ensuring players remain at their best during matches (Dambroz et al., 2022). In conclusion, this study provides information regarding the influence of sleep quality on football performance. The research concluded that sleep quality has a significant influence on football performance, but the level of influence is not mostly low. The reason behind the low influence of sleep quality on football performance is that every athlete has a different physique.

Conflict of Interest

The authors have declared no conflicts of Interest.

Ethics of the Research

This study followed ethical standards and received approval from the Institute for Research and Community Service, Universitas Pendidikan Indonesia, with Letter Number B-298/UN40.D/PT.01.02/2024.

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Author Contributions

Study Design, ISD and ASL; Data Collection, ISD, ASL and DD; Statistical Analysis, ASL and RR; Data Interpretation, ISD, ASL and RR; Manuscript Preparation, ASL, DD and RR; Literature Search, ISD, ASL, DD and RR. All authors have read and agreed to the published version of the manuscript.

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RESEARCH ARTICLE

Approach to the Game Take the Ball to Practice Swimming Skills for Beginners in Physical Education

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Abstract

This study aims to explore the effectiveness of the grab the ball game approach as an alternative method of teaching swimming skills to beginners in physical education. Teaching swimming skills to beginners in physical education is often challenged by the need to create an engaging and effective learning environment for students. This research method uses an experimental approach one group pretest postest with the need for 8 sessions. Swimming skills were assessed before and after the intervention. The research sample was 15 students at Bina Darma University with the category of not able to swim or beginners. Data were collected by measuring test of swimming 50 meters freestyle. Data analysis using paired test between pre-test and post-test with SPSS version 21. Empirical findings show that students who were taught the grab-the-ball approach experienced significant improvements in swimming skills. The resulting t-statistics (23.858 for the pre-test and 19.192 for the post-test) indicate that these differences are very statistically significant, with p-values (Sig.) that are extremely low ($p<0.0001$). This means that the observed difference between the sample group average and the expected test score is very unlikely to have occurred by chance. Conclusion The results of this study indicate that the grab-the-ball approach can be an effective alternative in teaching swimming skills to beginners in physical education. The implications of these findings highlight the importance of using engaging and playful methods to improve student learning outcomes in swimming skills. Suggestions for future research include extending the research by including a larger sample, which may provide greater statistical power to support research findings in the area of swimming 50 meters freestyle.

Keywords
Game Approach, Take The Ball, Swimming Skill, Beginner, Physical Education

INTRODUCTION

Physical education in schools plays a vital role in the development of pupils' physical and mental health (Aliriad et al., 2023a; Endrawan et al., 2023). One of the most important aspects of the curriculum is swimming, as the ability to swim is not only necessary for recreational activities, but also as a life-saving skill in water emergencies (Karatrantou et al., 2023). Swimming should be a good mastery of technical and physical skills and have wide benefits for physical and mental health. Physically, swimming uses almost every muscle in the body, increasing strength, endurance and

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flexibility. It improves cardiovascular and respiratory function and can be the sport of choice for people with certain health problems, such as joint injuries or asthma (Birrer & Morgan, 2010).

Swimming is one of the most popular sports among students and the community in general. Known to all people regardless of gender or age, swimming has become an integral part of an active lifestyle in society (Perrone et al., 2023; Tsalis & Kyriakidou, 2023). With the growing number of entrepreneurs and municipalities providing swimming pool infrastructure, the accessibility of swimming is increasing. This phenomenon also opens the door to introducing swimming at an early age, as well as facilitating the process of developing athletes and coaching performance (Dalamitros et al., 2023; Stanković et al., 2023). In addition, the appeal of swimming as a fun water sport has managed to attract the general public, creating a strong community spirit around swimming activities.

Swimming also has a positive effect on mental health. It can help reduce stress and anxiety, improve mood and provide a sense of relaxation and calm (Seifert & Carmigniani, 2023; Wirth et al., 2022). Swimming is also an effective form of aerobic exercise that has been shown to increase the production of endorphins, hormones that can increase feelings of happiness and relieve pain (van Duijn et al., 2021). The game approach to teaching swimming is a fun and effective way to overcome fear and increase motivation for beginners (Chan et al., 2023). By incorporating game elements into the learning process, students can feel more comfortable and motivated to overcome their fears, speeding up the learning process and increasing their confidence in the water.

The challenge for beginners in swimming is the fear of water, so the coach needs to research the right learning method to train mentally and have fun in the process of learning to swim (de Oliveira et al., 2023; Misimi et al., 2023). Previous research provides insight into the different methods of teaching swimming (Ostrowski et al., 2022; Wilson et al., 2023). However, it has not looked at approaches for beginners to have fun in the water to improve their mental and courageous swimming. Most studies also tend to focus on the technical and physical aspects of swimming (Nindorera et al., 2021; Warreman et al., 2023), without paying attention to the psychomotor and fun aspects of learning, which are the main focus of the grab the ball game approach.

The development of swimming techniques for beginners can be achieved through correct swimming technique, including an understanding of the simultaneous use of arms and legs to assist and control breathing exercises (Carter & Koch, 2022; Hello et al., 2022). Light strength training on land and endurance training in the water can be done to increase endurance and strength while swimming (Mao et al., 2021; Zhang et al., 2023). One way to increase strength in the water is to play the game of catching the ball. However, the use of correct technique should be the first priority when introducing the exercise. Games with balls are used to make students feel comfortable and motivated while swimming. One option that can be considered is to use coordination and flexibility exercises to improve motor skills in swimming (Sundan et al., 2023; Tsai & Hsu, 2022). Novice swimmers can also make use of available technology, such as recording videos of themselves swimming and then reviewing them with instructors or peers. This can help them to better understand their body movements and identify areas for improvement.

This study offers a new approach to teaching swimming that is expected to increase motivation and make the learning process more enjoyable for beginners (Borioni et al., 2022; Veiga et al., 2022). The aim of this study is to determine the benefits of the game approach and to make recommendations for the further development of learning to swim in physical education. Although many studies have highlighted the use of AIDS in learning to swim, there have been no studies specifically investigating the use of the ball as an aid in training the ability to pick up the ball in the water for beginners. This gap indicates the need for more research focused on developing effective approaches to training this skill.

There are many theories in the literature that support the use of AIDS in learning to swim. The concept of learning through play has also been shown to be effective in improving students' motivation and skills in a variety of learning contexts, including aquatics. Numerous studies have shown that students' interaction with buoy media aids in swimming activities can help them feel more confident and increase their enjoyment of learning (Ramadhan et al., 2023). Constructivist learning theory also supports this concept, emphasising that fun and memorable learning

experiences can facilitate students' understanding of the concepts of movement in water (Backes et al., 2022; Do et al., 2023). Furthermore, studies by (Chalmers et al., 2021; Demarie et al., 2022) show that learning through play, including the use of the ball in swimming activities, can increase students' motivation and optimise the development of their motor skills. From this perspective, exercises specifically designed to improve swimming skills with games in the water have been shown to be effective in increasing the success rate of students in achieving swimming learning objectives (Wei et al., 2023).

The findings of this study are expected to contribute significantly to the development of more effective swimming learning methods, particularly for beginners, and pave the way for further research in the field of swimming. The aim of this study is to test the effectiveness of the 'take the ball' approach as a tool to train the ability to take the ball in the water for beginners learning to swim. In addition, this study also aims to evaluate the effectiveness of this approach in improving students' swimming ability and confidence in the water.

MATERIALS AND METHODS

This research method uses an experimental approach one group pretest posttest with the need for 8 sessions (Aliriad et al., 2024).Swimming skills were assessed before and after the intervention. Independent study population of 32 students. The sample was selected using purposive sampling. The sample consisted of 15 students of Bina Darma University with the category of unable to swim or beginner. The study was conducted for 2 months. The procedure for the game of "catching the ball in the water" begins with the preparation of safety and the division of the teams, before the ball is placed in the centre of the pool. Each team swims to retrieve the ball using the appropriate technique and then tries to bring it back to the edge of the pool, while protecting it from the opposing players. Points are awarded to the team that manages to bring the ball back to the edge of the pool, and safety is paramount during the game.

Ethical clearance (No.114/KEPK/RSI-U/V/2024) for this research was obtained from the Research Ethics of Health Research Ethics Committee of Malang Islamic hospital, Malang City, East Java, Indonesia Participant provided informed consent, with the volunteer form covering research details, risks, benefits, confidentiality, and participant rights. The research strictly adhered to the ethical principles of the Declaration of Helsinki, prioritizing participant's rights and well-being in design, procedures, and confidentiality measures.

Statistical Analysis

In the study, a 50-meter freestyle swimming test was performed using a device. Data analysis was performed using paired t test between pretest and posttest with SPSS version 23 (Wijaya, 2019). Percentage and frequency values were used to analyze demographic characteristics.

Table 1. Observation

Direct Observation			
Sample	Ability To Swim Before (1-5)	Ability To Swim After (1-5)	Difference
Sample 1			
Sample 2			
Sample 3			
Sample 4			
and so on			

Table 2. Questionnaire

Questionnaire for students	1	2	3	4	5
What do you think of the 'take the ball' approach to learning to swim?					
Do you feel more confident about swimming after using this approach?					
Do you feel more interested in learning to swim after using this approach?					
Questionnaire for instructors	1	2	3	4	5
How effective do you think the 'grab the ball' approach is in teaching swimming skills to beginners?					
Have you noticed a significant improvement in the students' swimming skills after using this approach?					

Table 3. Swimming Skills Test

Swimming Skills Test			
Sample	Before	After	Difference
Sample 1			
Sample 2			
and so on			

RESULTS

Table 4 shows the results of direct observation of swimming ability before and after training. Swimming ability is measured on a scale of 1 to 5, where a score of 1 indicates the lowest ability and a score of 5 indicates the highest ability. The results showed that most of the participants improved their swimming ability after the training. On average, the participants experienced an increase in swimming ability of 1.7333 points, with a mean swimming ability score of 2.1333 before training and 3.8667 after training. In addition, the standard deviation for both pre and post training scores was 0.74322, indicating that the distribution of the data was relatively consistent. The minimum pre-training score was 1 and the maximum post-training score was 3. The maximum pre-training score was 3 and the maximum post-training score was 5. This shows that the training provided was effective in improving the participants' swimming skills.

Table 4. Direct Observation Results

Name	Ability To Swim Before (1-5)	Ability To Swim After (1-5)	Difference
Sample 1	2	4	2
Sample 2	3	4	1
Sample 3	2	4	2
Sample 4	3	5	2
Sample 5	2	4	2
Sample 6	1	3	2
Sample 7	1	3	2
Sample 8	2	4	2
Sample 9	2	4	2
Sample 10	3	5	2
Sample 11	3	5	2
Sample 12	2	3	1
Sample 13	3	3	0
Sample 14	2	3	1
Sample 15	1	4	3
Min	1	3	0
Max	3	5	3
Mean	2.1333	3.8667	1.7333
Std. Dev	.74322	.74322	.70373

Table 5 shows the results of two different questionnaires, one for students and one for instructors, on the 'take the ball' approach to learning to swim. From the students' perspective, the majority felt that this approach was effective, with 8 students scoring 4 and 9 students scoring 5. They also felt more confident (score 4) and more interested (score 5) in learning to swim after using this approach. From the instructors' perspective, the majority (10) gave a score of 4 to the effectiveness of the 'take the ball' approach in teaching swimming skills to beginners. Most instructors also reported a significant improvement in students' swimming skills after using this approach. With a total of 14, 19 and 42 for scores of 1, 2 and 3 on the instructor questionnaire, the proportion of scores was 19%, 25% and 56% respectively. From the data presented it can be concluded that both students and instructors feel that the 'take the ball' approach is effective in learning to swim, with most feeling more confident, interested and seeing improvements in their swimming skills after using it.

Table 5. Questionnaire

Questionnaire for students	1	2	3	4	5
What do you think of the 'take the ball' approach to learning to swim?			4	3	8
Do you feel more confident about swimming after using this approach?			3	5	7
Do you feel more interested in learning to swim after using this approach?			2	4	9
Questionnaire for instructors	**1**	**2**	**3**	**4**	**5**
How effective do you think the 'grab the ball' approach is in teaching swimming skills to beginners?			2	3	10
Have you noticed a significant improvement in the students' swimming skills after using this approach?			3	4	8
Total			14	19	42
Prosentase			19%	25%	56%

Data collection was conducted in two stages, namely before treatment (pretest) and after treatment (post-test). The purpose of the post-test is to compare pretest and post-test results. Table 6 shows the results of the pre-test and the post-test for the 50 metre freestyle with an evaluation based on specific categories. It can be seen that none of the participants reached the "Excellent" category on the pre-test with a time of less than 33.22 seconds, but no one reached this category on the post-test either. A total of five participants (33.33%) reached the "good" category with a time between 33.22 and 40.55 seconds on the pre-test, increasing to nine participants (60%) on the post-test. However, the number of participants who reached the "fair" category decreased from six participants (40%) in the pre-test to three participants (20%) in the post-test. Meanwhile, the results for the "less" category remained stable with two participants (13.33%) in both the pretest and the posttest. For the "less than once" category, two participants (13.33%) in the pre-test and one participant (6.66%) in the post-test achieved a time of more than 55.20 seconds.

From the results of the pre-test and post-test on the 50-meter freestyle, it can be concluded that most of the participants experienced an increase in performance after undergoing a set program or exercise. Although none of the participants initially fell into the "excellent" category, a significant increase occurred in the "Good" category, where the number of participants who reached this category increased from five participants to nine participants. However, there was a decrease in the "moderate" category, which indicates that some participants may have difficulties or not have improved as expected. Despite this, there were no significant changes in the "less" category, indicating that participants who fall into this category remain stable in their abilities. In addition, there was a decrease in the number of participants who fell into the "less than once" category, indicating that most participants were able to improve their performance so as to reduce the time required to complete the track.

Table 6. Results of pre-test and post-test 50-meter freestyle swimming

Assessment norms	Category	Frekuensi Pretest		Frekuensi Postest	
		Absolute	Relative	Absolute	Relative
< 33,22	Very Good	0	0%	0	0%
33,22 - 40,55	Good	5	33,33%	9	60%
40,56 - 47,87	Moderate	6	40%	3	20%
47,88 - 55,20	Less	2	13,33%	2	13,33%
> 55,20	Less Than Once	2	13,33%	1	6,66%
Total		15	100%	15	100%

The data presented are the results of a 50 metre freestyle pre-test and post-test for 15 samples table 7. The pre-test measures the time it takes each sample to complete a 50-metre freestyle swim before a specific intervention or treatment, while the post-test measures the time it takes after the intervention has been administered. The results showed significant variation in the time taken, with pre-test times ranging from 35.42 seconds to 60.25 seconds and post-test times ranging from 33.30

seconds to 56.32 seconds. The average pre-test time was approximately 46.4080 seconds, while the average post-test time was approximately 39.5333 seconds. The difference between the post-test and pre-test times for each sample, reflecting the effect of the intervention or treatment administered, varied from 2.12 seconds to 11.59 seconds, with an average difference of 6.8747 seconds. These results indicate an improvement in 50 metre freestyle swimming performance after the intervention or treatment was administered, with significant variation in response to the intervention between the different samples.

Table 7. Descriptive analysis of pre-test and post-test 50-meter freestyle swimming

Name	50 Meters (Pre-test)	50 Meters (Post-test)	Difference
Sample 1	35.42	33.30	2.12
Sample 2	37.44	34.32	3.12
Sample 3	41.60	36.43	5.17
Sample 4	46.74	42.70	4.04
Sample 5	45.72	34.14	11.58
Sample 6	40.55	34.35	6.2
Sample 7	44.79	35.42	9.37
Sample 8	45.87	34.32	11.55
Sample 9	44.81	33.64	11.17
Sample 10	38.53	35.12	3.41
Sample 11	46.87	35.28	11.59
Sample 12	54.12	43.56	10.56
Sample 13	55.20	48.76	6.44
Sample 14	58.21	55.34	2.87
Sample 15	60.25	56.32	3.93
Min	35.42	33.30	2.12
Max	60.25	56.32	11.59
Mean	46.4080	39.5333	6.8747
Std. Deviation	7.53363	7.97780	3.67903

The results of the one-sample test in table 8. showed that there was a significant difference between the sample mean and the assigned test score (0). The resulting t-statistics (23,858 for the pre-test and 19,192 for the post-test) show that these differences are very statistically significant, with significance values (Sig.) that are very low (0.000). This indicates that the difference between the sample group average and the expected test score is very unlikely to occur by chance in the sample. The average difference between the pre-test group and the expected test score was 46.40800, while for the post-test group it was 39.53333. The 95% confidence interval indicates that we are 95% confident that the difference between the pre-test average and the test score is between 42.2360 and 50.580, while the difference between the post-test average and the test score is between 35.1154 and 43.9513.

Table 8. One-Sample Test pre-test and post-test 50-meter freestyle swimming

	Test Value = 0					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Pretest	23.858	14	.000	46.40800	42.2360	50.5800
Postest	19.192	14	.000	39.53333	35.1154	43.9513

DISCUSSION

The results of the data analysis showed that the intervention or treatment given to learn to swim, in this case indicated by the time difference between the pre-test and the post-test in 50 metre freestyle swimming, the results showed a significant impact on the students' performance. The improvement occurs after the intervention game of catching the ball at a predetermined time. This is in line with the theory of motor learning, which states that with the right practice and appropriate intervention, individuals can experience an improvement in their motor skills (H. Wu et al., 2021).

These findings are consistent with previous research supporting the effectiveness of interventions to improve motor performance in a variety of contexts, including swimming (Hassan et al., 2022; J. Wu et al., 2023). Previous research has shown that targeted practice and effective learning techniques can lead to significant improvements in motor skills (Capio et al., 2021; Misimi et al., 2022). This study reinforces the understanding that a systematic and focused approach to learning to swim can lead to significant improvements in students' skills (Ramadhan et al., 2023; Richards et al., 2021). However, there are several issues that need to be considered when interpreting these findings. Firstly, individual differences in response to such interventions suggest that not all students are likely to respond in the same way to the same learning programme. Factors such as an individual's initial level of fitness, motivation and learning style may influence the effectiveness of an intervention (Barbosa et al., 2021; Demarie et al., 2022; Mao et al., 2021). There is therefore a need to differentiate learning approaches to meet individual needs.

Improvement in post-test time indicates progress in motor skills, but other aspects of learning to swim such as breathing technique, efficient swimming style and confidence in the water must also be considered. It is important that the learning programme not only focuses on performance outcomes, but also pays attention to the development of technical skills and psychosocial aspects that are essential to becoming a competent swimmer. The implications of this research can help swimming coaches and instructors to design more effective and targeted learning programmes (Matsuda et al., 2021; Rajeh et al., 2023; Zeng et al., 2023). By understanding that appropriate interventions can improve student performance, coaches can integrate learning strategies that meet individual needs and desired learning goals.

Based on the description above, the researchers provide a form of the Take the Ball exercise game, where the Take the Ball game is an exercise method used for beginners in swimming practice. This can be seen from the swimming speed results, which show an increase in the students' swimming speed. This is because one of the supporting components of an athlete's speed is strength (Johnson & Lawson, 2023; Polach et al., 2021; Seifert & Carmigniani, 2023). The strength of the swimmer's arm muscles has a great influence on the speed of the athlete during the race (Ananthapavan et al., 2023; Backes et al., 2022; Karatrantou et al., 2023). The stronger the arm muscles, the faster the swimmer. During the study, the athletes were enthusiastic about a particular training programme. The main aim of learning to swim is to improve the athlete's technical skills and performance in the water (Chalmers et al., 2021; Papadimitriou & Loupos, 2021; Wirth et al., 2022). In an effort to achieve this goal, various training and intervention methods have been developed and implemented. One of the training methods that has proven to be effective is the catching game.

Conclusion

This study aimed to explore the effects of using the ball grab game training method to increase swimming speed in students. This study has some limitations that need to be considered. Generalisation of the findings must be made with caution, as the study sample may not be representative of the population as a whole. In addition, the long-term effects of such interventions need to be considered to ensure the sustainability of the performance improvements observed. Exercise methods such as grab-the-ball games may be an effective approach to improving students' swimming speed. However, further research is needed to gain a deeper understanding of the effects of these training methods and to explore other factors that may influence overall swimming performance.

Conflict of interest

The authors declare no conflict of interest. No financial support was received

Ethics Statement

Ethical clearance (No.114/KEPK/RSI-U/V/2024) for this research was obtained from the Research Ethics of Health Research Ethics Committee of Malang Islamic hospital, Malang City, East Java, Indonesia

Author Contributions

Study Design, MM; Data Collection, MM, HA; Statistical Analysis, MM, HA, IBE and KD; Data Interpretation, MM, HA and KD; Manuscript Preparation, MM, IBE, KD and NJ; Literature Search, KD and NJ. All authors have read and agreed to the published version of the manuscript

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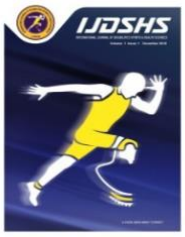

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REVİEW ARTICLE

Positive Youth Development (PYD) in Martial Arts Activities: Literature Review

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Abstract

Several literatures provide indications on the results of their research that martial arts activities can have a positive effect on the development of adolescents. However, martial arts activities that have been running still do not reveal programs that lead to positive youth development. Apart from that, there is still uncertainty regarding the martial arts training program which is still focused solely on achieving achievements. This study reveals the contribution or role of martial arts activities by providing an overview and explaining the results of the latest research on martial arts activities for positive adolescent development. Literature data collection techniques were taken using systematic computer searches consisting of several journal articles and dissertations, as well as manual data search results. Data collection was carried out for two months in January and February 2024. Several articles were eliminated which were then focused on the 17 articles used in this study. The results show that martial arts activities have had a major impact on positive adolescent development in recent years. The main topics in several research results in general are about prosocial behavior, antisocial behavior, aggression and resilience. There is strong agreement among researchers about the potential of martial arts activities for positive adolescent development. In addition, the discussion in several studies shows clearly that the main influence in martial arts activities is closely related to how the trainers make a strong contribution in providing understanding and also the teaching style used in martial arts activities.

Keywords
Possitive Youth Development, Martial Arts, Physical Activity

INTRODUCTION

Adolescence is a developmental stage during which young individuals go through a period of personal growth. Teenagers generally struggle with decision-making and accepting responsibility for their actions. This is because the brain is still developing (Crone, 2009). This element is significantly influenced by contextual and personality characteristics (Capuzzi & Gross, 2014). Due to continuous brain development, if a teen struggles or behaves in a way that is incompatible with the society in which they live, this will affect their aberrant behavior. Examples are cases of dropping out of school and termination of employment (Capuzzi & Gross, 2014; DiClemente, 2013), and criminal behavior (Baron, 2003; Estévez & Emler, 2011).

According to Bailey et al. (2013), sports activities have a good effect on teenagers' psychosocial development and may encourage more desired conduct. There are numerous signs that self-defense activities (MA) can have a favorable impact on teenagers' development (Elling & Wisse, 2010). Furthermore, martial arts can serve as an alternative activity for teens, as evidenced by the fact that it is ranked 10th among sports that appeal to youths (Gubbels et al., 2016). The

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popularity of martial arts competitions encourages scholarly investigation into the effects of martial arts themselves. This problem is presented in sports scientific conferences, martial arts scientific meetings, and scientific publications on martial arts. It is also articulated in several scientific studies that have been published in national and international journals.

Due to the favorable effects of martial arts training, they have been widely incorporated into both the educational and professional fields in practice (Abrahams, 2004; Gail et al., 2001; Theeboom & Knop, 1999; Vertonghen & Theeboom, 2008). Public opinion on this beneficial effect is still divided, though. Numerous media sites have published stories concerning young people who had previously participated in martial arts but are now actively participating in terrorist operations (Gubbels et al., 2016). In contrast to other media, martial arts are thought to have a powerful influence and be able to lower juvenile crime (van der Kooi, 2020).

It has been unclear how martial arts training affects development based on a variety of empirical research findings and youth-related literature. Positive socio-psychological developmental consequences, on the other hand, have been observed (Kurian et al., 1994; Steyn & Roux, 2009; Trulson, 1986). On the other hand, certain findings Reynes & Lorant (2001) and Wargo et al. (2015) indicated that martial arts practice had little effect on adolescent development. According to several research findings, martial arts involvement was negatively impacted (Reynes & Lorant, 2002).

Few literature evaluations of various research findings have been done thus far (Vertonghen & Theeboom, 2010). Vertonghen & Theeboom (2010) performed and collated recent literature studies. The outcomes of this research looked at the sociopsychological effects of youth martial arts training. Their investigation was quantitatively restricted and concentrated on publications published in scholarly journals up until 2010. This prompts the query of whether involvement in martial arts is associated with behavior modification. But there are issues with the connection. There has never been any qualitative research done on this topic.

There are two components to the study done by Vertonghen & Theeboom (2010). The first talks about the potential effects of practicing martial arts. The study discovered that involvement in martial arts activities had a positive effect on teenage development. like improved self-control and a decline in violent conduct. This is consistent with the degree of adolescent aggression linked to martial arts practice. However, given the paucity of convincing data, several of the study's findings seem dubious. According to certain research findings, engaging in martial arts exercises had no adverse effects on the participants' sociopsychological makeup. The second section addresses the drawbacks of reported research findings (Vertonghen & Theeboom, 2010). Cross-sectional or longitudinal designs are used in published studies. Some researchers who employ a cross-sectional methodology do not manage the sample background in terms of personality traits. Additionally, the majority of the research findings did not examine the function of the trainer or the various traits of the various martial arts.

In a review of two or more research findings, (Gubbels et al, 2016) was conducted. This study looks at the connection between adolescent martial arts participation and outward behavior. Only rage, aggression, violence, hostility, and antisocial behavior are shown by the research. The analysis is restricted to quantitative studies released through 2011. Clarification on the relationship is provided while still reiterating the original query, "Is there a relationship between martial arts participation and behavior change?" According to the findings of (Gubbels et al, 2016), there is no link between adolescent martial arts engagement and outward behavior in general. However, the findings of these articles find it ambiguous because it demonstrates that teenagers who engage in martial arts activities exhibit more external behavior than adolescents who do not. Compared to karate, the martial art of judo has a stronger association with outward behavior, according to the study's findings Gubbels et al. (2016). The findings of this study also suggest that team sports players, non-martial athletes, and practitioners of martial arts share a level of external conduct.

However, Vertonghen & Theeboom (2013) devised a model to show martial arts practice. The goal of this study, which is based on some literature, is to identify the variables that affect how pencak silat training affects behavior development in general and how it affects the behavior development of teens in particular. According to Vertonghen & Theeboom (2013), the structural quality of the martial arts, the training methods used to guide

participants, and the characteristics and social background of the martial arts participants are the most crucial factors in martial arts activities. The method by which these elements operate is not fully explained by the current research, which is still in its early stages. As a result, it is concluded that there is a good chance that the variables influencing the association between martial arts and behavioral development are not fully understood (Vertonghen & Theeboom, 2013).

The aforementioned study demonstrates that the impact of martial arts (MA) activities on adolescent development is still uncertain and not well understood, according to several research findings on MA (Vertonghen & Theeboom, 2013). This study tries to shed some light on the ambiguity around the benefits of martial arts training for young people.

MATERIALS AND METHODS

Research findings from September 2016 to April 2017 were used in this literature. EBSCO Host, PubMed, Web of Science, and Scopus were used in an online computer search to find the research data. Using three keywords in three categories, search data from diverse study findings are produced. The first is the martial arts category, which includes wrestling, aikido, karate, kickboxing, and taekwondo. The second search area focuses on behavioral development outcomes and covers aggressiveness, self-identity, interaction, motivation, and social networks. This category is consistent with research by Gubbels et al., (2016) and Vertonghen & Theeboom (2013). Young people, adolescents, and children make up the third category of the subject of research. 153 items were found after searching these three categories. To support this study, the articles used must meet six main criteria including the following:

1. Martial arts and psychosocial behavior must be related.
2. Youth and adolescents must be the target audience. Vertonghen & Theeboom (2010) used a broader scope in their research, but this study narrowed the focus to focus on adolescents between the ages of 15 and 21. Teenagers are going through a period of personality development, which is why.
3. Litelatur riview is part of this study. Vertonghen & Theeboom (2010) used exclusively quantitative research in their study.
4. New research is not examined to serve as a reference source in evaluating the outcomes of martial arts activities, as is done when researchers explain the findings of a study conducted by Vertonghen & Theeboom (2010).
5. Peer review was used in this study since martial arts is such a distinctive subject that it calls for input from practitioners or subject matter experts. Sixth, this study only has studies and research outcomes in English and Dutch linked.

As was mentioned in the last debate, the goal of this topic is to help solve the riddle surrounding juvenile martial arts training by offering an overview and analysis of some of the most recent studies on the maturation of adolescent behavior. Given that this study was not undertaken to compare other studies or research methodologies, it included the findings of qualitative and qualitative research. This study was conducted on the basis of similarities and linkages between the differences in the results of previous studies. The results of the study were analyzed independently by researchers using qualitative data analysis software. Although this research was carried out independently, the researchers spoke with martial arts experts, teachers, and coaches about the findings to lessen the possibility of ambiguity during the research process.

RESULTS

In contrast to the research done by Vertonghen & Theeboom (2010). The types of martial arts that have been seen have changed. In the past, research has been done on traditional martial arts like taekwondo, gambling, and karate. Their investigation of adolescent behavior also made this clear. The study of martial arts like boxing, Thai, kickboxing, and mixed martial arts (MMA) has become more popular during the past ten years. This is due to an increase in studies on contemporary martial arts (boxing, Thai boxing, kickboxing, and MMA) that are connected to teenage behavior since 2010.

Although most studies on martial arts use quantitative methods (Baar & Wubbels, 2011; Bogdan Iulian & Sabina, 2015; Bayansalduz, 2014; Kuśnierz et al., 2014; Rutten et al., 2011; Vertonghen & Theeboom, 2012; Lotfian et al., 2011; Ziaee et al., 2012), this study uses qualitative methods. This suggests that certain martial arts

research goals exclusively concentrate on athletic results. The method and significance of the martial art itself are only briefly discussed in the research on martial arts. The findings of this study are presented in two parts since the majority of research focuses on the outcomes of practicing martial arts (sport outcome) and some other research focuses on the significance of martial arts activities. Specifically, the process features, influencing factors, and social psychological components.

Table 1. Search results for articles ıncluded in the literature review

No	Writer and year	Country	Design and research methods	Martial arts type	Positive or negative results
1	Vertonghen & Theeboom (2008)	Belgium	Qualitative and quantitative; interviews with children (98) and teachers (15), questionnaires with parents (68)	Judo, aikido, Thai boxing kick	Positive
2	Elling & Wisse (2010)	Dutch	Quantitative and qualitative; observations, questionnaires and interviews with youth, parents, and staff	Martial arts in general	Positive
3	Vertonghen & Theeboom (2010)	Belgium	Quantitative and qualitative; observation, questionnaires and interviews with adolescents	Judo, Aikido, Thai boxing kick	Neutral
4	Rutten et al. (2011)	Dutch	Quantitative; questionnaire with young athletes	Taekwondo	Positive regulates anti-social behavior in the context of martial arts sports, Negative on moral grounds between martial arts
5	Lotfian et al. (2011)	Iran	Quantitative; questionnaire with teenage girl	Judo, Karate	Negative on judo, neutral on karate
6	Baar & Wubbels (2011)	Dutch	Quantitative; questionnaire with young people	Martial arts in general	Positive
7	Ziaee et al. (2012)	Iran	Quantitative; questionnaire with young athletes	Judo, Karate	Neutral on judo, ositive on karate
8	Haudenhuyse et al. (2012)	Belgium	Qualitative; observation, interviews, and focus groups with participants (15), trainers (13), and key witnesses (7)	Boxing	Neutral
9	Vertonghen & Theeboom (2012)	Belgium	Qualitative; observations and interviews with teachers	Judo, aikido, Thai boxing kick	Neutral
10	Bayansalduz (2014)	Türkiye	Quantitative; questionnaire with young people	Taekwondo	Positive
11	Vertonghen et al. (2014)	Belgium	Quantitative; questionnaire with youth and their parents	Judo, Aikido, Thai	Neutral
12	Kuśnierz et al. (2014)	Poland	Quantitative; questionnaire with Young man (150)	Capoeira, Boxing, Jiu-Jitsu	Positive
13	Bogdan Iulian & Sabina (2015)	Romania	Quantitative; questionnaire with young people	Judo	Positive
14	Asscher (2015)	Dutch	Qualitative; interviews and observations	Various martial arts	Positive, but critical on the inside implication
15	Pierce et al. (2016)	United States of America	Qualitative, interview with athletes, parents, and staff	Wrestling	Positive
16	Walker Research Group (2016)	Great Britain	Qualitative	Boxing	Positive
17	Emfield (2016)	United States of America	Qualitative; observations, interviews with athletes, parents, and staff	Self defense/ Jiu-Jitsu	Positive

Socio-Psychological Results

Antisocial and prosocial behavior is a research issue that is frequently studied in martial arts research. The study was revealed utilizing a variety of techniques, and the data was primarily based on cross-sectional survey results. As an illustration, research was done Rutten et al. (2011) comparing the prosocial and antisocial behavior of adolescents engaging in three different sports, one of which is taekwondo. According to the study, taekwondo practitioners do worse than those who participate in other sports in terms of behavior (morality). But the study also discovered that, in contrast to other sports, involvement in taekwondo activities had a beneficial impact on prosocial conduct in young people. In numerous other investigations, including those by Baar & Wubbels (2011), Bayansalduz (2014), Bogdan Iulian & Sabina (2015), Pierce et al. (2016), & Vertonghen & Theeboom (2008), this beneficial effect was also discovered. Similar findings were made by Baar & Wubbels (2011), who stated that this encouraging outcome was attained based on the assumption that the majority of the kids who participated in martial arts activities did not play other sports. Another study was carried out using a qualitative methodology by Pierce et al. (2016) and focused on the psychological activity of wrestlers who were participating in intense training camps. According to the study's findings, high-intensity training in a boot camp has a significant impact on psychological growth in the context of good conduct.

The connection between martial arts practice and aggressive behavior and emotional control is the subject of another study. A questionnaire and an analysis of prior research were used to perform this study. According to the findings of Kuśnierz et al. (2014), teenagers are influenced by sports that fall under the "fighting" category in martial arts activities to manage their emotions and anxieties under duress, which can lower their level of hostility. This study contrasts pupils who do not participate in martial arts activities with young people who do so in the fighting category. The differences attained are dependent on the coach's traits in the particular martial activity (Kuśnierz et al., 2014). Athletes' aggressiveness can be controlled by coaches, who can also teach them strategies for controlling their rage during competition. This was also seen in other research that found practicing martial arts improved emotional regulation and decreased levels of aggression (Baar & Wubbels, 2011; Bayansalduz, 2014; Emfield, 2016; Lotfian et al., 2011; Ziaee et al., 2012).

Lotfian et al. (2011) and Ziaee et al. (2012) found disparities in the emotional states of karate and gambling practitioners. Judo practitioners in this study had higher emotional levels than karate practitioners. Other research has discovered that martial arts athletes exhibit an increase in resilience in addition to their degree of aggression. Teenagers that participated in wrestling training camps showed a rise in self-responsibility, according to (Pierce et al., 2016). They frequently take on greater responsibility for what has to be done and are accountable to them. Emfield (2016) found that ju-jitsu martial arts had a significant impact on a person's capacity to react to intimidation. Children are more assured in their ability to handle any circumstance well. Similar to the findings of the Elling & Wisse (2010) study, 90% of martial arts practitioners report feeling more at ease and secure in public.

Factors that influence positive behavior in martial arts

The factors influencing socially vulnerable adolescents were the subject of a study on boxing activity in Belgium by Haudenhuyse et al. (2012) using a qualitative method. The study found that martial arts training had no beneficial effects on a child's age-related development. Activities related to martial arts are only seen to be able to lessen the detrimental influences that practitioners' backgrounds may have on them. Families with discord, struggling parents, and uneducated parents all have an impact on this undesirable conduct. Children who engage in martial arts activities are impacted by their upbringing (Asscher, 2015; Haudenhuyse et al., 2012; Vertonghen & Theeboom, 2008, 2012). In this conversation, we'll examine how martial arts training functions and how the environment there affects the maturation of teenage behavior.

As previously mentioned, the coach has a significant impact on some of the consequences of young people's engagement in martial arts activities. The impact of a martial arts trainer's position has been the subject of several research studies. Vertonghen & Theeboom (2012) compares the conventional approach, sports education, and efficiency as the three ways used by instructors in martial arts. The coach in the conventional method

has a teaching objective. Vertonghen & Theeboom (2012) argue that this objective is crucial to the sports education strategy. This method views martial arts as a sport. The efficiency approach, on the other hand, emphasizes technique and the potential effectiveness of martial arts. (Elling & Wisse, 2010; Vertonghen & Theeboom, 2012) did a study that looked at how different martial arts instructors teach. The method used by a coach or teacher has a big impact on how a pupil develops. Vertonghen & Theeboom (2012) discovered that each trainer used a different teaching approach. For instance, a trainer of kickboxing employs a strict teaching style and an efficiency approach, but a trainer of aikido or judo more frequently employs a traditional method by teaching martial arts holistically (overall). As a result, a trainer's qualities have a big impact on how martial arts practitioners grow. According to several research Asscher (2015), Elling & Wisse (2010), and Haudenhuyse et al. (2012), a trainer's cultural background and expertise provide them credibility in front of students. The coach's professional athletic background has an impact on how much a pupil respects his teacher. Because they are working with teens who are in a sensitive stage of identity development, coaches must have a high level of credibility (Haudenhuyse et al., 2012).

DISCUSSION

Numerous current martial arts practices have been shown to have favorable developmental outcomes in this study using both qualitative and quantitative methodologies. The amount of benefits related to martial arts training differs from diverse research findings in several ways. However, there appears to be a lot more consensus regarding the potential for martial arts practices to benefit adolescents when compared to the research done by (Vertonghen & Theeboom, 2010). The research topic during the past seven years has been in line with (Vertonghen & Theeboom, 2010) findings about the outcomes of adolescent growth. The research's main emphasis is on self-defense, aggressive, prosocial, and antisocial behaviors. According to (Galston, 2001), there is a research gap on the topic of bonding and bridging. Researchers' interest in the elements and methods that martial arts use to alter behavior has grown during the past seven years. This was described in more qualitative research, which can review martial arts activity practices. This is crucial to understanding how martial arts should be correctly practiced (Vertonghen & Theeboom, 2012).

Rutten et al. (2011) did an earlier study on sports participation among teenagers. To enhance the standard of teenage sports education, research emphasizes the interaction between coaches and athletes. This study demonstrates unequivocally that the influence of martial arts training and coaching cannot be separated. This is consistent with the findings of (Vertonghen & Theeboom, 2013) investigation. Three different training/teaching methods are used by trainers or martial arts instructors: conventional, sports education, and efficiency. This study also reveals the three distinct martial arts practices. But the part of teaching that emerges is how a martial arts teacher strikes a balance between firmness and empathy. This equilibrium is a distinctive quality of martial arts and is expressed in numerous forms of martial arts. According to evidence, this is particularly helpful for adolescents' development of positive conduct. Furthermore, the trainer's experience and abilities play a huge role in developing credibility (Haudenhuyse et al., 2012). The study done by Vertonghen & Theeboom (2013) does not indicate the socioeconomic background of a trainer, including ethnicity and age. The history of a coach is crucial to research in other sports (Rylander, 2015; Wargo et al., 2015; Zhang & Surujlal, 2011).

Although there are many differences and variations in the relationships between instructors and students in each martial arts activity, it is important to highlight these differences to promote positive behavior in teenagers (Van Dam et al., 2018). Therefore, more research is required to determine how the trainer's background affects adolescents' development of good behavior. The findings of Vertonghen & Theeboom's (2013) study also highlight several of each martial art's traits that have not yet been fully explained. The styles and characteristics of martial arts have been disclosed by numerous studies, but the findings of these studies mainly concentrate on the trainers' teaching methods. different. According to the peculiarities of martial arts, it is still unclear how martial arts activities affect adolescents' development of positive conduct. This is noteworthy to mention, though, as the genuine sport of martial arts differs significantly from other sports in both the individual and team branches.

Previous research has examined the social background and personality traits of martial arts practitioners (Vertonghen & Theeboom, 2012). In his research, Vertoghen offers crucial details on other aspects of martial arts training that influence participants' behavior. Activities related to martial arts, however, cannot have an impact on these variables. Further research is therefore required to learn more about how martial arts activities can have a positive impact on adolescent development, even though the social background and characteristics of martial arts participants are a significant part of the ambiguity of martial arts activities related to the development of positive behavior in adolescents. should place more emphasis on easily influenced factors. Numerous aspects of martial arts activities still need to be explored, including variables like interactions between instructors and students. A fascinating study topic for future research might be the system's variable social backdrop and personal traits in martial arts activities.

The issue of the public's perception of martial arts activities has been discussed in the introduction to this study. Researchers are studying the effects of martial arts practice on a variety of facets of life as a result of the significant societal debate that has been sparked by adolescents' interest in martial arts activities. This inevitably leads to "obscurity" among the general population, especially when it comes to research findings that are only supported by a single hypothesis. Researchers run the risk of conducting research that is just concerned with positive and negative effects, or that is focused solely on hypotheses, rendering the findings unsuitable for publishing. To confirm the accuracy of the procedures, outcomes, and "mystery" in martial arts exercises, this study compares quantitative and qualitative research. Researchers found it challenging to compare the findings of earlier investigations, however, due to the wide variety of research methods utilized in those studies. Due to the lack of a more thorough meta-analysis, this study can only be considered an overview and explanation of previous studies. A comparative meta-analysis review in the future will provide more detailed and specific information about all components of martial arts exercises. A meta-analytic review is necessary when doing the study.

Conclusion

Research on the impact of martial arts training on the development of teenage behavior is yet insufficient. The researchers contend that the only method that can demonstrate this is a longitudinal analysis. The effect of martial arts instruction on teenage maturation behavior, however, has not been the subject of long-term research in the preceding seven years. Along with the research findings, the factors that affect these findings also need to be identified and further investigated. Other elements, such as peer pressure, the martial arts community, and behavior transfer into daily life, might also have an impact on how people behave when they engage in pencak silat activities. However, it is necessary to do a qualitative study once more to more accurately characterize how pencak silat activities are carried out. It is hoped that this literature review will contribute to future studies that aim to better understand the influencing elements and mechanisms at play when martial arts activities are used to encourage young people to behave well.

Conflict of Interest

Authors declare that they have no conflict of interest.

Author Contributions

Conception and Design of the Study, MNA, KK; Data Collection, MNA, KK, TM, MM; Data Analysis and Interpretation, KK and TM; Drafting the Article, MNA, KK, TM, MM. All authors have read and agreed on the published version of the manuscript.

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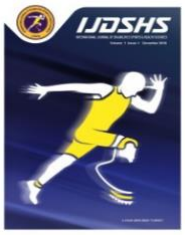

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REVİEW ARTICLE

Low Back Pain Risk Among Athlete: A Scientometric Study

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Abstract

Low back pain (LBP) emerges as a prevalent concern within the athletic community, characterized by a noteworthy proclivity for recurrence. The repeated occurrence of LBP substantially impedes athletes and adversely affects their performance. As such, it becomes imperative to discern the underlying factors contributing to injuries in the lumbar region. The scientometric analysis will provide a clear pathway for researchers to understand the current state and evolution of the theme research area of low back pain risk among athletes. No scientometric study on this theme has been undertaken until today. Therefore, this research objective was to collect data from the database to identify the present trend of low back pain risk, development patterns, and current research. Software that has been utilized for commonness, co-occurrence, clustering, co-citation and analysis of burst was CiteSpace. A scientometric review of studies on athletes' low back pain risk from 2000 to 2023 finds considerable additional studies in the amount of literature, the citation frequency, and the hotspots available. The most influential author is Douglas W. Jackson, the most influential article is Biomechanical measures of neuromuscular control and valgus loading of the knee predict anterior cruciate ligament injury risk in female athletes: a prospective study. Thoraco-lumbar spine is the most common cluster, whereas the most popular keyword is spondylolisthesis. In conclusion, low back pain is becoming one of the future study topics. Furthermore, many stakeholders must be aware of current trends and advances in the athlete's low back pain risk.

Keywords
Low Back Pain, Risk, Athletes, Visualization, Scientometric

INTRODUCTION

The escalating low back pain (LBP) among athletes prevalence has emerged as a worldwide concern. LBP is a common occurrence in sports, with prevalence estimates spanning from 1% to over 30% (Bono, 2004). Further corroborating this, a literature review indicates that LBP's prevalence in athletes falls within the range of 1% to 30%, with low back trauma accounting for 10-15% of all sports-related injuries (Mortazavi et al., 2015). As a result, athletes' performance could be negatively impacted by injuries, which also add to the club's expenses and, more importantly, impact the individual athlete (De Visscher et al., 2021). Elite athletes who are frequently injured may struggle to achieve their peak performance levels throughout their careers due to missed training sessions and a lack of competitive exposure (Pfirrmann et al., 2016). LBP is generally linked to high activity levels, smoking, obesity, poor overall health, and low socioeconomic position (Hartvigsen et

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al.,2018). Psychosocial factors such as stress, exhaustion, worry, poor sleep, and mood swings may make athletes more susceptible to low back pain (LBP), even though they are less likely to be impacted by them (Hainline et al., 2017; O'Sullivan et al., 2018). Apart from psychological factors, other aspects are contributing to low back pain (LBP) among athletes, as shown in previous research. According to studies, the type of sport plays a crucial role in developing LBP (Bahr et al., 2004; Hangai et al., 2010). Additionally, repetitive loads contribute to stress and strain on the lower back (Horton et al. 2001; Memari et al., 2014). The frequency of training sessions is another factor that shows a connection between regular training and the occurrence of LBP (Maselli et al., 2015; Kordi et al. 2011). Moreover, athletes may get LBP due to stress reactions in epiphyseal rings, spondylolysis/spondylolisthesis or disc degeneration (Schmidt et al., 2014). Understanding these factors emphasizes the need for a comprehensive approach to prevent and manage LBP among athletes.

Identifying the risks of LBP is essential because it can impair athletes' performance (Pfirrmann et al., 2016). Injury can affect postural control (Steffen et al., 2017), and influence the biomechanics of the entire body which will influence the osteokinematics and arthrokinematics that can lead to a decrease in performance level (Krosshaug et al., 2005). It has been proven by previous literature that reported low back pain (LBP) can negatively impact performance and is linked to recurring episodes in popular sports in Netherlands which are field hockey, football and speed skaters (van Hilst et al., 2015). In addition, LBP is a prevalent issue in sports and it tends to happen again in the future (Pasanen et al., 2014). Future episodes of LBP can be reliably predicted from past episodes (Hoy et al., 2010). Because of that, it is crucial to identify possible risk factors that contribute to LBP.

Scientometrics has evolved into a vital instrument for studying and evaluating academics' exploration and growth, their output, and the partnership between institutions and intellectual excellence (Moral-Muñoz et al., 2020). This data assists the scientific society in updating the growth of linked data and education over time, the relationship between numerous fields (particularly targeting low back pain and athlete concerns), and the rational critical point of the specialty (Chen, 2017). Because of the opportunity of big corporate databases such as Web of Science, Scopus and PubMed, as well as visualization and software that utilized text mining packages (Adriaanse & Rensleigh, 2013; Bar-Ilan, 2008; Martín-Martín et al., 2018; Xu et al., 2021), scientometrics analysis was selected for the suggested research. The scientometrics study's anticipated outcomes can contribute to analytical and accurate results analysis by decreasing human bias (Chen & Leydesdorff, 2014; Chen et al., 2010; Xu et al., 2021). Scientometrics or bibliometric comprehensively synthesizes research growth, collaborations, and knowledge foundations, addressing the critical need for integration in this multifaceted field (Azizan, 2024). Hence, scientometrics is a valuable tool for analyzing data on research topics, advancement in a field, literature production patterns, and the most prolific institutions, countries, and researchers in a certain issue, such as low back pain among athletes (Kokol et al., 2021).

Furthermore, as the growing reputation of low back pain among athletes-relevant publication theme and the potential risk, a scientometrics study that systematic is required to assess imminent patterns as well as ongoing challenges including vital changing points in the focus study aim. It can also help policymakers and academicians discover new changes in difficulties and issues of low back pain risk among athletes, particularly at the worldwide level. Moreover, the findings of this study can inform the development of more effective prevention and management strategies for low back pain in athletes.

Thus, our study's primary goal is to use scientometric analysis to ascertain the global research trends concerning low back pain risk among athletes which can help in identifying potential impact on athlete health, performance, and overall sports participation. In particular, we focused on publication trends, influential authors and affiliations related, countries that actively engaged, and co-citation analysis of references as well as impactful articles and keywords. This will support the development of future funding proposals on these populations, the identification of research needs, and future opportunity prediction. We also hope that our assessment will encourage more researchers to get involved in this valuable low back pain injury prevention in the future, particularly postgraduate students and early career researchers.

METHODS

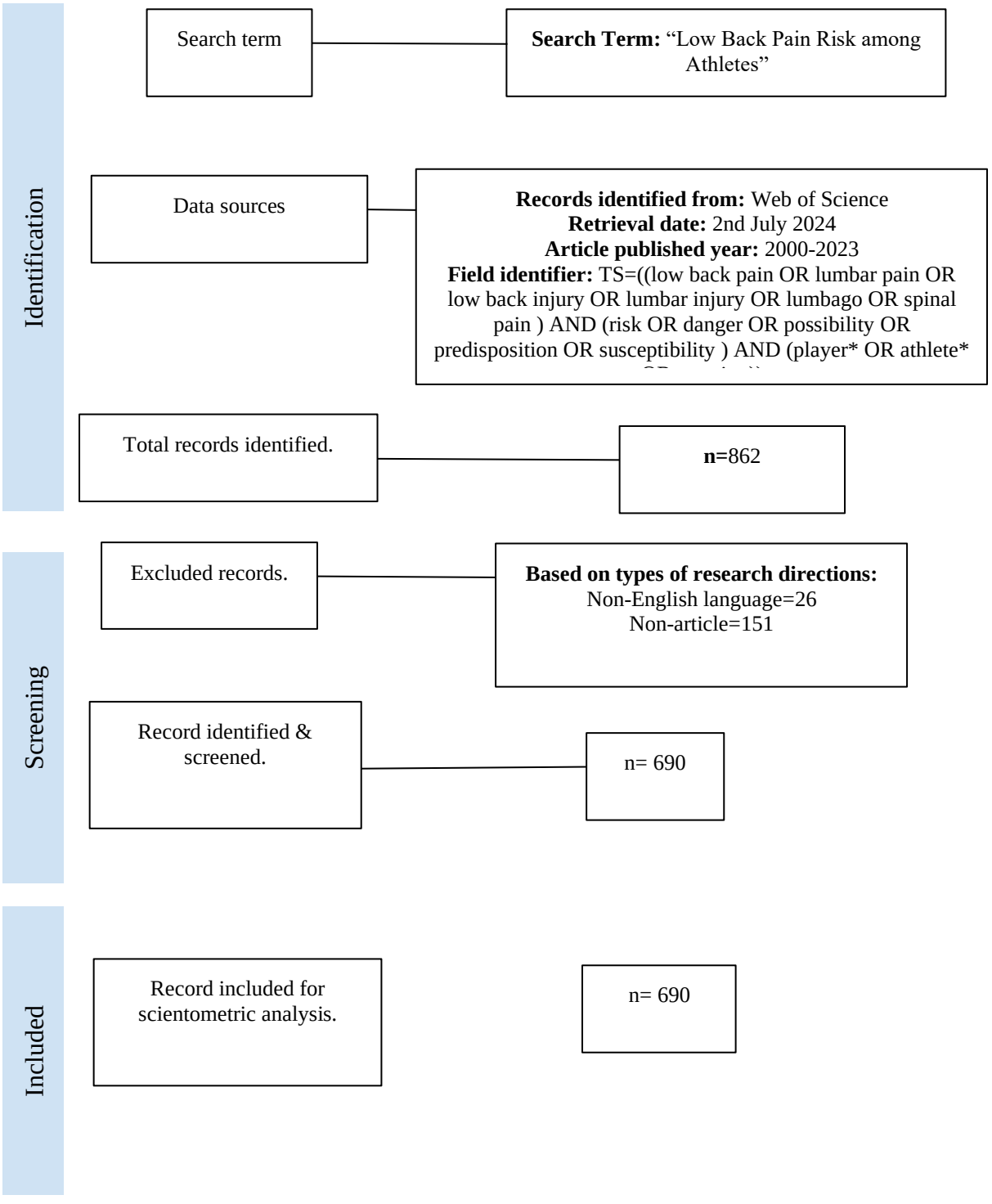

Figure 1. Methodological framework

Source of Data

Web of Science (WOS) is the database that has been used for the search. The "topic" (TS) field comprises titles of the articles, keywords, abstracts and "KeyWords Plus" was used for the WOS searches (phrases will be produced based on cited article titles accordingly). According to current sources, WOS is a prominent largest scientific database with about 34,000 publications with over one billion references that have been cited. All the articles are peer-reviewed as well as indexed publications with good standard journals and contain a wide range of disciplines (Aryadoust & Ang, 2021). Moreover, WOS has been the only

citation database and publication that covers all disciplines of research for many years (Chadegani et al., 2013).

Article Searching

The associated keywords were identified using online literature from previous studies as well as keywords provided by Web of Sciences. The hunt took place on July 2, 2024. Below is the search string.

TS=((low back pain OR lumbar pain OR low back injury OR lumbar injury OR lumbago OR spinal pain) AND (risk OR danger OR possibility OR predisposition OR susceptibility) AND (player* OR athlete* OR sporting))

Eligibility Criteria

Inclusion Criteria

Articles found using WOS searches were included in the following analyses only if the publication had been made in English and in peer-reviewed journals. The timeframe was set from 2000-2023.

Exclusion Criteria

We rejected studies that were not original study, non-peer-reviewed publication journal and in language other than English. Proceedings reviews, articles, abstracts, book reviews, editorial papers, correspondence, or news may have been included in such studies.

Data Analysis

Table 1. Analysis of approaches and instruments applied to address research questions

ID	Research Question Focus	Software	Summary of approaches / tools
RQ1	Output trends of publication	Excel	Descriptive Analysis for amount of publications, journal publications, authors, institutions, and region/country
RQ2	Dominant knowledge carriers	CiteSpace	Co-citation Analysis for (Author and Articles) to identify growth status and each variable scientific structure
RQ3	Dominant topic/cluster	CiteSpace	Analysis of Document Cluster to determine the top research cluster in target theme.
RQ4	Impactful keyword and publications	CiteSpace	Burstness metric was utilized to identify the impactful publications and famous keywords.

Analysis of Scientometric

Citespace enables the building of numerous bibliometric associates and the utilization of numerous ways of analysis (Chen & Leydesdorff, 2014; Chen, 2004). Because of that, CiteSpace was utilized for knowledge graph visualization and analysis. As a result, CiteSpace showed the top 50 most referenced articles and ranked accordingly. "Time Slicing" was fixed at 2000-2023, and "Years per slice" was fixed to one year. The "Pruning" parameter was used to prune the produced network. For text processing, all term sources available were picked, including abstract, title, keywords plus and author keywords.

Co-citation Analysis

The position of scientific advancement and development in scientific hierarchy are determined via analysis of co-citation. The analysis of co-citation provides nodes with a scientific map, links, and values of density to depict the overall structure of the variables under consideration.

Analysis of Document Cluster

Clustering in multidimensional was utilized to determine research clusters in priority scope based on the papers collected. The log-likelihood ratio (LLR) was utilized to straightaway take out the label of cluster since it may deliver the best outcome in terms of distinctiveness and coverage. The "timeline view" and "cluster view" of Document Cluster Analysis were utilized to see the network form and shape. The "timeline view" presented a vertical range time periods in chronology, from left to right, and the "cluster view" visualized a landscape-formatted spatial network of color-coded and automatically annotated description (Aryadoust & Ang, 2021; Chen & Leydesdorff 2014; Chen 2004).

To examine the standard and the document cluster analyses homogeneity, the particular clusters, average silhouette meter and the modularity Q index, centrality metric were utilized (Chen & Song, 2019; Chen, Chen, Horowitz, et al., 2009; Chen, Ibekwe-SanJuan, & Hou, 2010). The modularity Q index ranges from 0 to 1, with a higher index suggesting greater dependability. The average silhouette measure with higher values than 0 attributing better uniformity, the range of the value is between -1 and 1. Centrality is an influence measure that proves how close publications or journals are to one another, with high centrality

publication having more reliability on the network due to more publications and journals are connected to them, which allows more data and channels to flow over them.

Analysis of Burstness

Both sigma and citation burstness, which are temporal measures, were employed to describe prominent articles and top keywords. A red ring surrounding the node indicates burst existence, which is defined as "an abrupt elevation of the frequencies [of citations] over a specific time interval" (Chen & Song, 2019; Chen, Chen, Horowitz, et al., 2009; Chen, Ibekwe-SanJuan, & Hou, 2010). High-value research articles have the greatest sigma value. The total of the centrality and burstness values is known as sigma, which vary from 0 to 1 (Chen & Song, 2019; Chen, Chen, Horowitz, et al., 2009; Chen, Ibekwe-SanJuan, & Hou, 2010).

RESULTS

Descriptive Statistics

Publication Evolution

Only scientific articles published between 2000 and 2023 were included in the study (Fig. 2). A total of 690 articles were gathered throughout this period. There is an inconsistent publication trend in terms of publication numbers, but still, we can observe quite an obvious increasing trend from 2000 until 2023 and a significant decreasing trend from 2021 to 2023.

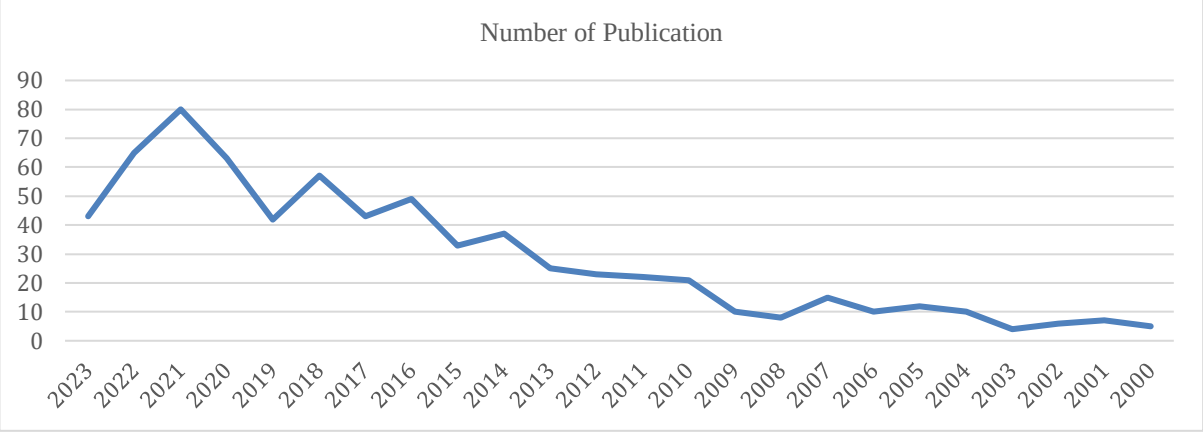

Figure 2. Number of articles published since 2000

Productive Authors

There is a total of 96 publications regarding low back pain risk among athletes by top eleven authors since 2000. (Fig. 3). Brumitt J had the most publications (12), followed by Bahr R (10) and Hides JA (9).

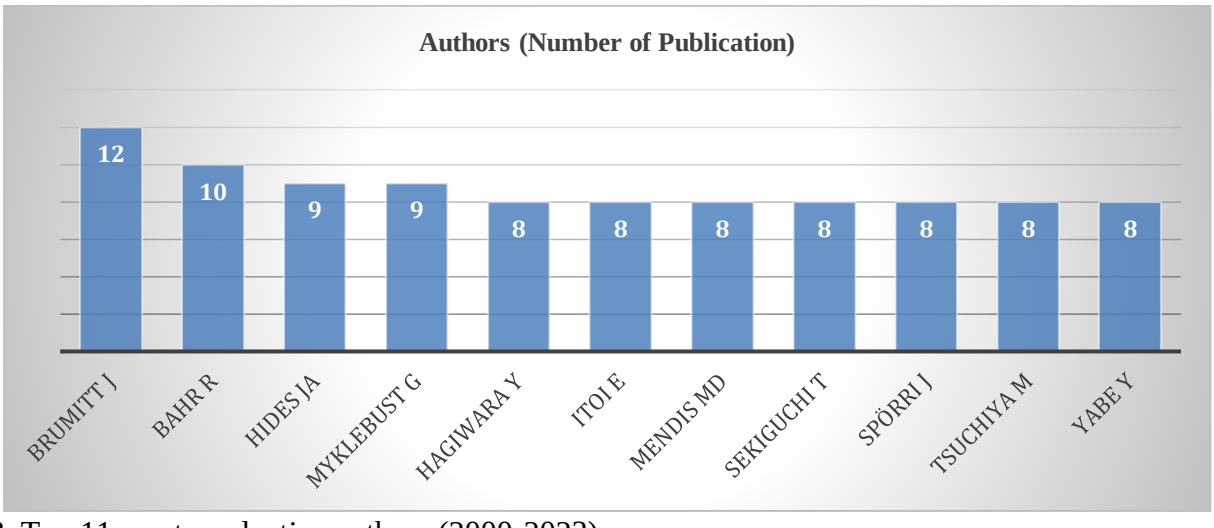

Figure 3. Top 11 most productive authors (2000-2023)

Best Universities

Fig. 4 shows the top 10 universities in terms of the overall number of publications. Harvard University was the highest publisher, with 23 publications, followed by the Norwegian School of Sport Science (20), and last but not least University of Queensland (17). In a nutshell, there are a total of 156 publications by the top ten institutions between 2000 to 2023.

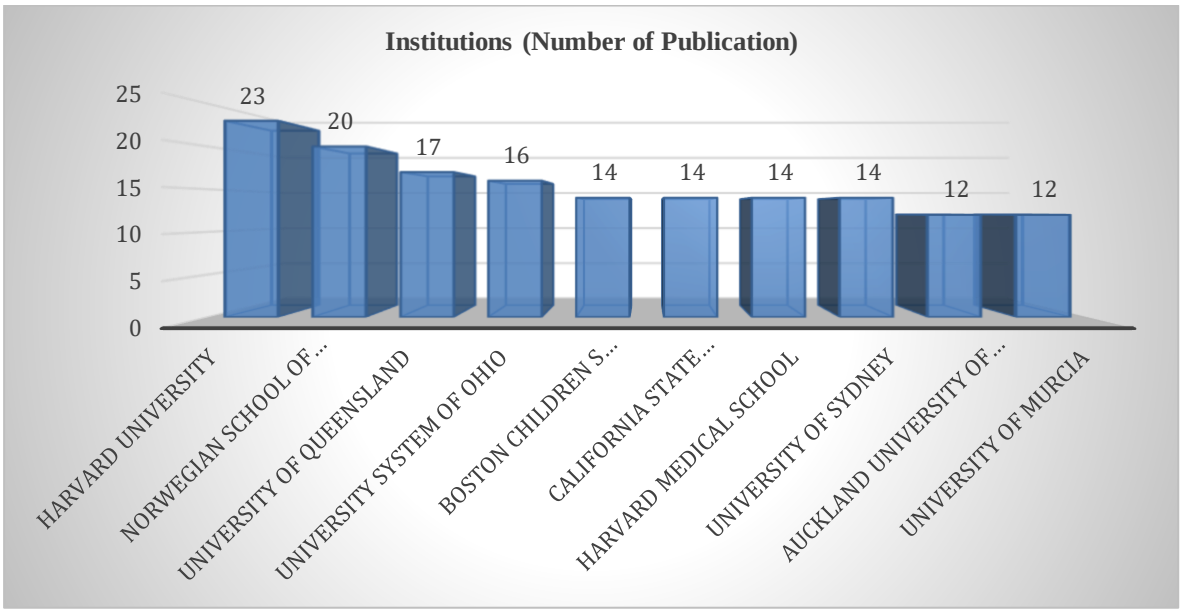

Figure 4. Top ten number of publications (institutions)

Productive Journals

The top ten journal publications number are visualized in Fig. 5. Elsevier published the highest (91), followed by Lippincott Williams & Wilkins (88) and Sage (71). Between 2000 and 2023, the top ten journals contribute 70.87% of total number of publications.

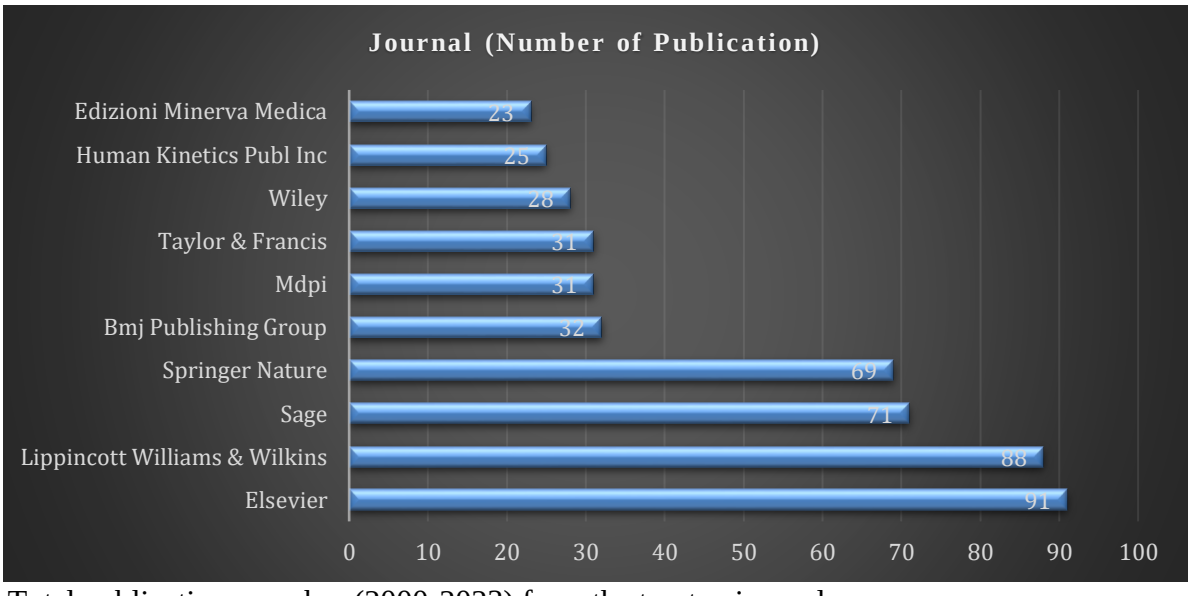

Figure 5. Total publications number (2000-2023) from the top ten journal

Distribution of Region

Fig. 6 lists the ten countries with the highest publication numbers. 25 countries had publications with the top ten countries contributing to 91.304% of total publications. The United States of America had the highest number of publications (232), followed by Australia (85), and England (65).

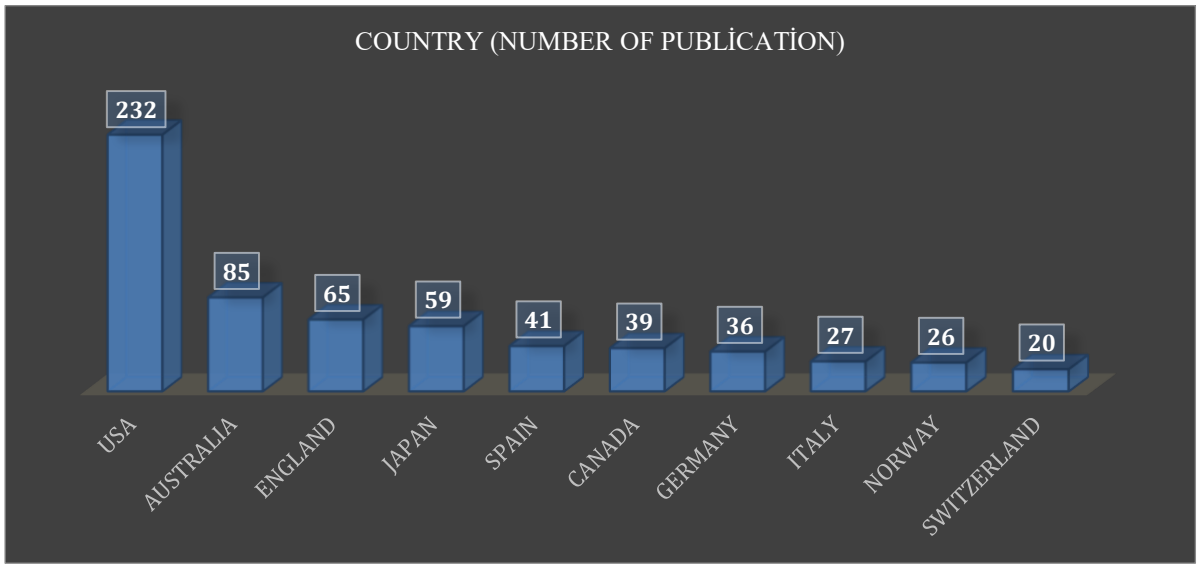

Figure 6. Number of publications (2000-2023) from the top ten country/region

Scientometric Analysis

Co-Citation Analysis

Co-citation analysis creates a scientific map that shows the evolution of a variable's fundamental structure over time, complete with nodes, linkages, and value of density. Below are the findings of the analysis of co-citation for the author and the document.

Author Co-citation Analysis

The author co-citation network included 2970 connections and 787 nodes. The density of the co-citation network is 0.0096. Three factors are utilizzed to decide which author is the most influential: degree, centrality, and sigma in that order. A higher degree indicates more citations. Degree parameters show how many citations that particular author obtains from others for the same works. Centrality parameters evaluate how many times an author is positioned "between" two or more authors. The highest "betweenness centrality" author has the most impact on the focus areas. A sigma number higher than 1 indicates that the author is in the center of the focus area. The sigma value is a mixture of the degree and centrality characteristics.

Table 2 shows the top ten most popular authors from 2000 to 2023. The most influential author is Jackson DW (Degree: 47; Centrality: 0.08, Sigma: 1.57), followed by Hwett TE (Degree: 39; Centrality: 0.08, Sigma: 1.48) and third place Clarsen B (Degree: 19; Centrality: 0.07, Sigma: 1.46). Besides that, Fig. 7 shows the author network co-citation.

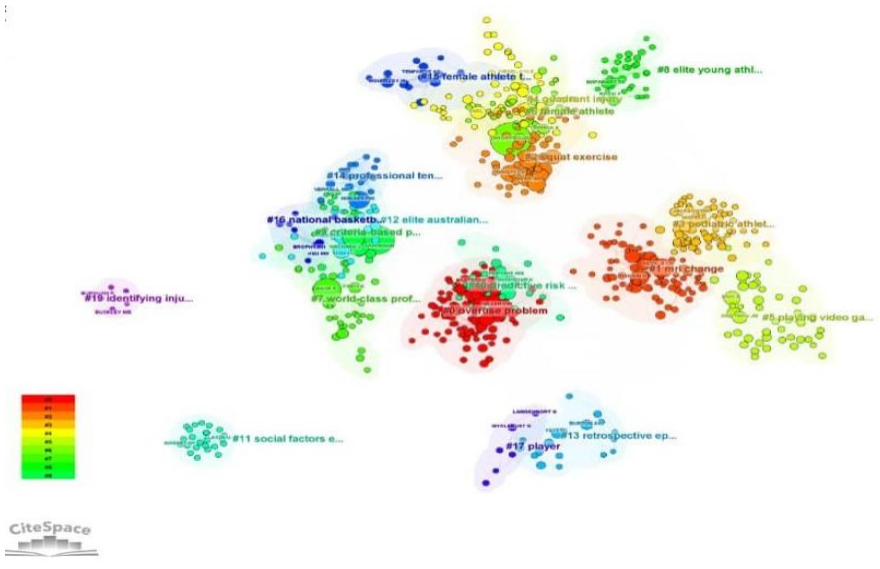

Figure 7. Authors Co-citation network

Table 2. Influential authors

Author	Degree	Centrality	Sigma
JACKSON DW	47	0.08	1.57
HEWETT TE	39	0.08	1.48
CLARSEN B	19	0.07	1.46
HOY D	20	0.04	1.18
TAIMELA S	17	0.03	1.18
CROISIER JL	25	0.04	1.16
BIERINGSORENSEN F	20	0.04	1.16
HUTCHINSON MR	26	0.03	1.15
HOPKINS WG	20	0.03	1.13
BRUMITT J	14	0.02	1.12

Document Citation Analysis

The document co-citation network included 2756 connections and 876 nodes. The density of the co-citation network is 0.0072. Table 3 shows the top ten most influential papers from 2000 to 2023. The most influential paper is Biomechanical measures of neuromuscular control and valgus loading of the knee predict anterior cruciate ligament injury risk in female athletes: a prospective study (Degree: 41; Centrality: 0.18, Sigma: 18), followed by Delayed Trunk Muscle Reflex Responses Increase the Risk of Low Back Injuries (Degree: 24; Centrality: 0.18, Sigma: 1.72) and third place Consensus statement on injury definitions and data collection procedures in studies of football (soccer) injuries (Degree: 15; Centrality: 0.07, Sigma: 1.34). Furthermore, Fig. 8 shows the document network co-citation.

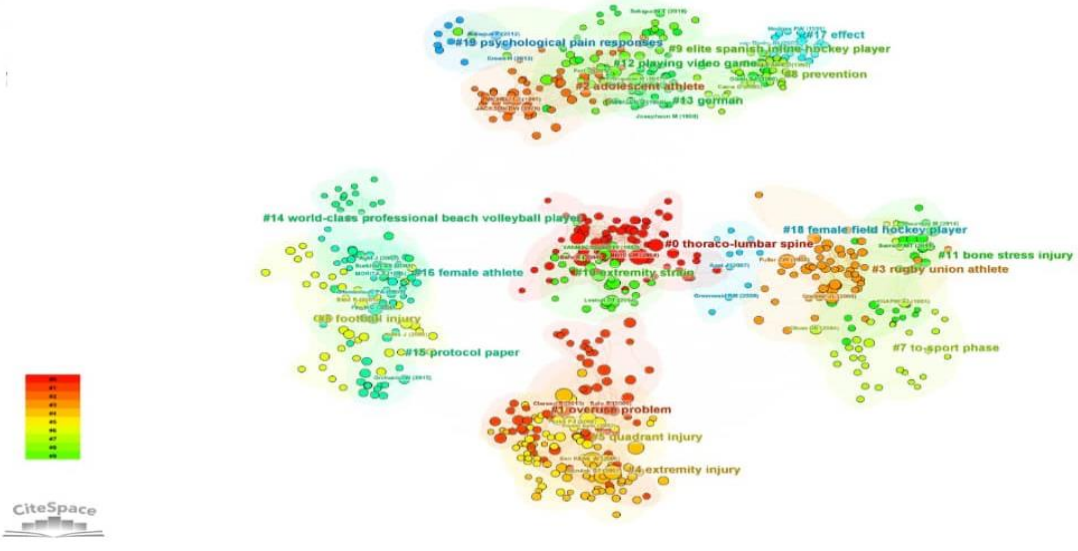

Figure 8. Document Co-citation network

Document Cluster Analysis

The Modularity Q Index and Mean Silhouette measures of the Document Cluster Analysis were 0.8364 and 0.9209, respectively, showing the that homogeneity is above-average and network dependability. The investigation produced a total of 24 co-citation clusters. The clusters were grouped and numbered according to size, with the largest cluster is cluster #0 . A yellow line indicates the duration of each cluster. Using CiteSpace software's text mining and keyword analysis technique, the cluster labels were calculated. In order to name these clusters, the loglikelihood ratio (LLR) was utilized.

The four largest clusters identified by Document Cluster analysis are displayed in Table 4. The number of articles in the cluster is determined by its size. Cluster #0 shows the highest number of publications (70). The publications within each cluster had a significant degree of similarity, as indicated by the cluster silhouette scores ranging from 0.768 to 0.943 (a number higher than 0 implies homogeneous).

Table 3. Document co-citation score

Title	Source	Year	Degree	Centrality	Sigma
Biomechanical Measures of Neuromuscular Control and Valgus Loading of the Knee Predict Anterior Cruciate Ligament Injury Risk in Female Athletes	AM J SPORT MED	2005	41	0.18	1.8
Delayed Trunk Muscle Reflex Responses Increase the Risk of Low Back Injuries	SPINE	2005	24	0.18	1.72
Consensus statement on injury definitions and data collection procedures in studies of football (soccer) injuries	BRIT J SPORT MED	2006	15	0.07	1.34
Strength Imbalances and Prevention of Hamstring Injury in Professional Soccer Players A Prospective Study	AM J SPORT MED	2008	17	0.06	1.3
Low Back Pain Among Endurance Athletes With and Without Specific Back Loading—A Cross-Sectional Survey of Cross-Country Skiers, Rowers, Orienteerers, and Nonathletic Controls	SPINE	2004	18	0.08	1.29
Risk factors for sports injuries—a methodological approach	BRIT J SPORT MED	2003	18	0.05	1.19
Dynamic Balance Performance and Noncontact Lower Extremity Injury in College Football Players: An Initial Study	SPORTS HEALTH	2013	26	0.05	1.17
The long-term effects of physical loading and exercise lifestyles on back-related symptoms, disability, and spinal pathology among men	SPINE	1995	15	0.04	1.16
Deficits in Neuromuscular Control of the Trunk Predict Knee Injury Risk A Prospective Biomechanical-Epidemiologic Study	AM J SPORT MED	2007	14	0.03	1.14
Can serious injury in professional football be predicted by a preseason functional movement screen?	N AM J SPORTS PHYS THER	2007	22	0.03	1.12

Table 4. Research Cluster

ClusterID	Size	Silhouette	Label (LLR)	Average Year
0	70	0.768	thoraco-lumbar spine	2004
1	61	0.824	overuse problem	2010
2	56	0.943	adolescent athlete	1996
3	53	0.914	rugby union athlete	2006

Burst Analysis

To find the most popular or impactful papers as well as keywords, we used a burst analysis. The trends between studies and keywords are shown here.

Document Burst

Table 5. Top ten key articles with the highest citation burst

Title	Journal	Year	Strength	Begin	End	2000-2023
The Long-Term Effects of Physical Loading and Exercise Lifestyles on Back-Related Symptoms, Disability, and Spinal Pathology Among Men	Spine	1995	3.83	**2006**	2012	
Back Pain in Young Athletes Significant Differences From Adults in Causes and Patterns	Archives of pediatrics & adolescent medicine	1995	3.63	**2006**	2014	
Spondylolysis in the Female Gymnast.	Clinical Orthopaedics and Related Research	1976	3.59	**2006**	2013	
Preseason strength and flexibility imbalances associated with athletic injuries in female collegiate athletes	The American journal of sports medicine	1991	3.35	**2006**	2012	
Delayed trunk muscle reflex responses increase the risk of low back injuries	Spine	2005	3.3	**2007**	2017	
MRI study of the size, symmetry and function of the trunk muscles among elite cricketers with and without low back pain	British journal of sports medicine	2008	4.09	**2010**	2011	
Deficits in Neuromuscular Control of the Trunk Predict Knee Injury Risk: Prospective Biomechanical-Epidemiologic Study	The American journal of sports medicine	2007	4.52	**2012**	2018	
Core Stability Measures as Risk Factors for Lower Extremity Injury in Athletes	Medicine & Science in Sports & Exercise	2004	3.55	**2012**	2018	
Biomechanical Measures of Neuromuscular Control and Valgus Loading of the Knee Predict Anterior Cruciate Ligament Injury Risk in Female Athletes: A Prospective Study	The American journal of sports medicine	2005	3.53	**2012**	2015	
Can serious injury in professional football be predicted by a preseason functional movement screen?	North American journal of sports physical therapy: NAJSPT	2007	3.73	**2013**	2020	

Document Burst

The highest citation burst from top ten articles with are depicted in Table 5. The highest burst article is The Long-Term Effects of Physical Loading and Exercise Lifestyles on Back-Related Symptoms, Disability, and Spinal Pathology Among Men from Spine (strength: 3.83) that begin from 2006 and end in 2012. The lowest burst article is Can serious injury in professional football be predicted by a preseason functional movement screen? From North American journal of sports physical therapy (strength: 3.73) that begin during 2013 and end in 2020.

Top ten keywords with the strongest citation burst are shown in Table 6. The highest burst keyword is spondylolisthesis (strength: 3.79) that begin from 2000 and end in 2006. The lowest burst article is sport (strength: 3.64) that begin during 2017 and end in 2020.

Document Burst

Table 6. Top ten popular keywords with the highest citation burst

Keywords	Strength	Begin	End	2000-2023
Spondylolisthesis	3.79	**2000**	2006	
Spondylolysis	4.41	**2002**	2006	
Follow-up	3.89	**2005**	2011	
Cross sectional area	3.55	**2007**	2011	
Fast bowlers	3.28	**2010**	2016	
Motion	5.3	**2012**	2015	
Kinematics	5.31	**2013**	2015	
Professional football	4.35	**2014**	2018	
Physical activity	3.84	**2016**	2019	
Sport	3.64	**2017**	2020	

DISCUSSION

A descriptive analysis was carried out on the publication numbers, published journals, authors, universities, and countries where authors were connected at the time the articles were published to address the publication output trends research question. In terms of number of publications, there is an increasing trend from 2000 until 2021 with the highest number in 2021 with 80 publications. However, there is a subsequent decline from 2021 to 2023 due to potential shifts in research focus, changes in funding priorities, or the emergence of new research areas. There is a total of 96 publications regarding low back pain risk among athletes have been published by the top eleven authors since 2000. In terms of authors, Brumitt J had the most publications (12), followed by Bahr R (10) and Hides JA (9). For institutions, there are 156 publications by the top ten institutions between 2000 to 2023 with Harvard University achieving the highest publisher, with 23 publications. Dr. Jason Brumitt graduated with a Bachelor of Science in Business Administration from Southern Oregon State College, a Master of Science in Physical Therapy from Pacific University, and a PhD in Orthopedic and Sports Science from Rocky Mountain University of Health Professions. Although orthopedic and sports physical therapy constitute his clinical expertise, he has also rendered therapy services in acute and skilled nursing settings. Dr. Brumitt is the author of several textbooks, textbook chapters, and numerous research publications in sport physiotherapy.

In the meantime, between 2000 and 2023, the top ten journals contribute 70.87% of total number of publications, with Elsevier publishing the highest (91). In terms of country, the highest number of publications is United States of America (232). Although affluent nations and prestigious universities may have had greater resources available to carry out scientific assessments, we are advocating for more global scientific research collaboration and exchanges be carried out in the future.

To answer the dominant knowledge carriers research question, a co-citation analysis of the author and articles was done. Douglas W. Jackson, M.D is the most influential author. He is an orthopedic surgery specialist in Long Beach, CA with over 57 years of medical experience. He is also part of the research team at Noyes-Giannestra

Biomechanics Laboratory, University of Cincinnati, Cincinnati, Ohio. The second most influential author is Timothy Hewett, Ph.D. He is a Professor and Director of Research in the Department of Orthopaedic Surgery at Marshall University's School of Medicine. Dr. Hewett is described as a "pioneering researcher, expert team builder, and collaborative leader" on the plaque he received when Mayo Clinic awarded him an Endowed Professorship. He has held numerous leadership posts, including Director of the Sports Medicine Research Center, Biomechanics Laboratories, and the Biomechanics Institute. The third place goes to Ben Clarsen. Ben Clarsen works as a physiotherapist at the Norwegian Olympic Training Centre (Olympiatoppen) and as a postdoctoral research fellow at the Oslo Sports Trauma Research Center at the Norwegian School of Sports Sciences. He served as senior editor for the textbook Brukner and Khan's Clinical Sports Medicine, Fifth Edition, and has experience working as a team physiotherapist for a number of major cycling teams. His research interests are sport and overuse injury prevention.

Biomechanical measures of neuromuscular control and valgus loading of the knee predict anterior cruciate ligament injury risk in female athletes: a prospective study article from The American Journal of Sports Medicine is the most influential article. This study became popular at that time due to it was proven that motion of knee and knee loading during a landing task are one of the predictors of injury risk in female athletes as well as kinetic chain association between lumbo-pelvic-hip (LPH) complex with knee and lower limb complex. The second highest article with co-citation score is the Delayed Trunk Muscle Reflex Responses Increase the Risk of Low Back Injuries from Spine. It has become one of the most popular articles due to the outcome of this study indicating that the delayed muscle reflex reaction considerably increases the likelihood of suffering a low back injury. These delayed latencies appear to represent a preexisting risk factor rather than the result of a low back injury which can be one of the risk factors for low back pain. The third most popular article is Consensus statement on injury definitions and data collection procedures in studies of football (soccer) injuries from BJSM. It’s become popular due to the paper was discussing the definitions of injury, recurring injury, severity, training and match exposures in football, as well as criteria for determining injuries in terms of location, nature, diagnosis and etiology, which include low back area.

To answer the fourth research question which is the dominant cluster, document cluster analysis was performed. Its revealed 24 clusters and the top four clusters are shown above. Publications were grouped together because the same publications group mentioned them, proving a co-citation connections. According to our findings, "thoraco-lumbar spine," "overuse problem," and " adolescent athlete " were the most preferred research subjects and directions. This indicates that most of the research prioritizes on spinal issues with risk of low back pain and proves that thoracolumbar becomes the main topic when research is done related to risk of low back pain. Hence, future researchers need to incorporate subjects with spinal issue in order to determine risk of low back pain among athletes.

Document burst analysis was done to answer the fifth research question which is impactful keywords. The top ten strongest are revealed above. The burst analysis of documents indicated a design of a new research area arising, with earlier burst publications slowly being displaced by the latest ones. Spondylolisthesis was the strongest keyword that started from 2000 and end in 2006, followed by spondylosis (start:2002; end: 2006) and third place keyword is follow-up (start: 2005; end: 2011).This proves that spinal condition always becomes the main topic when studies have been done for risk of low back pain among athletes. Starting 2014, new pattern on research topics appears with the topics more related to sports and physical activity being used. The shift indicates that previous study focuses more on spinal conditions as risk for low back pain and current research focuses more on the relationship between sports activity and risk of low back pain. The result is not the same as the document co-citation result. The gap between the co-citation and burst scores emphasizes the necessity of broadening the scope of the study as new findings are discovered. This will require more funding or a different strategy to guarantee that a significant amount of scientific innovation research is published in this area.

Conclusions

We may have introduced publication bias into our analysis by using Web of Science (WOS) databases articles only. Another possible restriction is that using CiteSpace software instead of manually collecting data may have led to the

inclusion of some unimportant subjects, hence biasing the dataset. Upcoming research with a reliable accuracy target must utilize more rigid keyword searches to limit the possibility of inappropriate studies.

Furthermore, the names of the principal authors are the only ones mentioned in the co-citation analyses in this study. Regardless of the fact that there was no such restriction on citing articles, the databases of cited papers that WoS provided did not contain the identities of other contributing authors. In spite of these limitations, this analysis provides a complete assessment of current studies on athletes with low back pain risk. We are advocating the necessity for more collaboration globally, as addressing the risk of low back pain is crucial to the research agenda in the long term.

With the world still trying to figure out what causes low back pain in athletes, athletes are still suffering from low back pain and damage. We gathered related research from several fields, as well as a determined major gap in the research and goals of the future. Future researchers can benefit from this study by referring to the influential authors, popular keywords, and top articles. Our research outcome indicates that a considerable gap still exists that demands deeper investigation and collaboration. Coaches, trainers, and healthcare providers working with athletes also will have clear direction to construct preventative and therapeutic strategies for managing LBP in athletes. Last but not least, the present study may have been inadequate due to only the English language being used and the choice of journals without considering grey literature.

Conflict of Interest

The authors declare that they have no competing interests.

Availability of Data and Materials

All data generated or analyzed during this study are included in this published article (and its supplementary information files).

Author Contributions

Conceptualization, Methodology, Writing - Original Draft, Funding acquisition, MAH; Software, Formal analysis, Writing - Original Draft, Investigation, SAB; Validation, Formal analysis, Writing - Review & Editing, Investigation, MIMN; Validation, Writing - Review & Editing, Investigation, NAMN; Data Curation, Writing - Review & Editing, Funding acquisition, Project administration, UMMA; Validation, Writing - Review & Editing, Investigation, HM. All authors have read and agreed to the published version of the manuscript.

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REVİEW ARTICLE

Effect of Duration of Pain Neuroscience Education on Pain Catastrophizing and Kinesiophobia in Patients with Chronic Low Back Pain: A Systematic Review of the Literature

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Abstract

Objective: This study aims to examine the available evidence regarding the effect of the total duration in minutes of Pain Neuroscience Education (PNE) on pain catastrophizing and kinesiophobia in patients with chronic low back pain (CLBP). Methods: A systematic literature search was conducted on PubMed/MEDLINE, Web of Science, Scopus, and PeDro databases covering the last 5 years up to February 2024. No meta-analysis was performed, and qualitative analysis was conducted in narrative and tabular form. Results: Six randomized controlled trials were included in this systematic review. All studies included patients with chronic low back pain aged over 18. PNE was provided either as a standalone intervention or in combination with other therapies such as exercise, with total duration ranging from 100 to 240 minutes. Primary outcome measures focused on pain catastrophizing and kinesiophobia, while secondary outcomes included pain and functional disability. Conclusions: No significant correlation was established between the total duration of PNE and improvement in primary outcome measures. However, findings suggest that combining PNE with exercise in the treatment of chronic low back pain leads to greater improvements in kinesiophobia and pain catastrophizing compared to exercise alone.

Keywords
Pain Education, Kinesiophobia, Catastrophizing, Low Back, Pain

INTRODUCTION

Low back pain is recognized as the most common musculoskeletal disorder (MSK) (Maselli et al. 2020), characterized by pain localized between the thoracolumbar junction and the lower gluteal fold (HAS, 2020). When these symptoms persist beyond 12 weeks, it is referred to as chronic low back pain (CLBP) (Abenhaim et al. 2000). CLBP represents one of the most prevalent health issues globally, significantly contributing to the burden of disease worldwide (Rabiei et al. 2021). Thus, treating this pain is crucial to prevent its psychological, social, financial, and occupational consequences (GTCD, 2019). Current recommendations, issued by Cochrane and the Canadian Chronic Pain Working Group, advocate for a biopsychosocial approach focusing on multidimensional interventions, such as Pain Neuroscience Education (PNE) (GTCD, 2019; Aldington & Eccleston, 2019).

PNE is a therapeutic approach that leverages neurophysiological knowledge to educate patients that pain can be overprotective and occur even in the absence of tissue damage (Moseley & Butler, 2015). Its primary goal is to correct patients' misconceptions and maladaptive thoughts regarding pain (Meeus et al. 2010). Numerous studies have explored the effectiveness of this intervention. A meta-analysis investigating the effects of PNE on kinesiophobia in patients with

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chronic pain demonstrated that a combined intervention of PNE, manual therapy, and exercises was more effective in improving chronic pain and kinesiophobia (Mills et al. 2021; Louw et al. 2016; Arguisuelas et al. 2017).

Similarly, a systematic review highlighted PNE as a promising therapeutic option for CLBP, influencing pain, physical disability, psychological aspects, and social function of patients (Clarke et al. 2011).

Other studies have examined the application of PNE in individual or group sessions. In 2003, Moseley showed that group education, which is less costly than individual sessions, was less effective in terms of reducing pain intensity and disability (Moseley, 2003).

However, the question of dosage (i.e., total session duration) of pain neuroscience education has been underexplored in the literature (Louw et al. 2011). In this regard, it would be beneficial to determine the optimal duration required for pain neuroscience education in CLBP patients to induce clinically significant changes in pain, disability, and psychosocial aspects, thereby designing personalized interventions for future research and clinical practice (Salazar-Méndez et al. 2023).

METHODS

This systematic review was conducted following the guidelines of the PRISMA 2020 Statement (Page et al. 2021), and its protocol was registered with PROSPERO (Booth et al. 2012) (CRD42024500793).

Eligibility Criteria

Study Design

Only randomized controlled trials (RCTs) published in French or in English were considered eligible. No further restrictions were applied.

Participants

Inclusion criteria focused on patients aged over 18 years experiencing persistent chronic low back pain for at least 3 months

Inclusion Criteria: Inclusion criteria were based on the PICOS methodology (population, intervention, comparison, outcomes, and study).

(1) Population: Adults aged>18 years suffering from chronic low back pain; (2) Intervention: PNE alone or combined with other therapeutic modalities; (3) Comparison: Active or passive therapeutic interventions or waiting list; (4) Outcomes: Assessment of kinesiophobia and pain catastrophizing. Knowledge regarding pain and functional disability were considered secondary outcomes; (5) Study Design: Randomized controlled trials (RCTs) and peer-reviewed original articles, written in English or French, published in the last 5 years up to February 2024.

Exclusion Criteria: RCTs involving patients aged <18 years; specific populations (elderly subjects, women or men only, or patients who have undergone surgical intervention); Symptomatic, acute, or subacute low back pain, or any pain caused by specific pathologies (pulmonary, cardiac, neurological, oncological, visceral, cognitive, psychiatric disorders).

Interventions

RCTs were included if they involved an intervention based on PNE in any form, without restriction on its combination with other interventions.

Comparisons

Educational interventions, waiting lists, placebo interventions, and other active therapeutic approaches (e.g., strengthening exercise) or passive approaches (e.g., manual therapy) were eligible for inclusion.

Outcomes and Outcome Measures

RCTs evaluating at least one of the following criteria were included: (1) kinesiophobia, (2) pain catastrophizing, (3) pain, and (4) functional disability.

Search Methods for Inclusion of Studies

A systematic search was conducted on PubMed/MEDLINE, Web of Science, Scopus, and PeDro databases for articles published in the last 5 years, using MeSH (Medical Subject Headings) terms and keywords combined with Boolean operators (AND, OR, and NOT) according to the PICO model. The comprehensive search strategy for the 4 databases is available in the appendix (Appendix 1).

Study Selection and Data Extraction

After removing duplicates, the titles and abstracts of articles were reviewed by the first author (A-I), and abstracts were reviewed by the second author (I-Z).

Full-text articles were requested from the library service of the Faculty of Medicine and Pharmacy of Rabat. If unavailable, requests made via direct email contact with the corresponding authors.

Subsequently, the two were evaluators (A-I, I-Z) individually extracted data from the selected articles according to the inclusion criteria, using a data extraction form developed in accordance with the PICO model of the clinical question. In case of missing data, an email was sent to the authors. Disagreements were resolved by a third examiner (S-K) not involved in the data extraction process.

Inter-Rater Agreement

To quantify inter-rater agreement between the two authors (A-I, I-Z) for full-text selection, Cohen's Kappa (K) was used. The K value was calculated and interpreted according to Altman's definition (Altman, 1990): poor ($k < 0.2$), fair ($0.2 < k < 0.4$), moderate ($0.41 < k < 0.61$), good ($0.61 < k < 0.80$), excellent ($x > 0.80$).

Risk of Bias

The PEDro score was used to assess the methodological quality of each RCT (De Morton, 2009; Maher et al. 2003). A positive score on a minimum of 5 items qualified a study as high quality.

Analysis

Due to study heterogeneity, no meta-analysis was conducted. Results were presented qualitatively. An alpha level with a significance threshold set at $p < 0.05$. All relevant data were reported for each outcome measure, including point estimates, confidence intervals, and effect sizes

RESULTS

Following the electronic search, a total of 278 articles were identified. After removing duplicates, the retrieved articles underwent title and abstract screening, resulting in the identification of 184 potentially relevant studies. Based on full-text examination, an additional 155 articles were excluded, leaving 29 articles for in-depth evaluation. Among these, 23 were further excluded after comprehensive review. Ultimately, 6 articles met the inclusion criteria and were included in this systematic review. The selection process is presented in Figure 1.

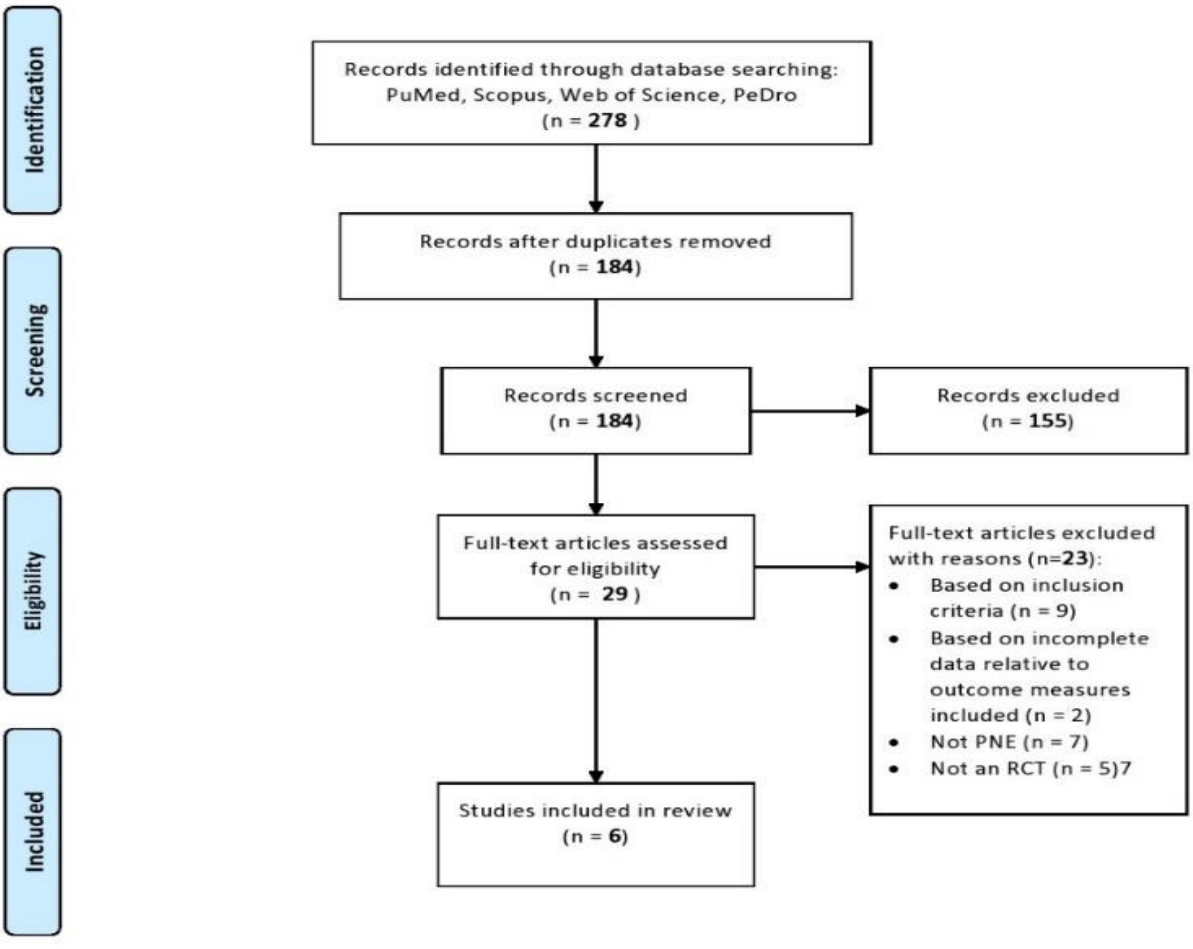

Figure 1: Flowchart and Process of Primary Studies Inclusion

Study Characteristics

Six RCTs were selected for this analysis (Saracoglu et al. 2022; Gül et al. 2021; Orhan et al.

2021; Rabiei et al. 2021; Yamada et al. 2023; Song et al. 2023). All relevant characteristics including study design, recruitment, age, gender, duration of pain, intervention, comparison, and number of participants are detailed in Table 1. Specifically, 5 studies divided participants into 2 groups (intervention group and control group) (Gül et al. 2021; Orhan et al. 2021; Rabiei et al. 2021; Yamada et al. 2023; Song et al. 2023), except for the study by Saracoglu et al. (2022), which adopted a multi-arm approach.

Table 1: Characteristics of RCTs included in the systematic review

Author (y), Country	Randomi-sation Method	Total sample size, Age, Recruitment	Duration Of Symptoms	Intervention (Participants, Gender)		Comparison (Participants, Gender)		Intervention Group	Comparison Group	Outcome Measures and Follow-Up
				Number	Gender	Number	Gender			
Saraco-glu et al., 2020 Turkey	Three-arm, Single-blind randomi-zed controlled trial	N = 69 Age: 18-65 Patients recruited by the physical therapy department of Kutahya University Hospital	CLBP > 6 months	Group 1 N = 20	Group 1 M = 9 F = 12	Group 2 N = 19 Group 3 N = 18	Group 2 M = 11 F = 10 Group 3 M = 10 F = 10	Group 1: PNE + Manual Therapy + Home exercise program	Group 2: Manual Therapy + Home exercise program Group 3: only home exercise program	*Numerical Pain Rating Scale* (NPRS) *Oswestry Disability Index* (ODI) *Tampa Scale of Kinesiophobia* (TSK-17) Baseline 4 weeks 12 weeks
Gül et al., 2021 Turkey	Randomi-zed controlled trial	N = 31 Age: 20-58 Patients recruited from the clinic in Antalya	CLBP > 3 months	N = 16	-	N = 15	-	TNE + Physiothe-rapy	Physiothe-rapy	*Visual Analogue Scale* (VAS) *Tampa Scale of Kinesiophobia* (TSK-11) *Roland Morris Disability* Questionnaire (RMDQ) Baseline 3 weeks
Orhan et al., 2021 Belgium	Randomi-zed controlled trial	N = 29 Age: 18-65 Patients recruited at a private medical center in Ghent (BE).	CLBP > 3 months	N = 15	M = 4 F = 11	N = 14	M = 4 F = 10	Culture-sensitive PNE	Standard PNE	*Numerical Rating Scale* (NRS) *Roland Morris Disability* Questionnaire (RMDQ) *Pain Beliefs Questionnaire* (PBQ) *Pain Catastrophizing Scale* (PCS-13) *Tampa Scale of Kinesiophobia* (TSK-17) Baseline 1 weeks 4 weeks
Rabiei et al., 2021 Iran	Randomi-zed controlled trial	N = 73 Age: 30-60 Patients recruited by physiothera pists through leaflets exposed in rehab clinics	CLBP > 3 months	N = 37	M = 16 F = 21	N = 36	M = 18 F = 18	PNE + Motor control exercise (MCE)	Group-based exercise (GE)	*Visual Analogue Scale* (VAS) *Roland Morris Disability* Questionnaire (RMDQ) Fear Avoidance Beliefs Questionnaire (FABQ) *Pain Self Efficacy*

										Questionnaire (PSEQ) Baseline 8 weeks
Yamada et al., 2023 Brazil	Single-blind randomi-zed clinical trial	N = 40 Age > 18 Participants registered at the Clinical School of Physiotherapy at CEULP/ULBRA, in Palmas/TO	CLBP > 3 months	N = 20	M = 8 F = 12	N = 20	M = 5 F = 15	The PNE intervention + Physiothe-rapy treatment	Physiothe-rapy treatment	*Numerical pain scale* (NPS) *Central sensitization* (CSI) *Roland Morris disability questionnaire* (RMDQ) *Pain catastrophizing scale* (PCS) *Tampa scale of Kinesiophobia* (TSK) *Hospital anxiety and depression scale* (HADS) SF-6D questionnaire Baseline 6 weeks
Song et al., 2023 Korea	Randomi-zed Single-Blind Controlled Trial	N = 28 Age: 20 -75 Participants registered at the Gwangju Heemang Hospital.	CLBP > 3 months	N = 14	M = 8 F = 6	N = 14	M = 9 F = 5	PNE + Soft-tissue mobilization (STM)	Soft-tissue mobilization	*Numerical Pain Rating Scale (NPRS)* *Korean version of the Roland Morris Disability Questionnaire (K-RMDQ)* *Central sensitization (CSI)* *Pressure pain threshold (PPT)* *Pain catastrophizing scale (PCS)* *Tampa scale of kinesiophobia-17 (TSK-17)* Baseline 4 weeks 6 weeks 8 weeks

Follow-ups

Post-treatment follow-up periods vary considerably from one study to another. Follow-up intervals range from a minimum of one week after treatment (Orhan et al. 2021) to a maximum of 12 weeks (Saracoglu et al. 2022). Additional details are available in Table 1.

Type of Participants

All studies included patients aged over 18 years suffering from chronic low back pain. Five studies (Gül et al. 2021; Orhan et al. 2021; Rabiei et al. 2021; Yamada et al. 2023; Song et al. 2023) recruited patients with chronic low back pain persisting for more than 3 months, while only one study (Saracoglu et al. 2022) included patients with chronic low back pain for more than 6 months. However, only the study by Gul et al. did not specify the gender of participants (Table 1).

Sample

The total sample size of included and randomized participants was 270 individuals. The study conducted by Song et al. (2023) had the smallest sample size (n=28), while the study by Rabieri et al. (2021) had the largest sample size (n=73).

Dropout and Loss to Follow-up

Among the 270 recruited patients, 15 (5.55%) dropped out, and 12 (4.44%) were lost to follow-up. Details are specified in Table 2.

Table 2. Dropout and loss to follow-up in included RCTs

Study	Drop-Outs (n° ; %)		Lost to Follow-Up (n°; %)	
	Experimental Group	Control Group	Experimental Group	Control Group
Saracoglu et al., 2020	0	0	Group 1: 3 at 12 weeks (13%) Group 2: 4 at 12 weeks (17,39%)	Group 3 : 5 at 12 weeks (21,73%)
Gül et al., 2021	0	0	0	0
Orhan et al., 2021	4 at 1 week (26,6%)	4 at 1 week (28,5%)	0	0
Rabiei et al., 2021	3 (8,1%)	4 (11,1%)	0	0
Yamada et al., 2023	0	0	0	0
Song et al., 2023	0	0	0	0

Type of Interventions

Therapeutic experimental interventions varied in content and execution methods across studies. Five studies used therapeutic approaches without PNE as the comparison group. The types of exercises used were varied: soft tissue mobilization (Song et al. 2023); physiotherapy protocol (Gül et al. 2021; Orhan et al. 2021; Rabiei et al. 2021; Yamada et al. 2023); home exercise program and manual therapy (Gül et al. 2021); sensorimotor control exercises and low back strengthening exercises (Rabiei et al. 2021). In contrast, only one study used PNE as a single experimental intervention (culture-sensitive PNE approach, based on beliefs, cognitions, and pain-related behaviors of Turkish patients, adapted from a previous Delphi study) (Orhan et al. 2021).

The mode of execution also varied across studies, including group sessions (Song et al. 2023) and individual sessions (Saracoglu et al. 2022; Gül et al. 2021; Orhan et al. 2021; Rabiei et al. 2021; Yamada et al. 2023). The total duration of PNE sessions ranged from 90 minutes (Orhan et al. 2021) to 240 minutes (Gül et al. 2021).

PNE administration modalities differed in terms of frequency, number of sessions, total session duration, responsible professional, and content used (Table 3).

Type of Control Groups

Participants in the comparison group were exposed to various therapeutic approaches, including soft tissue mobilization (Song et al. 2023); physiotherapy protocol (Gül et al. 2021; Orhan et al. 2021; Rabiei et al. 2021; Yamada et al. 2023); home exercise program and manual therapy (Saracoglu et al. 2022); sensorimotor control exercises and low back strengthening exercises (Rabiei et al. 2021). Only the study by Orhan et al. (2021) administered PNE in the control group (standard PNE). Additional information is provided in Table 3.

Table 3. Characteristics and types of interventions

Author, Y	Comparaison Details					PNE intervention Details			
	Type	Freque-nce	Total session duration	Progr-am length	Method of delivery	Type	Frequ-ence	Total session duration	Method of delivery
Gül et al., 2021	Physiotherapy: Hot-pack, ultrasound, TENS and acupuncture TENS. + isotonic and isometric reinforcement, exercises for trunk muscles, stretching	15 sessions of physiotherapy, 5 each week	Hot-pack=20 min TENS=20 MIN	3 weeks	One-on-one sessions applied by a physiotherapist	TNE concept, as described by Moseley and Butler (2015)	2 sessions per week 3 weeks	Each session 40 min Total = 240 min	Conducting a one-to-one interview performed by a physiothe-rapist
Yamada et al., 2023	kinesiotherapy exercises: bridge; board; spinal mobility exercise; walking on the treadmill for 4 min; sensory-motor training; motor coordination; trunk extension; hip	12 physiotherapy sessions, twice a week	Each session lasted 50 min	6 weeks	One-on-one sessions applied by the treatment researcher	PNE as described by Louw et al. (2013)	3 individual sessions of PNE	Each session 50 min Total = 150 min	individual PNE sessions Performed by the education researcher

	abduction; pelvic tilt and posterior chain muscle stretch.								
Song et al., 2023	STM techniques: transverse sliding of the lumbar muscles; thoracolumbar myofascial release; quadratus lumborum myofascial release; and psoas myofascial release	8 STM sessions, 2 sessions per week	40 min per session	4 weeks	One-on-one sessions performed by a physical therapist	PNE based on PNE by Louw et al. (2018), Pardo et al. (2018)	2 sessions, one before and one after receiving STM program	Each session 30 - 50 min Total = 100 min	Group sessions in the hospital's rehabilitation treatment room
Orhan et al., 2021	Standard PNE translated into Turkish by 2 independent native Turkish-speaking translators.	2 educational sessions in 2 weeks	The first session lasting around 45 to 60 min. The second session was lasted 45 min	4 weeks	An individual education session performed by the first author instructed by 2 physiotherapists experts in PNE	Culture-sensitive PNE approach developed during a study "Delphi modified" (Orhan et al., 2019) based on: "*Explain Pain*" (Butler and Moseley, 2003) and "Pijneducatie: Een Praktische Handleiding voor (Para) medici" (Van Wilgene Nijs, 2010).	2 educational sessions in 2 weeks	The first session lasting around 45 to 60 min. The second session was lasted 45 min Total = 105 min	An individual education session performed by the first author instructed by 2 physiotherapists experts in PNE
Rabiei et al., 2021	Exercise program: group warm-up; muscle strengthening exercises; light exercises	2 times a week	Each session lasting 60 min (10 min group warm-up, 45 min muscle strengthening exercises, 5 min light exercises).	8 weeks	An individual session performed by a physiotherapist not involved in the intervention group	PNE according to the method recommended by Nijs (2014)	3 educational sessions	each lasting 30 - 60 min Total = 180 min	An individual education session performed by Persian native physiotherapist, trained in PNE program
Saracoglu et al., 2020	Group 2: Manual therapy: personalized treatment Use different techniques with variable speed, range, direction of force application and patient position 2. Home exercise program: stretching, heating, reinforcement. The program was developed by Koumantakis, Watson and Oldham (2005). Group 3: only home exercise program, with the same group 1 and group 2 modes	Group 2: 1. Manual therapy: 2 sessions per week 2. Home exercise program: 10 repetitions, 3 times a day.	Manual therapy: Each session lasting 30 min	4 weeks	Group 2: 1. Manual therapy: physiotherapist (I.S.) who holds an MSc degree and has 10 years of experience in MT. 2. Home exercise program: The same physiotherapist (I.S.)	PNE according to the method recommended by Louw, Nijs and Puentedura (2017).	4 individual educational sessions, one per week	Each lasting about 40-45 min, after the manual therapy session Total = 180 min	An individual education session performed by a physiotherapist (I.S.) trained at the International Spine and Pain Institute

Type of Outcome and Outcome Measures

There is significant diversity in outcome measures used across all included studies. Regarding pain intensity assessment, two studies used the NPRS scale (Saracoglu et al. 2022; Song et al. 2023), two others used VAS (Gül et al. 2021; Rabiei et al. 2021), one used the NRS scale (Orhan et al. 2021), and another used the NPS scale (Yamada et al. 2023). To assess disability, five studies used the RMDQ disability index (Gül et al.

2021; Orhan et al. 2021; Rabiei et al. 2021; Yamada et al. 2023; Song et al. 2023), while one used the ODI disability index (Saracoglu et al. 2022). Kinesiophobia was evaluated using the PCS questionnaire in 5 studies (Saracoglu et al. 2022; Gül et al. 2021; Orhan et al. 2021; Rabiei et al. 2021; Song et al. 2023), and pain catastrophizing was assessed using the PCS in 3 studies (Gül et al. 2021; Rabiei et al. 2021; Song et al. 2023)

Risk of Bias

The assessment of the quality of each article, established using the PEDro scale, is summarized in Table 5. The 6 included studies were RCTs, assessed as having a moderate to low risk of bias, all scoring 5/10 or higher on the PEDro scale (PEDro score ≥ 5). The main reason for score reduction was the inability to achieve blinding of subjects and therapists. This limitation is partly attributable to the fact that the PNE intervention is administered face-to-face, making blinding implementation challenging.

PEDro scores for 5 studies were extracted from the PEDro database (Saracoglu et al. 2022; Gül et al. 2021; Orhan et al. 2021; Rabiei et al. 2021; Song et al. 2023), while one study required score calculation by the authors (Yamada et al. 2023).

Table 4. Evaluation of the quality of included RCTs

Study	Question*											Score
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	
Orhan et al. 2021	**Y**	**Y**	**N**	**Y**	**N**	**N**	**N**	**N**	**Y**	**Y**	**Y**	5/10
Rabiei et al. 2021	**Y**	**Y**	**Y**	**Y**	**N**	**N**	**N**	**Y**	**N**	**Y**	**Y**	6/10
Gül et al. 2021	**Y**	**Y**	**N**	**Y**	**N**	**N**	**N**	**Y**	**N**	**Y**	**Y**	5/10
Saracoglu et al. 2022	**Y**	**Y**	**Y**	**Y**	**N**	**N**	**Y**	**Y**	**N**	**Y**	**Y**	7/10
Yamada et al. 2023	**Y**	**Y**	**Y**	**Y**	**N**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**9/10**
Song et al. 2023	**Y**	**Y**	**N**	**N**	**N**	**N**	**Y**	**Y**	**Y**	**Y**	**Y**	6/10

*** :** 1, eligibility criteria were specified (**not counted in PEDro score**); 2, subjects were randomly allocated to groups; 3, allocation was concealed; 4, the groups were similar at baseline regarding the most important prognostic indicators; 5, there was blinding of all subjects; 6, there was blinding of all therapists who administered the therapy; 7, there was blinding of all assessors who measured at least one key outcome; 8, measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups; 9, all subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome were analysed by "intention to treat"; 10, the results of between-group statistical comparisons are reported for at least one key outcome; and 11, the study provides both point measures and measures of variability for at least one key outcome.
N, no; **Y**, yes.

Agreement

The inter-rater agreement index (A-I and I-Z) was excellent (K = 0.8125) for the selection of full-text articles. The data are detailed in Table 6.

Table 5. Agreement for full-text selection

Agreement for Full-Text Selection		Evaluator 1 (A-I)		TOTAL
		Positive Evaluation	Negative Evaluation	
Evaluator 2 (I-Z)	Positive Evaluation	**24**	**1**	**25**
	Negative Evaluation	**2**	**5**	**7**
TOTAL		**26**	**6**	**32**

Intervention Effects

All included studies focus on the effect of PNE on kinesiophobia, pain catastrophizing, pain, and functional abilities in individuals with chronic low back pain. A qualitative synthesis of the results was presented based on the intervention dosage or total intervention duration in minutes ("moderate dose" ≤ 150 minutes and "high dose" > 150 minutes). Details are available in Table 7.

At Moderate Dose (≤ 150 min)

According to the included studies, participants underwent variable intervention durations. Studies by Orhan et al. (2021), Song et al. (2023), and Yamada et al. (2023) examined the intervention's effectiveness when the duration was ≤ 150 minutes.

Three studies (Orhan et al. 2021; Yamada et al. 2023; Song et al. 2023) assessed the effectiveness of PNE on pain (NRS, NPS, NPRS), functional disability (ODI, RMDQ), and kinesiophobia (TSK), while 2 studies (Yamada et al. 2023; Song et al. 2023) investigated pain catastrophizing (PCS).

Kinesiophobia and Pain Catastrophizing

In Orhan et al.'s study (2021), no significant difference was observed between the intervention group (sensitized PNE) and the control group (standard PNE) regarding PCS or TSK, although both PNE types showed significant improvements over time in both groups (Orhan et al. 2021).

In contrast, Song et al. (2023) demonstrated significant improvement in TSK and K-PCS in the group receiving PNE combined with soft tissue mobilization (BG; PNE + STM) compared to the group receiving only soft tissue mobilization (SMG) at post-test follow-ups, at 2 and 4 weeks ($p<0.013$). Similar results were observed in Yamada et al.'s study (2023), where the group (IG) receiving PNE combined with physiotherapy showed significantly lower kinesiophobia compared to the group (CG) receiving only physiotherapy ($p <0.001$).

Pain and Disability

Orhan et al.'s study (2021) revealed significantly lower scores compared to baseline scores for NRS at week 1 ($p = 0.02$) and for RMDQ scores at week 1 ($p = 0.01$) and week 4 ($p = 0.01$). Similarly, Yamada et al. (2023) observed a clinically significant decrease in pain intensity (NPS) and functional disability (ODI) in both groups, with more pronounced improvement in the IG. However, no significant improvement was observed in the experimental group compared to the control group in these two trials (Orhan et al. 2021; Yamada, 2023).

In contrast, Song et al. (2023) showed significant improvement in pain intensity (NPRS) and functional abilities (K-RMDQ) in the group receiving PNE (BG) compared to the SMG group at 2 and 4 weeks ($p<0.013$). In NPRS, the MCID was reached in the experimental group (BG) with a decrease of more than 2 points (Table 7).

At High Dose (More than 150 min)

Three studies assessed the effectiveness of PNE on pain and functional abilities when the intervention duration exceeded 150 min. Two studies examined the effectiveness of PNE on kinesiophobia under these conditions (Saracoglu et al. 2022; Gül et al. 2021), while no study evaluated pain catastrophizing.

Kinesiophobia and Pain Catastrophizing:

In Saracoglu et al.'s study (2022), TSK-17 scores were significantly lower in group 1 (PNE+ HEP+MT) receiving PNE combined with home exercise and manual therapy compared to groups receiving only home exercise (HEP) or home exercise plus manual therapy (HEP+MT) (Table 7). However, Gül et al.'s clinical trial (2021) did not show statistically significant improvement in kinesiophobia in the experimental group compared to the control group.

Pain and Disability:

A post-hoc test showed that group 1 (PNE+HEP+MT) had significantly lower NPRS values than group 2 (HEP+MT) ($p= 0.01$) and the control group (HEP) ($p< 0.001$), similarly for the ODI score which was significantly lower in group 1 ($p<0.001$) and group 2 ($p=0.05$) compared to the control group (Table 7).

In Rabiei et al.'s study (2021), a statistically significant improvement in pain intensity and functional disability was observed in the experimental group PNE + combined with motor control exercise (MCE) at 8 weeks ($p < 0.001$). Indeed, the group (PNE+MCE) showed greater improvements with a moderate effect on pain intensity VAS ($P = 0.041$) and on disability and RMDQ ($P=0.021$) compared to the EG group.

In contrast, the study conducted by Gül et al. (2021) did not show statistically significant improvement in pain (VAS) or function (RMDQ) in the experimental group at 3 weeks after the intervention ($p> 0.05$).

Table 6. Results of included RCTs

Study	Intervention	Comparison	Total duration of PNE and Follow-up	Results (EX: Experimental Group; C: Control Group)	*p* value
					No Difference between Groups
Orhan et al.,2021 Belgium	PNE "culture-sensitive"	PNE standard	90 min = 1h30 Baseline 1 weeks 4 weeks	**NRS** EX: 6.50 ± 1.80 → 5.80 ± 2.07 → 5.86 ± 2.35 C: 6.85 ± 2.21 → 5.85± 2.24 → 6.00 ± 2.48 **RMDQ** EX: 16.66 ± 4.32 → 15.40 ± 4.82 → 15.60 ± 6.12 C: 16.21 ± 4.62 →14.42 ± 5.98 → 13.07 ± 5.91 **PBQ (organic score)** EX: 4.23 ± 0.93 → 3.67 ± 0.99 → 3.87 ± 0.65 C: 4.02 ± 0.75 →3.64 ± 0.70 → 3.50 ± 0.92 **PBQ (psychological score)** EX: 4.10 ± 1.22 → 4.86 ± 1.22 → 4.36 ± 1.14 C: 4.35 ± 0.93 → 4.51 ± 1.04 → 4.12 ± 1.07 **PCS-13** EX: 29.40 ± 10.68 → 25.93 ± 11.21 → 24.80 ± 11.21 C: 24.14 ± 10.86 → 19.35 ± 10.77 → 19.00 ± 11.08 **TSK-17** EX: 45.33 ± 5.17 → 42.73 ± 5.37 → 43.26 ± 6.06 C: 43.64 ± 3.65 → 41.71 ± 3.45 → 40.50 ± 3.87	Both follow-ups: **NRS** ($p > 0.05$) **RMDQ** ($p > 0.05$) **PBQ** ($p > 0.05$) **PCS-13** ($p > 0.05$) **TSK-17** ($p > 0.05$)
Song et al., 2023 Korea	PNE + Soft-tissue mobilization	Soft-tissue mobilization	100min = 1h40 **Baseline** 4 weeks (post-test) 6 weeks 8 weeks	**NPRS** EX: 4.73 ± 0.90 → 2.40 ± 0.85 → 1.95 ± 0.65 → 1.78 ± 0.50 C: 4.66 ± 0.92 → 2.59 ± 0.64 → 2.64 ± 0.67 → 2.93 ± 0.67 **K-RMDQ** EX: 9.71 ± 2.46 → 5.07 ± 1.38 → 14.36 ± 1.22 → 4.21 ± 1.19 C: 9.07 ± 2.76 → 6.29 ± 1.86 → 6.64 ± 2.02 → 7.14 ± 2.07 **CSI-K** EX: 41.00 ± 7.39 → 33.07 ± 6.11 → 31.64 ± 5.84 → 29.57 ± 5.69 C: 39.93 ± 8.07 → 36.57 ± 7.45 → 35.43 ± 6.98 → 34.79 ± 6.49 **PPT** EX: 33.13 ± 11.95 → 52.90 ± 8.21 → 54.13 ± 8.58 → 54.89 ± 7.98 C: 29.23 ± 8.74 → 40.36 ± 8.32 → 39.18 ± 8.56 → 37.47 ± 8.39 **K-PCS**	**NPRS** ($p < 0.001$) **K-RMDQ** ($p < 0.001$) **CSI** ($p < 0.001$) **PPT** ($p < 0.001$) **K- PCS** ($p < 0.001$) **TSK-17** ($p < 0.001$)

				EX: 29.86 ± 3.80 → 20.14 ± 3.08 → 18.57 ± 2.38 → 17.57 ± 1.91 C: 30.93 ± 5.01 → 27.93 ± 5.27 → 28.86 ± 6.49 → 30.00 ± 6.30 **TSK-17** EX: 39.21 ± 5.12 → 31.57 ± 3.41 → 29.93 ± 2.84 → 29.50 ± 3.11 C: 40.86 ± 4.93 → 38.43 ± 3.78 → 37.43 ± 3.99 → 37.57 ± 3.63		
Yamada et al., 2023 Brazil	PNE + Physiotherapy treatment	Physiotherapy treatment	150 min = 2h30 Baseline 6 weeks	**NPS** EX: Δ → 3.20 ± 2.69 C: Δ → 4.30 ± 2.60 **CSI** EX: Δ → 40.3 ± 14.16 C: Δ → 37.65 ± 17.8 **RMDQ** EX: Δ → 9.10 ± 7.28 C: Δ → 11.6 ± 6.46 **PCS** EX: Δ → 0.89 ± 1.07 C: Δ → 1.29 ± 1.12 **TSK-11** EX: Δ → 32.4 ± 8.83 C: Δ → 40 ± 7.33 **HADS-A** EX: Δ → 6.45±3.47 C: Δ → 8.5±4.01 **HADS-D** Δ → 5.10±4.08 C: Δ →6.7±3.54 **SF-6D** EX: Δ → 0.75±0.09 C: Δ → 0.75±0.08	**TSK-11** 6 weeks (*p*=0.006)	**NPS** (*p* > 0.05) **CSI** (*p* > 0.05) **RMDQ** (*p* > 0.05) **PCS** (*p* > 0.05) **HADS-A** (*p* > 0.05) **HADS-D** (*p* > 0.05) **SF-6D** (*p* > 0.05)
Saracoglu et al., 2020 Turkey	Group 1: PNE + Manual therapy + Home exercise	Group 2: Manual therapy + Home exercise Group 3: Home exercise	180 min = 3h Baseline 4 weeks 12 weeks	**NPRS** G1: 7.29 ± 1.41 → 3.05 ± 1.50 → 2.09 ± 1.64 G2: 7.58 ± 1.47 → 4.42 ± 1.78 → 4.52 ± 1.84 C: 7.32 ± 1.48 → 5.89 ± 2.03 → 5.47 ± 1.95 **ODI** G1: 34.45 ± 7.39 → 22.80 ± 6.77 → 19.90 ± 5.72 G2: 32.00 ± 6.87 → 25.00 ± 7.88 → 25.89 ± 7.37 C: 34.74 ± 8.55 → 31.77 ± 9.27 → 32.33 ± 8.49 **TSK-17** G1: 44.35 ± 4.30 → 35.55 ± 5.75 → 35.19 ± 3.99 G2:	**NPRS** Both follow-ups: Group 1 vs. G. 3 (*p* < 0.001) **ODI** Both follow-ups: Group 1 vs. G. 3 (*p* < 0.001) **TSK-17** Both follow-ups: Group 1 vs. G. 2 (*p* < 0.001) Group 1 vs. G.3 (*p* < 0.001)	**NPRS** Both follow-ups: Group 1 vs. G. 2 (*p* = 0.01) **ODI** Both follow-ups: Group 1 vs. G.2 (*p* = 0.67)

				45.10 ± 4.45 → 41.63 ± 5.23 → 42.21 ± 5.04 C: 45.55 ± 4.10 → 44.94 ± 4.70 → 44.88 ± 5.10		
Rabiei et al., 2021 Iran	PNE + Motor control exercise	Group-based exercise	180 min = 3h Baseline 8 weeks	**VAS** EX: 6.45 ± 1.21 → 3.79 ± 1.02 C: 6.36 ± 1.14 → 4.91 ± 1.67 **RMDQ** EX: 14.6 ± 1.55 → 7.94 ± 2.17 C: 15.0 ± 2.14 → 9.50 ± 3.25 **FABQ-W** EX: 24.2 ± 10.4 → 11.5 ± 6.41 C: 21.6 ± 8.02 → 14.9 ± 6.43 **FABQ-PA** EX: 17.2 ± 4.25 → 8.24 ± 3.72 C: 15.7 ± 5.17 → 10.2 ± 4.15 **PSEQ** EX: 26.6 ± 9.53 → 43.9 ± 11.6 C: 29.5 ± 10.9 → 38.9 ± 12.0	**VAS** 8 weeks (p = 0.041) **RMDQ** 8 weeks (p = 0.021)	**FABQ** 8 weeks (p > 0.05) **PSEQ** 8 weeks (p > 0.05)
Gül et al., 2021 Turkey	PNE + Physiotherapy	Physiotherapy	240 min = 4h Baseline 3 weeks	**VAS** EX: Δ → −35.9 ± 28.3 C: Δ →33.8 ± 29.5 **TSK-11** EX: Δ → −17.3 ± 12.1 C: Δ →−2.9 ± 6.4 **RMDQ** EX: Δ → −8.8 ± 5.5 C: Δ →−5.7 ± 4.4		**VAS** 3 weeks (p > 0.05) **TSK-17** 3 weeks (p = 0.410) **RMDQ** 3 weeks (p > 0.05)

DISCUSSION

This systematic review aims to examine the impact of intervention duration on the effectiveness of PNE in patients with CLBP, to optimize outcomes and better tailor the implementation of this intervention in clinical practice. It is noteworthy that this is the first systematic review specifically evaluating the impact of total PNE duration on individuals with CLBP. The six clinical trials included in this review provided data on differences in pain intensity, disability, kinesiophobia, and pain catastrophizing, using both moderate and higher doses of PNE.

Results from these studies are heterogeneous within different dosage groups, yet they demonstrated significant differences in all outcome measures favoring the combination of PNE with other therapeutic approaches compared to the use of therapeutic approach alone. Indeed, only the studies by Song, Yamada (for moderate doses), and Saracoglu (for high doses) reported a positive effect of the intervention on kinesiophobia and pain catastrophizing. In Song's study, a significant reduction in both criteria was observed only in the group receiving PNE, surpassing the clinically important difference (MCID) reported for TSK-17 (5.5 points) (Monticone et al. 2016), and the minimal detectable change (MDC) for K-PCS (10.28 points) (Cho et al. 2013). For Yamada et al. (2023), a statistically significant difference was observed between the intervention group and the control group regarding kinesiophobia (p = 0.006). While Saracoglu et al. found a significant improvement in kinesiophobia in patients receiving PNE with manual therapy (MT) and home exercise program (HEP) compared to the other two groups (MT + HEP and HEP alone).

These findings are consistent with previous literature on the effectiveness of PNE in treating chronic musculoskeletal pain in adults (Siddall et al. 2022; Romm et al. 2021; Watson et al. 2019).

However, contrary to expectations, no correlation was observed between intervention duration and improvement in kinesiophobia and pain catastrophizing. It is important to note that most studies included in this review presented either non-significant or significant results for one or more criteria, except for one. Song's study is the only one to have found a significant difference in all variables, which may be attributed to the application of PNE in groups.

These findings diverge from those of a previous meta-analysis which suggested a linear relationship between PNE duration and reduction in symptoms of these two factors (Salazar-Méndez et al. 2023). In reality, estimates suggest that a duration of 400 minutes of PNE is needed to achieve a clinically significant improvement in pain catastrophizing (Salazar-Méndez et al. 2023), measured by a clinically important change MCID of 6.71 points for PCS (Woby et al. 2005), whereas a dose of 100 min is needed to observe an MCID of 4 points for TSK-11 (Suzuki et al. 2020). Although the dosage (PNE duration) has been statistically significant (Salazar-Méndez et al. 2023), the fact that many studies use shorter sessions of 30 to 45 minutes suggests that PNE is more effective when combined with other therapies (Nijs et al. 2011; Louw et al. 2018)

These observations also extend to secondary criteria of pain and functional disability. Three studies in each group concluded a benefit of PNE in reducing pain and improving function. At moderate doses, only Song's study showed a statistically significant improvement on NPRS and K-RMDQ scales. Conversely, at higher doses, combining PNE with other therapies such as manual therapy and home exercises led to more significant improvements in pain and disability in the short and mid-term. Available data suggests a moderate to significant improvement in pain and functional disability, immediately after treatment (Tegner et al. 2018) in the short term in CLBP patients who underwent PNE (Woby et al. 2005).

However, the meta-analysis by Wood and Hendrick revealed a clinically insignificant effect on pain intensity, although clinically and statistically significant improvements were observed in disability index (RMDQ), likely due to a better understanding of pain and reduction in fear-avoidance beliefs among patients (Fletcher et al. 2016).

Indeed, it has been reported that reconceptualization through increased pain knowledge via PNE leads to a positive improvement in pain catastrophizing, which could potentially reduce kinesiophobia by gradually decreasing fear and encouraging physical activity (Tu et al. 2019; Kong et al. 2013; Mittinty et al. 2018). Additionally, the significant improvement in RMDQ scores is due to the fact that the disability index correlates with fear avoidance (Chung et al. 2013). Despite variability in PNE duration and dosage among studies, the content of PNE remains relatively standardized, which appears to lead to improved pain-related outcomes (Romm et al. 2021). Lastly, while most studies included in this review presented either significant or non-significant results for various criteria, only one study showed a significant difference in all variables, suggesting that implementing PNE in groups may have additional benefits in terms of improving outcomes

Strengths and Limitations

The strengths and limitations of this systematic review deserve particular attention when evaluating its results and their relevance for clinical practice and future research. Firstly, only 6 studies were included in this review after selection. This small number may be considered insufficient to provide a comprehensive representation of the scientific literature on this topic. This limitation can be partly attributed to the inclusion criterion regarding the publication date, which excluded studies prior to 2019.Moreover, the lack of precise data on the exact duration of PNE sessions in some studies (Saracoglu et al. 2022; Orhan et al. 2021; Rabiei et al. 2021; Song et al. 2023) may introduce classification errors and affect the obtained results.

Another significant limitation concerns the absence of data on the pain catastrophizing variable in three studies (Gül et al. 2021; Rabiei et al. 2021). This gap diminishes the robustness of the analysis of results related to this primary variable, highlighting the importance of including a sufficient number of studies for a more reliable interpretation. The authors also identified other limitations such as short-term follow-up and evaluation of interventions, rendering long-term effects unknown. Future trials, with larger samples, will be necessary to assess these long-term effects and provide robust conclusions.

Despite these limitations, this review presents several strengths that justify its interest. Firstly, it

addresses a common condition and studies a technique applicable in different care contexts, thus reinforcing its clinical importance. Secondly, PNE is part of a patient-centered bio-psycho-social care approach, in line with the current physiotherapy model and evidence-based approaches. Lastly, the fact that all articles included in this review were published after 2020 ensures that the review examined the most recent literature available on this topic, strengthening its relevance.

Conclusion

This study focuses on evaluating the impact of the total duration of PNE on kinesiophobia and pain catastrophizing in patients with chronic low back pain. The results of the systematic review, based on randomized controlled clinical trials, reveal no significant correlation between the total duration of PNE and improvement in key criteria, although a longer duration (exceeding 100 minutes) appears to be associated with increased reduction in kinesiophobia and pain catastrophizing related to chronic musculoskeletal pain (Salazar-Méndez et al. 2023). This finding opens up interesting perspectives for future research. Furthermore, it is important to note that PNE does not seem to result in any undesirable side effects in patients and that its combination with exercise therapies leads to more significant improvements compared to exercise alone in the treatment of chronic low back pain.

However, it should be noted that clinical trials have methodological biases, including lack of blinding and lack of standardization of therapist discourse. These limitations emphasize the need for future studies that are better controlled and more rigorous to confirm the conclusions of this review and establish more precise recommendations for clinical practice.

Author Contributions

Conceptualization, A.I., I.Z and H.E.; methodology, A.I., I.Z. and H.E.; investigation, A.I.; data curation, A.I.; writing - original draft preparation, A.I. and S.K.; writing - review and editing, A.I. and S.K.; supervision, S.K. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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Addition

Appendix 1

DATABASES	SEARCH STRING	RESULTS
PubMed	((((((((((((((((((((chronic lower back pain[MeSH Terms]) OR (chronic lower back pain[Title/Abstract])) OR (chronic back pain[MeSH Terms])) OR (chronic back pain[Title/Abstract])) OR (Low Back Pain[MeSH Terms])) OR (Low Back Pain[Title/Abstract]))) OR (chronic non-specific low back pain[MeSH Terms])) OR (chronic non-specific low back pain[Title/Abstract])) AND (pain neuroscience education[Title/Abstract])) OR (pain neuroscience education[MeSH Terms])) OR (pain neurophysiology education[MeSH Terms])) OR (pain neurophysiology education[Title/Abstract])) OR (neuroscience education[Title/Abstract])) OR (neuroscience education[MeSH Terms])) OR (neurophysiological pain education[MeSH Terms])) OR (neurophysiological pain education[Title/Abstract])) OR (neurobiology education[Title/Abstract])) OR (neurobiology education[MeSH Terms])) OR (therapeutic neuroscience education[MeSH Terms])) OR (therapeutic neuroscience education[Title/Abstract])) AND (pain OR sore OR disability OR invalidity OR handicap OR kinesiophobia OR catastrophizing)	**TOTAL = 41**
Web of Science	((((((((((TI="chronic lower back pain" OR AB="chronic lower back pain")) OR ((TI="chronic back pain" OR AB="chronic back pain"))) OR ((TI="chronic low back pain" OR AB="chronic low back pain"))) OR (ALL="Low Back Pain")) OR (ALL="chronic low back pain"))) OR (ALL="low back pain")) AND (ALL="chronic pain")) OR (ALL="Low Back Ache")) AND (ALL="chronic pain")AND ((((((((TI="pain neuroscience education" OR AB="pain neuroscience education"))) OR ((TI="pain neurophysiology education" OR AB="pain neurophysiology education"))) OR ((TI="neuroscience education" OR AB="neuroscience education"))) OR ((TI="neurophysiological pain education" OR AB="neurophysiological pain education"))) OR ((TI="neurobiology education" OR AB="neurobiology education"))) OR ((TI="therapeutic neuroscience education" OR AB="therapeutic neuroscience education"))) OR ((TI=PNE OR AB=PNE)) AND ((((((((((((ALL="clinical trials") OR ((TI="clinical trials" OR AB="clinical trials"))) OR ((TI="clinical trials as a topic" OR AB="clinical trials as a topic"))) OR (ALL="clinical trials as a topic")) OR (ALL="randomized controlled trial")) OR ((TI="randomized controlled trial" OR AB="randomized controlled trial"))) OR ((TI="Randomized Controlled Trials as Topic" OR AB="Randomized Controlled Trials as Topic"))) OR (ALL="Randomized Controlled Trials as Topic")) OR (ALL="controlled clinical trial")) OR (ALL="controlled clinical trial")) OR (ALL="Double-Blind Method")) OR ((TI="Double-Blind Method" OR AB="Double-Blind Method"))) OR ((TI="Single-Blind Method" OR AB="Single-Blind Method"))) OR (ALL="Single-Blind Method")	**TOTAL = 98**
Scopus	(((((((((((((((((((INDEXTERMS ("chronic lower back pain")) OR (TITLE-ABS ("chronic lower back pain"))) OR (INDEXTERMS ("chronic back pain"))) OR (TITLE-ABS ("chronic back pain"))) OR (INDEXTERMS ("Low Back Pain"))) OR (TITLE-ABS ("Low Back Pain")))) OR (INDEXTERMS ("chronic non-specific low back pain"))) OR (TITLE-ABS ("chronic non-specific low back pain"))) AND (TITLE-ABS ("pain neuroscience education"))) OR (INDEXTERMS ("pain neuroscience education"))) OR (INDEXTERMS ("pain neurophysiology education"))) OR (TITLE-ABS ("pain neurophysiology education"))) OR (TITLE-ABS ("neuroscience education"))) OR (INDEXTERMS ("neuroscience education"))) OR (INDEXTERMS ("neurophysiological pain education"))) OR (TITLE-ABS ("neurophysiological pain education"))) OR (TITLE-ABS ("neurobiology education"))) OR (INDEXTERMS ("neurobiology education"))) OR (INDEXTERMS ("therapeutic neuroscience education"))) OR (TITLE-ABS ("therapeutic neuroscience education"))) AND (pain OR sore OR disability OR invalidity OR handicap OR kinesiophobia OR catastrophizing) AND (INDEXTERMS ("clinical trials" OR "clinical trials as a topic" OR "randomized controlled trial" OR "Randomized Controlled Trials as Topic" OR "controlled clinical trial" OR "Controlled Clinical Trials" OR "random allocation" OR "Double-Blind Method" OR "Single-Blind Method" OR "Cross-Over Studies" OR placebos OR "multicenter study" OR "double blind procedure" OR "single blind procedure" OR "crossover procedure" OR "clinical trial" OR "controlled study" OR randomization OR placebo)) OR (TITLE-ABS-KEY (("clinical trials" OR "clinical trials as a topic" OR "randomized controlled trial" OR "Randomized Controlled Trials as Topic" OR "controlled clinical trial" OR "Controlled Clinical Trials as Topic" OR "random allocation" OR "randomly allocated" OR "allocated randomly" OR "Double-Blind Method" OR "Single-Blind Method" OR "Cross-Over Studies" OR placebos OR "cross-over trial" OR "single blind" OR "double blind" OR "factorial design" OR "factorial trial"))) OR (TITLE-ABS ("clinical trial*" OR trial* OR rct* OR	**TOTAL = 88**

	random* OR blind*)) AND PUBYEAR > 2018 AND PUBYEAR < 2024 AND (LIMIT-TO (LANGUAGE , "English") OR LIMIT-TO (LANGUAGE , "French")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (EXACTKEYWORD , "Controlled Study"))	
PEDro	**First search :** • **Abstract & Title: neuroscience** • **Therapy: education** • **Problem: pain** • **Topic: chronic pain.** • **Method: clinical trial** **Second search :** • **Abstract & Title : neurophysiology** • **Therapy: education** • **Problem: pain** • **Topic: chronic pain.** • **Method: clinical trial**	**First search = 38** **Second search = 13** **TOTAL = 51**