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ORIGINAL ARTICLE

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RESEARCH ARTICLE

Satisfaction with The Life and Self-Esteem of Portuguese Disabilities Elite Athletes of Boccia and Adapted Athletics

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Abstract

This study is to compare the degree of satisfaction with life and self-esteem of Portuguese elite athletes of adapted sport according to the modality practiced, gender and sport experience. The sample consisted of 30 Portuguese elite athletes, 15 of adapted Athletics and 15 of Boccia, aged between 17 and 54 years (31.03 ± 10.26). The sports experience of these athletes was 13.33 (± 9.0) years of practice, in which 20 were male and 10 were female and all these athletes have disabilities. A questionnaire on biographical data, Satisfaction with Life Scale (Diener et al., 1985), the Self-Anchoring Rating Scale (Cantril, 1965) and the Self-Esteem Scale (Rosenberg, 1965) translated and adapted by (Bandeira et al., 2005) were applied. The questionnaire to assess subjective well-being (Translate adapted by (Fortes-Ferreira et al., 2006). The t-test was used to compare levels of satisfaction with life and self-esteem according to modality, sex, and years of practice. The results of this study allow us to conclude that Portuguese adapted athletes (8,83±4,71) and bocce (5,53±4,52) present there are statistically significant differences (0.050) in self-esteem between. The lower functional capacity, as well as the severity of Boccia athletes' deficiency, which requires the use of ancillary means, may be a reason to justify the fact that they present lower values of self-esteem than athletes. The same reason may justify a lower level of satisfaction with the lives of athletes with any less more sporting experience (25,47±4,33) than more sporting experience (28,85±4,63) since they are also older athletes.

Keywords
Athletes, Satisfaction, The Life, Self-Esteem, Disabilities, Boccia, Adapted Athletics

INTRODUCTION

Nowadays nobody questions the importance or benefits of the practice of physical activity and sport for the well-being of everyone including people with disabilities. In recent times there has been a steady increase in the number of sports for people with disabilities, at a competitive level, creating more opportunities for these athletes to participate in worldwide (Blauwet & Willick, 2012; Phytanza et al., 2023). However, there are few studies that analyze the psychological variables of these athletes, especially at the elite level. The characterization of the psychological profile makes it possible to complement a broader understanding at a physiological and technological level, allowing for a more holistic view of the success of these athletes, and facilitating the optimization of sports performance as well as their well-being (Burhaein et al., 2023; Jefferies et al.,

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2012). Adapted sport is an important mechanism of social connections (Wilhite & Shank, 2009), promoting physical and emotional health, and helping individuals with disabilities to focus on their potential (Demirci & Pinru Phytanza, 2021; Yazicioglu et al., 2012). Adapted sport promotes several benefits to its practitioners, namely about the confidence and self-efficacy of individuals with disabilities (Blauwet & Willick, 2012) and higher levels of quality and satisfaction with life compared with individuals do not practice sport (Burhaein et al., 2022; Phytanza et al., 2022; Yazicioglu et al., 2012). This study is based on the absence of research that compares the psychological advantages of the different modalities for people with disabilities.

Hence, the objective of this study is to compare the degree of satisfaction with life and self-esteem of Portuguese elite athletes of adapted sport according to the modality practiced, gender and sport experience.

MATERIALS AND METHODS

Participant

The sample consisted of 30 Portuguese elite athletes, 15 of adapted Athletics and 15 of Boccia, aged between 17 and 54 years (31.03 ± 10.26). The sports experience of these athletes was 13.33 (± 9.0) years of practice, in which 20 were male and 10 were female. This study followed ethical standards and received approval from the Unıversıtas Ma'arıf Nahdlatul Ulama Kebumen (UMNU) Kebumen with reference number (070/A/VI/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.

Research Instruments

A questionnaire on biographical data, Satisfaction with Life Scale (Diener et al., 1985), the Self-Anchoring Rating Scale (Cantril, 1965) and the Self-Esteem Scale (Rosenberg, 1965) translated and adapted by (Bandeira et al., 2005) were applied. The questionnaire to assess subjective well-being (Translate adapted by (Fortes-Ferreira et al., 2006), can be seen in Figures 2, 3, and 4. The t-test was used to compare levels of satisfaction with life and self-esteem according to modality, sex and years of practice.

RESULTS

The descriptive analysis of the results shows that elite athletes adapted from Boccia and Athletics present high values of life satisfaction (7.65 ± 1.61 in the Self-Anchoring Rating Scale and 29.93 ± 4.71 in Satisfaction with Life Scale) and low levels of self-esteem (7.23 ± 4.85). The results of the t-test demonstrate that there were significant differences in self-esteem when comparing the two modalities (p = 0.05), with athletes showing values higher than those of Boccia (8.93 ± 4.71 vs. 5.53 ± 4.52). Compared to the sports experience, there were significant differences in life satisfaction (p = 0.05), with athletes with less sport experience (<11 years of practice) being more satisfied with life (28.85 ± 4.63 vs. 25.47 ± 4.33). There were no significant gender differences in any of the variables.

Table 1. Results – differences between modalities

	Boccia (n=15)	**Adapted Athetics (n=15)**	P- Value
Satisfaction with life (Seccion B)	26,53±4,76	27,33±4,78	0,650
Your presente life in moment (Seccion C)	7,53± 1,72	7,79±1,53	0,680
Your present life in general (Section C)	27,40±3,40	29,07±3,83	0,218
Self-esteem	5,53±4,52	8,83±4,71	**0,050***

Source: Primary Data

Table 2. Results – differences between gender

	Female(n=10)	Male (n=20)	p
Satisfaction with life (Seccion B)	26,00±4,99	27,40±4,62	0,468
Your presente life in moment (Seccion C)	7,50± 1,43	7,74±1,73	0,698
Your present life in general (Section C)	29,60±3,78	27,55±3,49	0,169
Self-esteem	8,30±5,91	6,70±4,31	0,459

Source: Primary Data

Table 3. Results – differences between years of practice

	Less than 11 years (n=17)	More than 11 years (n=13)	p
Satisfaction with life (Seccion B)	26,00±4,99	27,40±4,62	0,468
Your presente life in moment (Seccion C)	7,50± 1,43	7,74±1,73	0,698
Your present life in general (Section C)	29,60±3,78	27,55±3,49	0,169
Self-esteem	8,30±5,91	6,70±4,31	0,459

Source: Primary Data

DISCUSSION

Satisfaction with life and self-esteem are important aspects in the life of every individual, including athletes with disabilities (Ida Ayu Dian Pramantik, 2021; Naderi et al., 2016). Although they may face unique challenges and obstacles, many athletes with disabilities have proven that satisfaction with life and positive self- esteem can be achieved through achievement in sports and other activities.

The results of this study allow us to conclude that Portuguese adapted athletes and bocce are satisfied with life. Nonetheless, they present very low levels of self-esteem. The lower functional capacity, as well as the severity of Boccia athletes' deficiency, which requires the use of ancillary means, may be a reason to justify the fact that they present lower values of self-esteem than athletes.

The following are some of the factors that can contribute to satisfaction with life and self-esteem in athletes with disabilities. Sports Achievements, achievements in sports competitions, whether at the local, national, or international level, can provide a sense of accomplishment and pride that enhances an athlete's self-esteem. They can prove their abilities to the world and feel appreciated for their efforts and dedication (Weinberg & Gould, 2019).

Social Support, support from family, friends, coaches, and the community can have a positive impact on the self-esteem of athletes with disabilities. By feeling supported and acknowledged by those around them, they can develop a positive perception of themselves.

Social Support, support from family, friends, coaches, and the community can have a positive impact on the self-esteem of athletes with disabilities. By feeling supported and acknowledged by those around them, they can develop a positive perception of themselves. Understanding of Disabilities, understanding and accepting yourself and your disabilities is an important step in building strong self-esteem. Athletes who can overcome embarrassmentor mistrust regarding their disability tend to have higher levels of satisfaction. Overcome Challenges, the ability to overcome obstacles and challenges in sports and everyday life can increase feelings of accomplishment and self-worth. When athletes overcome obstacles, they feel stronger and more empowered.

Education and Community Awareness, a society that is more inclusive and aware of disability issues can help reduce stigma and discrimination. A supportive and inclusive environment can promote positive feelings of self-esteem for athletes with disabilities. Focus on Potential, developing potential and talent in sports or other fields can provide a sustained sense of accomplishment and boost self-esteem. Focusing on what can be achieved rather than limitations can help athletes see themselves in a positive light.

Mental and Emotional Health, caring for mental and emotional health is important for all individuals, including athletes with disabilities. Psychological support, stress management, and emotional understanding can help maintain satisfaction with life and self-worth.

It is important to remember that everyone's experience is unique, and feelings of satisfaction with life and self-worth can vary. For athletes with disabilities, creating a supportive environment, facilitating opportunities for development, and promoting inclusion can significantly contribute to increasing their satisfaction with life and self-esteem.

Conclusions

The results of this study allow us to conclude that Portuguese adapted athletes and bocce are satisfied with life. Nonetheless, they present very low levels of self-esteem. The lower functional capacity, as well as the severity of Boccia athletes' deficiency, which requires the use of ancillary means, may be a reason to justify the fact that they present lower values of self-esteem than athletes. The same reason may justify a lower level of satisfaction with the lives of athletes with more sporting experience, since they are also older athletes whose functional capacity deteriorates. Future research suggests the use of instruments that use multidimensional models of self-esteem and satisfaction with life, as well as the use of a control group, without sports practice and with similar sociodemographic deficiencies and characteristics.

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Conflict of Interest

We declare that this article we wrote is not involved in any conflict of interest.

Ethics Statement

The writing of this article has gone through all ethical procedures related to the academic realm. All the principles of the Declaration of Helsinki were complied with number ethical cleareance is 070/A/VI/2023, with special emphasis on informed consent and the vulnerability of the study population.

Authors Contribution

Study Design, CCVL and EB; Data Collection, CCVL, EB, DTPP and EC; Statistical Analysis, CCVL, EB, DTPP and EC; Data Interpretation, CCVL and EB; Manuscript Preparation, CCVL, EB, DTPP and EC; Literature Search, CCVL, EB, DTPP and EC. All authors have read and agreed to the published version of the manuscript.

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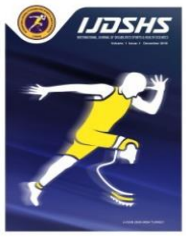

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RESEARCH ARTICLE

Seasonal Changes in Body Composition in Elite Male Handball Players

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Abstract
Having knowledge of an athlete's body composition values enables individuals to assess their physical condition and performance. It has become increasingly important in recent years to demonstrate the significant relationship between body composition and athletes' physical performance. The aim of this study is to examine the changes in body composition of elite male handball players during preparation and competition periods (42 weeks). Twenty-three elite male handball players volunteered for this study The Tanita brand body analysis device was used to evaluate body composition and eight measurements were taken. Athletes were divided according to their playing positions (playmakers n=8 and goalkeepers n=4, wings n=7 and pivots n=4). 7 measurements were evaluated, which were weight (W), body fat percentage (BF%), fat mass (FM), muscle mass (MM), total body water (TBW), body mass index (BMI), and basal metabolic rate (BMR). Wing players had lower body fat percentage and body fat mass than all other playing positions and regardless of position, all athletes' body fat percentage and body fat mass significantly decreased at T2 ($p<0.05$). As a result, increase in body fat percentage and fat mass was observed during the competition period, and this increase continued ($p<0.05$). The increase in fat mass during the competition period may be due to different training content and higher training intensity during the preparation period, changes in nutrition habits due to camps, long trips, and tournaments, as well as the ef-fects of fatigue and stress. Further studies are needed in these areas.

Keywords
Body Composition, Fat Mass, Handball, Male

INTRODUCTION

Body composition is only one of the many factors (physical, physiological, genetic, and psychological) that determine athletic performance. In addition to body size, the structure of body composition components is also important. Body weight can be divided into various components to achieve a more balanced and ap-propriate distribution of fat, muscle, and bone mass (Sundgot-Borgen et.al., 2013). Determining athletes' body composition (low fat and muscle ratios) is an important factor in increasing performance. Having knowledge of an individual's body composition values allows for interpretation of their physical condition and performance. In recent years, it has become increasingly important to show that there is a significant relationship between body composition and athletes' physical performance (Rybakova et. al., 2020). Human physique varies in many ways, and this diversity in physical characteristics in certain sports turns into specific advantages for athletes during the game. Each sport requires a specific body type. A body type unsuitable for a sport can be a significant obstacle to a player's progress. Also, knowing and understanding the effect of training and competition on body composition can help athletes control their weight and safely change their body composition. Additionally, tracking body composition trends in specific sports enables coaches to prepare their athletes correctly for specific competi-tions or positions (Singh et. al., 2011). Handball is an Olympic team sport

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characterized by defensive actions and fast-paced offensive actions to score goals (Martínez-Rodríguez et.al., 2021). It is difficult to determine the factors that affect performance in handball because it is complex and multifactorial, characterized by high-intensity explosive movements. Handball players must coordinate running, jumping, pushing, changing directions, passing, catching, throwing, and blocking movements well. The intensities during the game always vary between standing, walking, sprinting, running at a moderate pace, moving sideways and backward, so a high level of endurance is essential to maintain a high game tempo throughout the game (Póvoas et. al., 2012; Michalsik et. al., 2015). Due to the high physical demands of handball, players need highly devel-oped anthropometric and physical attributes (linear speed, change of direction speed, aerobic capacity, muscle strength, and power) to succeed (Bilge, 2012)

In handball, there are generally four playing positions: 1) goalkeeper: stops the ball in the goal and prevents the opposing team from scoring; 2) playmakers (right-left-center): they are the ones who indicate where the attacks should start, serving as an extension of the coach on the field, and command the team in both offense and defense. The right-left playmakers are effective in both offense and defense; 3) wings: they are the ones who stop closed defenses in the goal area and often assist in scoring; 4) pivot: responsible for creating space by entering the defense wall at possible openings (Karcher & Buchheit, 2014). Handball players need to possess well-developed physical characteristics, including linear and change of direction speed, aerobic capacity, muscular strength, and power, to be successful in the sport. These anthropometric and physical qualities are strongly associated with handball performance and play a crucial role in determining a player's success on the court. Evaluating the match between physical structure and composition, weight, and height is considered important factors in performance, even depending on the sport and player positions (Martínez-Rodríguez et.al., 2020).

In the sport of handball, player profiling can be an effective method of identifying talent, assessing strengths and weaknesses, determining optimal playing positions, and designing personalized strength and conditioning training programs (Karcher & Buchheit, 2014; Schwesig et al., 2017). Through the use of profiles, coaches and coaches can gain valuable information about each player's unique physical and physiological characteristics, which can be used to improve their overall performance and contribute to team success. Evaluation of body composition, with a focus on fat and skeletal muscle content, is particularly important in sports science and practice (Cavedon et. al., 2018). Previous research suggests that certain physical characteristics, including high body mass and stature, are associated with high-level handball performance (Lidor et. al., 2005). In addition, higher values of fatfree mass were associated with better performance, particularly due to increased muscular power and strength (Granados et. al., 2013) and physical characteristics can vary considerably across different player positions in the team (Karcher & Buchheit, 2014; Lidor et. al., 2005).

In talent selection, assessing players' body composition is important in determining their playing positions and developing training programs (Schwesig et al., 2017; Fieseler et. al., 2017). Studies on anthropometry and body composition in handball are available (Milanese et. al., 2011; Owen et. al., 2017). However, no study has been found that examines changes in body composition values in elite male handball players during a season. The aim of this study is to examine changes in body composition between different playing positions in elite male handball players during the preparation and competition periods (42 weeks). We have two hypotheses in this study. Especially in fat and muscle mass: 1- We expect a decrease in fat mass, an increase in muscle mass, at the end of the preparation periods and during the competition period, 2- A decrease in fat mass and an increase in muscle mass between positions.

MATERIALS AND METHODS

Study Design

Twenty-three elite male handball players participated in this study voluntarily (age: 25.41 ± 5.44 yr, height: 190.53 ± 5.79 cm, body weight: 93.71 ± 10.9 kg). After explaining the objectives of the study, written informed consent was obtained from each subject. This study followed ethical standards and received approval from the Zonguldak Bülen Ecevit University Non-invasive

Clinical Research Ethics Committee, reference number (no: 2023/01, date 11.01.2023). 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.This study was designed to examine the changes in body composition during the preparation and competition period (42 weeks) of a handball team competing in the super league in the 2021-2022 season in Turkey. Measurements were taken at 8 different times: preseason (T1), end of preparation period (T2), end of tournament and preparation match period (T3), end of first half (T4), end of second preparation period (T5), second half (T6), after Turkish cup at the end of second half (T7), and end of season (T8) (Table 1).

Table 1. Body composition testing timeline

Month	**August**				**September**					**October**					**November**				**December**				
Week	1	2	3	4	1	2	3	4	5	1	1	2	3	4	1	2	3	4	1	2	3	4	5
Monday	***T1***	TR	TR	TR	TR	TO	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR
Tuesday	C	TR	TR	TR	TO	R	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR
Wednesday	C	TR	TR	TR	TO	TO	TR	TR	TR	TR	TR	TR	TR	M	TR	TR	TR	TR	TR	TR	TR	TR	TR
Thursday	C	TR	TR	TR	TO	TO	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR
Friday	C	TR	TR	TR	TO	TO	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR
Saturday	C	TR	TR	***T2***	TO	TO	TR	M	M	M	M	M	EC	TR	***T4***	M	M	M	M	M	M	TR	TR
Sunday	R	R	R	R	TO	R	R	***T3***	TR	R	R	R	EC	R	TR	R	R	R	R	R	***T4***	R	R
Month	**January**				**February**				**March**					**April**				**May**				**June**	
Week	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4	1	2	3	4	1	2
Monday	TR	TR	TR	TR	TR	TR	R	R	TR	R	R	R	***T7***	TR	TR	R	R	R	R	R	R	***T8***	R
Tuesday	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	R	R
Wednesday	TR	TR	TR	TO	M	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	TR	R	R
Thursday	TR	TR	TO	TR	TR	TR	TR	TR	TR	TR	TR	TC	TC	TR	TR	TR	TR	TR	TR	TR	TR	R	R
Friday	TR	TR	TO	TO	TR	TR	TR	TR	TR	TR	TR	TC	TR	TR	TR	TR	TR	TR	TR	TR	TR	R	R
Saturday	TR	TR	TO	TR	TR	TR	TR	M	TR	TR	TR	TC	TR	M	TR	TR	TR	TR	TR	TR	TR	R	R
Sunday	R	***T5***	R	***T6***	R	M	M	R	M	M	M	TC	R	TR	M	M	M	M	M	M	M	R	R

T- Measurement, C-Camp, TR- Training, TO-Tournament, M-Match, EC-European cup, TC- Turkey cup

The bioelectrical impedance analysis (BIA) is a frequently used method for the evaluation of body composi-tions due to its safety, speed, non-invasiveness, and relatively low cost (Özçetin et. Al., 2017). The assessment of body composition by BIA is based on the passage of a lowintensity (800 μA) and fixedfrequency (50kHz) electrical current through the body. When the electrical current is applied to the body, there is a resistance that opposes the current, called impedance. The drop in voltage between the electrodes provides a measurement of impedance. This is a vector sum of the resistance and conductance properties of body tissues, as well as a reactance (response) that arises from the resistance of cell membranes. Body water is a good conductor of electricity, and muscle clusters, like other tissues, are filled with electrolytes and water. Water offers little re-sistance to the passage of electrical current. Since body fat has a low hydration index, it has a high bioimpedance. Therefore, muscle conducts electricity more easily than fat, and the fat content can be calculated based on the difference between total weight, fatfree body mass, and fat mass (Sampei & Sigulem, 2009).

The Tanita (BC418) body composition analyzer was used to evaluate body composition. The measurement was conducted by an expert, and all measurements were supervised and performed by the sports science and medical team of the club. Athletes were instructed to avoid alcohol and caffeine for 24 hours before the test and to avoid food and fluids for at least four to five hours before the test. They were also instructed not to engage in any physical activity 12 hours before the test. Each measurement was taken at 10:00 in the morning. Athletes were divided into groups according to their playing positions (8 setters and 4

goalkeepers, 7 wings and 4 pivots). Seven measurements were evaluated, including weight, body fat percentage, fat mass, muscle mass, total body water, body mass index, and basal metabolic rate.

Statistical Analysis

The mean and standard deviation values of the weight, body fat percentage, fat mass, muscle mass, total body water, body mass index, and basal metabolic rate.variables were given according to the positions and repetition numbers of all players. The normality assumptions of the variables were examined using the Kolmogorov-Smirnov test. As the variables did not come from a normal distribution, the nonparametric Two-Way Friedman Test for repeated measures was performed.

The Wilcoxon test was used to determine which measurement caused the difference between positions. Statistical significance was set at $p < 0.05$ in all cases. All analyses were performed using IBM-SPSS 21 software.

Table 2. Body composition in handball players according to four playing positions at eight different points across the season (mean ± SD, n = 23)

7	T1	T2	T3	T4	T5	T6	T7	T8	Chi-Sq	*p* value
Weight (kg)										
All players	93.70 ± 10.92	93.71 ± 10.82	94.62 ± 10.66	94.68 ± 10.95	94.33 ± 10.74	94.92 ± 10.93	95.04 ± 10.45	95.04 ± 10.02	10.191	0.178
Goalkeeper	97.50 ± 11.88	97.05 ± 9.40	99.75 ± 5.30	97.95 ± 8.13	98.70 ± 8.20	101.15 ± 7.28	100.60 ± 7.50	100.20 ± 6.65	7.509	0.378
Playmaker	98.15 ± 7.55	97.58 ± 8.05	98.00 ± 8i31	99.10 ± 8.50	98.63 ± 8.90	98.60 ± 9.09	98.75 ± 9.23	98.53 ± 8.25	7.043	0.424
Wings	84.22 ± 7.81	84.58 ± 7.43	85.42 ± 8.82	85.24 ± 8.47	84.98 ± 8.13	85.06 ± 7.52	85.96 ± 7.87	86.48 ± 8.35	10.531	0.16
Pivot	104.70 ± 8.63	105.45 ± 11.24	105.70 ± 7.07	106.15 ± 7.71	104.75 ± 6.86	106.00 ± 6.65	104.75 ± 5.73	104.30 ± 6.08	4.939	0.667
Body fat Percentage (%)										
All players	14.95 ± 4.28	14.01 ± 4.16	14.78 ± 4.36	15.59 ± 3.8	15.38 ± 4.07	16.10 ± 4.14	16.01 ± 4.06	16.72 ± 3.75	27.53	**0.000***
Goalkeeper	19.20 ± 1.13	17.30 ± 0.14	19.60 ± 3.54	19.45 ± 1.06	19.80 ± 0.99	21.10 ± 1.41	21.50 ± 2.69	22.10 ± 3.25	11.275	0.127
Playmaker	14.53 ± 1.75	14.20 ± 1.91	14.08 ± 1.42	15.93 ± 1.07	15.58 ± 1.45	15.98 ± 1.20	15.43 ± 1.05	16.05 ± 1.00	8.413	0.298
Wings	11.98 ± 4.85	11.04 ± 5.07	11.70 ± 4.32	12.66 ± 4.33	12.12 ± 4.30	12.88 ± 4.26	12.86 ± 3.54	14.28 ± 3.74	13.95	**0.050***
Pivot	19.00 ± 1.13	17.75 ± 0.35	19.10 ± 1.27	18.40 ± 2.26	18.75 ± 1.48	19.40 ± 1.70	19.55 ± 0.64	18.80 ± 1.27	5.282	0.626
Body Fat Mass (kg)										
All players	14.28 ± 4.91	13.39 ± 4.65	14.24 ± 4.92	14.98 ± 4.33	14.79 ± 4.75	15.6 ± 4.96	15.47 ± 4.83	16.07 ± 4.36	30.04	**0.000***
Goalkeeper	18.65 ± 1.20	16.75 ± 1.48	19.45 ± 2.47	19.00 ± 0.57	19.50 ± 0.71	21.30 ± 0.14	21.55 ± 1.06	22.05 ± 1.77	11.048	0.137
Playmaker	14.30 ± 2.48	13.88 ± 2.39	13.80 ± 1.70	15.70 ± 0.86	15.45 ± 2.75	15.83 ± 2.41	15.30 ± 2.19	15.75 ± 0.73	9.839	0.198
Wings	10.26 ± 4.42	9.54 ± 4.57	10.14 ± 4.07	11.02 ± 4.16	10.46 ± 3.90	11.16 ± 4.02	11.18 ± 3.50	12.50 ± 3.75	15.737	**0.028***
Pivot	19.95 ± 2.76	18.70 ± 1.56	20.15 ± 0.07	19.45 ± 0.92	19.60 ± 0.28	20.55 ± 0.49	20.45 ± 0.49	19.65 ± 7.36	5.626	0.584
Muscle Mass (kg)										
All players	79.43 ± 7.53	80.33 ± 7.51	80.39 ± 7.75	79.71 ± 8	79.55 ± 7.3	79.34 ± 7.14	79.58 ± 7.22	78.98 ± 7.36	10.757	0.15
Goalkeeper	78.85 ± 10.68	80.30 ± 7.92	80.30 ± 7.78	78.95 ± 7.57	79.20 ± 7.50	79.85 ± 7.14	79.05 ± 8.56	78.15 ± 8.41	7.503	0.378
Playmaker	83.85 ± 5.67	83.73 ± 6.90	84.20 ± 7.53	83.40 ± 8.01	83.20 ± 6.18	82.78 ± 6.82	83.45 ± 7.26	82.78 ± 7.77	4.896	0.673
Wings	73.98 ± 6.14	75.04 ± 5.22	75.30 ± 7.03	74.24 ± 5.88	74.52 ± 6.60	73.92 ± 4.99	74.80 ± 6.07	74.00 ± 5.89	3.759	0.807
Pivot	84.80 ± 5.80	86.80 ± 9.62	85.60 ± 7.07	86.75 ± 8.70	85.15 ± 7.14	85.50 ± 7.21	84.30 ± 5.23	84.65 ± 3.61	2.19	0.949
Total Body Water										
All players	58.15 ± 5.52	58.81 ± 5.49	58.85 ± 5.67	58.35 ± 5.84	58.23 ± 5.35	58.08 ± 5.22	58.26 ± 5.28	57.82 ± 5.39	10.673	0.154
Goalkeeper	57.70 ± 7.78	58.80 ± 5.80	58.80 ± 5.66	57.80 ± 5.52	58.00 ± 5.52	58.50 ± 5.23	57.85 ± 6.29	57.25 ± 6.15	7.503	0.378
Playmaker	61.40 ± 4.17	61.28 ± 5.04	61.65 ± 5.49	61.05 ± 5.86	60.90 ± 4.54	60.58 ± 4.98	61.10 ± 5.31	60.60 ± 5.69	4.803	0.684
Wings	54.14 ± 4.49	54.94 ± 3.83	55.12 ± 5.16	54.36 ± 4.28	54.56 ± 4.86	54.12 ± 3.67	54.78 ± 4.45	54.16 ± 4.30	3.693	0.814
Pivot	62.10 ± 4.24	63.55 ± 7.00	62.65 ± 5.16	63.50 ± 6.36	62.30 ± 5.23	62.60 ± 5.23	61.70 ± 3.82	61.95 ± 2.62	2.506	0.927
Body Mass Index (kg/m^2)										
All players	26.04 ± 2.04	25.98 ± 2.08	26.18 ± 1.99	26.14 ± 1.98	26.09 ± 1.89	26.27 ± 2.06	26.28 ± 1.87	26.28 ± 1.81	7.276	0.4
Goalkeeper	27.20 ± 1.70	26.95 ± 1.20	27.75 ± 0.07	27.10 ± 0.99	27.50 ± 0.85	28.10 ± 0.57	27.95 ± 0.64	28.05 ± 0.21	8.383	0.3
Playmaker	26.40 ± 1.05	26.13 ± 1.14	26.28 ± 1.22	26.50 ± 1.15	26.38 ± 1.33	26.43 ± 1.39	26.40 ± 1.37	26.28 ± 1.07	7.27	0.401
Wings	24.52 ± 1.99	24.62 ± 1.98	24.78 ± 1.99	24.74 ± 2.08	24.66 ± 1.81	24.70 ± 1.85	25.02 ± 1.98	25.16 ± 2.01	13.041	0.071
Pivot	27.95 ± 2.47	28.15 ± 3.18	27.95 ± 2.47	27.95 ± 2.47	27.70 ± 1.98	28.05 ± 2.33	27.55 ± 1.91	27.35 ± 2.19	7.286	0.4
Basal Metabolic Rate										
All players	2364.4±241.9	2389.1±245.77	2394.6±249.11	2376.3±259.68	2368.4±237.51	2363.6 ± 235.3	2370.6±233.73	2353.6±236.68	11.001	0.139
Goalkeeper	2342.0±39.41	2377.0±257.39	2387.0±239.00	2343.0±241.83	2352.0±240.42	2379.0±227.69	2356.0±267.29	2328.0±260.22	7.503	0.378
Playmaker	2477.2±191.13	2472.0±227.46	2487.7±246.34	2470.2±260.03	2460.2±210.85	2449.0±229.29	2469.0±243.39	2450.2±251.85	4.902	0.672
Wings	2197.2±197.42	2226.6±170.44	2238.4±227.98	2208.0±194.49	2212.8±212.66	2192.4±165.90	2221.2±197.74	2200.2±194.32	4.394	0.733
Pivot	2579.5±193.04	2642.0±315.37	2607.0±224.86	2642.5±275.06	2590.5±225.57	2605.5±226.98	2562.0± 61.22	2569.5±116.67	3.564	0.828

T1: pre-season; T2: end of preparation period; T3: end of tournament and preparation match period; T4: end of first half; T5: end of second preparation period; T6: second half; T7: after Turkish cup at the end of second half; T8: end of season

RESULTS

The average values ± SD of the body composition (weight, body fat percentage, fat mass, muscle mass, total body water, body mass index, and basal metabolic rate) arranged according to all players and game positions for the eight applied measurements are shown in Table 2.

In the analysis, only differences were found in body fat percentage and body fat mass values between all athletes and wing players based on the eight measurements ($p<0.05$) (Figure 1, 2). Regardless of the positions, the body fat percentage and body fat mass of all athletes significantly decreased in T2 compared to T1. Compared to T2, an increase was observed in T4, T5, T6, T7, and T8. A decrease was observed in T5 compared to T4. In T6, an increase continued compared to T1, T2, T3, and T5, and in T7, it continued compared to T1 and T2. In T8, an

increase was observed again except for T6 and T7. Among the wing players, an increase was observed in T4 compared to T3, and a significant increase was observed in T2, T3, T5, and T7 compared to T8. Wing players had lower body fat percentage and body fat mass than all other game positions. Although it showed a decrease on average in T2 compared to T3, it was not significant. T4 showed an increase compared to T3. Similarly, in T8, it was significantly higher than T2, T3, T5, and T7. When evaluated both in all athletes and in positions, body fat percentage and body fat mass decreased significantly in the second measurement and increased significantly in the last measurement in wingers. However, in players playing in all positions, a decrease in body fat percentage, fat mass and body mass index was expected, and an increase in muscle mass, especially in the 2nd measurement and afterwards. Additionally, no significant changes were observed in weight, total body water, and basal metabolic rate measurements.

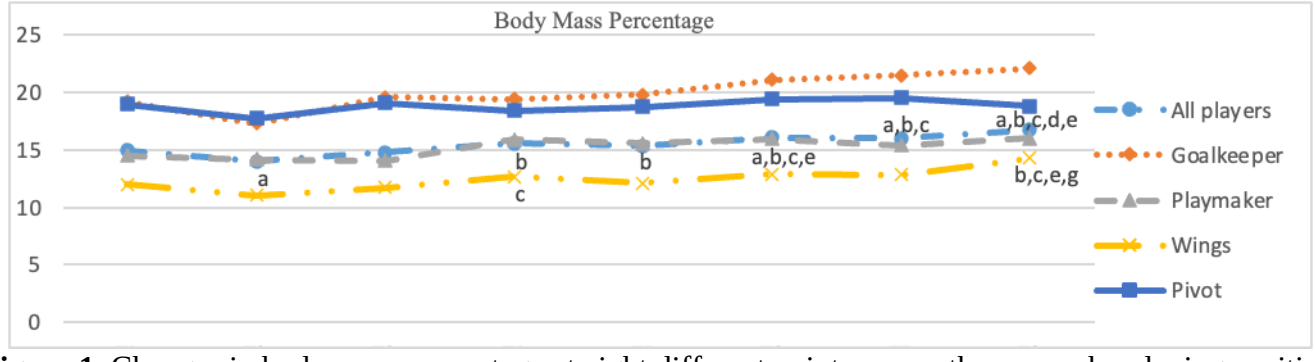

Figure 1. Changes in body mass percentage at eight different points across the season by playing position
[a] Significantly different from T1, [b] Significantly different from T2, [c] Significantly different from T3, [d] Significantly different from T4, [e] Significantly different from T5, [f] Significantly different from T6,[g] Significantly different from T7, [h] Significantly different from T8.

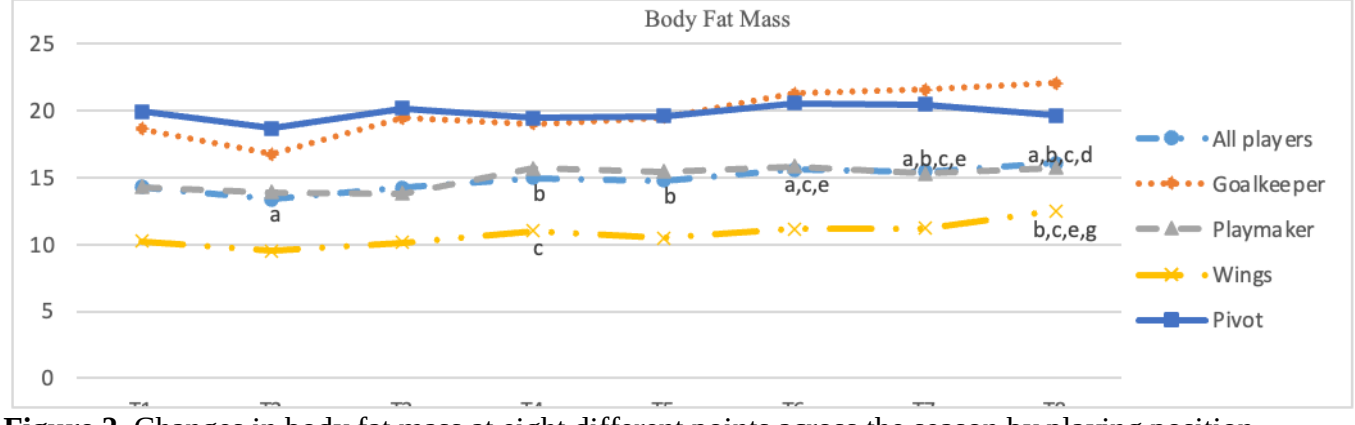

Figure 2. Changes in body fat mass at eight different points across the season by playing position
[a] Significantly different from T1, [b] Significantly different from T2, [c] Significantly different from T3, [d] Significantly different from T4, [e] Significantly different from T5, [f] Significantly different from T6,[g] Significantly different from T7, [h] Significantly different from T8.

DISCUSSION

The aim of this study was to examine changes in body composition of elite male handball players during preparation and competition periods (42 weeks). The main findings of these results are that during the preparation period before the season, all athletes experienced a significant decrease in body fat percentage and body fat mass. However, over the course of the season, a significant increase in body fat percentage and body fat mass was observed at several points, including T4, T5, T6, T7 y T8. It was also observed that wing players had lower body fat percentage and body fat mass than other playing positions. Finally, no significant changes were observed in weight, muscle mass, total body water, body mass index, and basal metabolic rate measurements.

As in the studies conducted by Owen et al. (2018), Lago Peñas et al. (2013) and Madic et al. (2018), it was found that there was a significant decrease in fat mass compared to preseason training start (T1) at T2 (Owen et.al., 2018; Lago-

Penas et. al., 2013; Madic et. al., 2018). The decrease in body fat percentage and fat mass at the end of the general preparation period indicates the result of the high level of aerobic, anaerobic and strength training applied during this period Reilly (1996). Although there was no significant difference in body fat percentage and fat mass at the end of the special preparation period for all players except for wing players playing in other positions, a decrease was observed in the averages. However, unlike the studies by Madic et al. (2018) and Ostojic (2003), in our study, the decrease in body mass percentage and fat mass did not continue after T2 with the competition period (Madic et. al., 2018; Ostojic, 2003). It was observed that there was an increase in body fat percentage and fat mass after T2, and this increase continued. This trend has been observed in other studies on team sport athletes Ostojic, (2003) and may be due to factors such as decreased training intensity and volume during the competitive season, increased travel, and changes in dietary habits.

In team sports, each game position has its own physiological characteristics due to different technical and tactical demands on the field. In handball, wing players have been measured to spend an average of 15 minutes more on the field than other players during the effective game time of 60 minutes. It has also been shown that wing players cover 1,200 meters more total distance than playmakers (2,882 m) or pivots (2,702 m), have two to three times more total sprint distance throughout the match, and have less body fat weight compared to players in other positions (Póvoas et. al., 2012; Büchel et. al., 2019; Mohoric et. al., 2022). Sibila et al. noted that goalkeepers and pivots generally have a higher height than wings, and pivots have more athleticism (more muscle mass) and a strong shot. Numerous studies have shown that wing players are fast, agile, and have a high jumping capacity with a low body mass index, and therefore generally have less weight and lower body fat percentage with the highest aerobic capacity (Schwesig et. al., 2017; Ghobadi et. al., 2013; Sporis et.al., 2010; Massuca et. al., 2015), while pivots are among the longest, heaviest, and slowest players Mohoric et. al., (2022), consisting of strong players constantly in contact and fighting with opponents (Sibila & Pori, 2009). These findings are in line with the results of our study, wing players had significantly lower body fat percentage and body fat mass compared to other positions, which is consistent with previous research on handball players (Martínez-Rodríguez et. al., 2020). This may be due to the specific physical demands of the wing position, which requires lighter and faster bodies to adcuire higher level of speed and capacity to change of movement rapidly (Bojić-Ćaćić et. al., 2018). Furthermore, no significant changes were observed in weight, muscle mass, total body water, body mass index, and basal metabolic rate measurements in all measurements. These findings are consistent with previous research on handball players after preseason training (Cichy et. al., 2020) and may indicate that changes in body composition during the season are primarily due to changes in body fat mass. However, there is limited distribution of body fat mass, there is not a sig-nificant change in most body composition parameters during the competition period (Milanese et. al., 2011).

It is important to note that the study was conducted on a single team and may not be representative of other teams or sports. Additionally, the study only measured body composition and did not take into account other factors that may have contributed to changes in performance, such as changes in strength, power, and sprint. Further research is needed to better understand the relationship between changes in body composition and changes in performance in handball.

As a result, unexpected results were obtained in our study, except for T2. An increase in body fat percentage and fat mass was observed during the competition period, and this increase continued. The increase in fat mass during the competition period could be attributed to the different training content and higher training intensity during the preparation period, changes in nutrition habits due to camps, long trips, and tournaments, as well as the effects of fatigue and stress. Further research is needed on these issues.

Examining body composition is important in sports such as handball, where body weight needs to be moved against gravity. In this study, norms were established for the body composition status of elite male handball players during the preparation and competition periods, and changes in specific periods were monitored. It was observed that handball players improved their body composition during the preparation period.

The increase in body fat percentage and fat mass during the competition process and at the end of the season showed that the transition period after the season should be well evaluated.

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 from the Zonguldak Bülen Ecevit University Non-invasive Clinical Research Ethics Committee, reference number (no: 2023/01, date 11.01.2023).

Author Contributions

Study Design, Data Collection, Statistical Analysis, Data Interpretation, 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

The Effect of Two Different Recovery Methods on Muscle Damage after High-Intensity Exercise

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Abstract
The study aims to determine which of the two recovery methods would be more appropriate after high-intensity exercise. Eight professional volleyball players participate in this research. Firstly, the muscle damage exercise protocol was applied to the athletes participating in the research, and then the Cold Water Immersion (CWI) protocol was applied as a recovery method. Aspartate Aminotransferase (AST), Lactate Dehydrogenase (LDH) and Creatine Kinase (CK) blood samples were taken from the athletes in resting conditions and 2 hours and 24 hours after CWI. Ten days later, the muscle damage exercise protocol was reapplied to the same group of athletes, the Massage protocol was used as a recovery method, and blood samples were taken again in a similar way. To compare the AST, LDH and CK changes of the athletes participating in the research, the two-way analysis of variance test was used in repeated measurements. Mann-Whitney U test was used for the dissimilarities between CWI and massage groups. According to the results of the research; It was determined that there were significant differences at the $p<0.05$ level for the AST and LDH variable between the measurement values of massage and CWI ($p<0.05$). No significant difference was found between massage and CWI for CK value. The use of recovery methods after exercise is relatively significant for athletes. Following the consequences of the research, was observed that the muscle damage of the athletes who received massage treatment was lower than those who were applied CWI.

Keywords
Cold Water Immersion, Massage, Muscle Injury, Recovery

INTRODUCTION

The main purpose of the exercises is to increase performance. Implementation of intense exercise programs can cause muscle damage. After exercise, minor muscle damage occurs at the cellular level in striated muscles. The term exercise-induced muscle damage, which is expressed as temporary damage at the cellular level in skeletal muscles after exercise, is also called micro-trauma, micro-injury or muscle damage (Çakir and Şenel, 2017). Exercise-induced muscle damage, which results in muscle pain, edema, swelling, increased intramuscular proteins, and decreased joint range of motion, is seen especially after unusual high-intensity exercises (Clarkson and Hubal, 2002). Although this situation disturbs the athletes, it is known that it negatively affects athletic performance (Burt and Twist, 2011).

With the right recovery method, ıt is possible to reduce or eliminate the muscle damage that occurs (Şenel and Akyüz, 2010; Murray and Cardinale, 2015). Due to some exercises challenging the organism, some breakdown may occur at the muscle fibre level (Çakir and Şenel, 2017). These pieces of training cause fatigue in the athlete and also cause psychological and physiological stress. The resulting fatigue leads to a decrease in the performance of the athlete (Bigland – Ritchie et al., 1986; Budgett, 1998; Ament and Verkerke, 2009). Depending on the

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scope and intensity of exercise, muscle damage, mental fatigue, decrease in desire and motivation, and increase in perceived difficulty are among the causes of fatigue (Stupnicki et al., 2010; Nedelec et al., 2012; Thorpe et al., 2017). The athlete's rest and recovery after the exercises are at least as essential as the exercise. Exercises done without too much difficulty do not have much effect after a particular level. For this reason, since compelling training is mandatory for the outcome, professional athletes also do compelling training at least once a day. This training cause fatigue in the athlete and also cause psychological and physiological stress (Ament and Verkerke, 2009; Krustrup et al., 2005). Therefore, trainers and technical staff should ensure that the athletes rest and recover after high-intensity exercises to minimize the effect of fatigue on performance, and different recovery methods should be developed and applied for each athlete. Thus, with appropriate recovery methods, the athlete can better prepare for training or competition and keep his/her performance at a high level (Bompa, 2009; Andersson et al., 2008). After high-intensity exercises, different recovery methods have been evolved with the developing technology.

Methods of reducing or preventing the effects of exercise-induced muscle damage symptoms have recently been widely explored. Muscle damage is determined by various methods, either directly or indirectly. Magnetic resonance imaging (MRI) method and evaluation of muscle biopsy findings are used as direct methods for defining muscle damage (McHugh et al., 1999). Monitoring of muscle enzyme serum levels increases such as muscle pain, edema, decrease in muscle strength, creatine kinase (CK), troponin (THS), lactate dehydrogenase (LDH), aspartate aminotransferase (AST) is used as an indirect method. Due to the difficulties in applying direct methods, indirect methods are commonly preferred in research. Markers of muscle damage, muscle soreness, muscle dysfunction, and appearance can vary significantly depending on the type, intensity, and duration of exercise performed (Jakeman et al., 2010).

When the relevant literature is examined, the importance of the effect of massage and CWI, which are applied for recovery, on muscle damage in athletes arouses interest in sports scientists. Athletes cannot find enough rest and recovery opportunities due to intense competition schedules and travels. This situation creates fatigue in athletes. The solution to this is only possible with an effective recovery strategy. To prevent efficiency and performance losses in recovery techniques, the knowledge of the athlete and his trainer facilitates the way to success.

MATERIALS AND METHODS

In this part of the research, the population and the research sample, the design of the study, the warm-up protocol, the Cold Water Immersion (CWI) protocol, the Massage protocol, the data collection process and the analysis are explained.

Population and Sample of the Research

The research consists of 8 male professional volleyball players between the ages of 20-30.

This study followed ethical standards and received approval from the Van Yüzüncüyıl University Non-Interventional Clinical Research Ethics Committeewith reference number (Date: 16.04.2021, Number: E-14010876, Meeting number: 2021/05-16). 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.

Design of the Study

The study is planned into two parts. CWI protocol was applied to the athletes participating in the study, respectively, and the massage protocol was applied ten days after the end of this protocol. Here, it is aimed to investigate the effects of two different recovery exercises on the same athletes on muscle damage.

For CWI; Just before the muscle damage protocol, AST, LDH and CK blood samples were taken from all the athletes participating in the study under resting conditions. Immediately after the muscle damage protocol, the group of athletes were immersed in water at 13.5 ^{o}C for 10 minutes, keeping the neck and shoulders out. AST, LDH and CK blood samples were taken from the study group 2 and 24 hours after the cold water application. As for the massage protocol; Just before the muscle damage protocol, AST, LDH and CK blood samples were taken from all athletes

participating in the study under resting conditions. Afterwards, the athletes in the study group were placed on a massage stretcher, respectively, and a 10-minute classical sports massage including effleurage, petrissage, friction, tapotement and vibration applications for the lower extremities was performed. AST, LDH and CK blood samples were taken from the study group 2 and 24 hours after the massage application.

Muscle Damage Exercise Protocol

The muscle damage exercise protocol consisted of a depth jump from a height of 60 cm. jumps; performed with 5 sets, 20 repetitions and 10 seconds intervals. A rest period of 2 minutes was given between the sets. The athletes who performed the jumps from a height of 60 cm were asked to jump as high as possible from 90 degrees of flexion as soon as they touched the ground. This protocol has been successfully applied in previous studies (Goodall and Howatson, 2008; Kirby et al., 2012; Çakır and Şenel, 2017).

Coldwater Immersion Protocol

The study group is immersed in water at an average of 13.5 °C for 10 minutes, leaving the neck and shoulders out. To keep the temperature of the water constant at 13.5 °C, the temperature of the water is monitored with a thermometer. If the water temperature rises, ice particles are added to the water (Takeda et al., 2014).

Massage Protocol

10-minute classical sports massage including effleurage, petrissage, friction, tapotement and vibration applications for the lower extremities was applied to the study group.

Data Collection Process

On the day before the tests for body composition, the height and body weights of the participants were measured with the Seca measurement scale. The height of the participants with bare feet and their weight with only shorts were measured. Bioelectrical Impedance was used to determine the body fat percentage of the participants. Body temperature was measured with a non-contact thermometer (F.Bosch Fb-Scan).

Biochemical Analysis

5 ml of venous blood samples were taken from the antecubital veins before and after the cold water and massage therapy to evaluate the results of the subjects regarding the biochemical variables. Afterwards, CK, LDH and AST levels of each athlete were determined.

Statistical Analysis

Data analysis was done in SPSS 18 package program. To compare the changes in CK, LDH and AST of the athletes participating in the study, the two-way analysis of variance test was used in repeated measurements. THE Mann-Whitney U test was used to differentiate between Cold Water Immersion and massage groups. The significance level of $p<0.05$ was determined in all of the statistical procedures.

RESULTS

Table 1. Descriptive data of the study group

	Group	n	Minimum	Maximum	X̄	Ss
Age(years)	Experiment	8	20.00	29.00	24.00	75.43
Height(cm)	Experiment	8	180.00	201.00	193.25	125.04
Body Weight(kg)	Experiment	8	74.00	106.00	87.87	600.93
Body Mass Index(kg/height^2)	Experiment	8	20.87	26.24	23.46	25.65

X̄: Average, ss: Sum of Suares

Age values of the study group were calculated as 24 years, height as 193.25 cm, bodyweight as 87.87 kg, body mass index as 23.46 kg/m^2.

Table 2. Comparison of the AST level differences of the massage and cold water ımmersion study group

Group	n	Pre test X̄±Ss.	Intermediate Test X̄±Ss.	Post test X̄±Ss.	Measurement*Group F	p
CWI	8	25.37±7.48	25.50±5.63	21.87±5.59	3,826	0.032*
Massage	8	24.75±5.47	25.12±6.10	21.75±3.91		
Between Groups						
z		-1,125	-3,428	-2.182		
p		0.021*	0.658	0.045*		

*p<0.05; Abbreviations: CWI: Cold Water Immersion, AST: Aspartate Aminotransferase

It was determined that there were significant differences at the p<0.05 level for the AST variable between the measurement values of massage and CWI (p<0.05). Among the study groups of CWI and massage for the AST variable; a significant difference was found for the pre-test and post-test values (p<0.05). No significant difference was found for the intermediate test values (p>0.05).

Table 3. Comparison of the AST level differences of the massage and cold water ımmersion control group

Group	n	Pre test X̄±Ss.	Intermediate Test X̄±Ss.	Post test X̄±Ss.	Measurement*Group F	p
CWI	8	25,27±4,83	27,11±8,64	22,61±6,21	2,262	0,038*
Massage	8	22,25±6,27	23,65±7,21	23,21±4,65		
Between Groups						
z		-1,624	-2,456	1,262		
p		0,042*	0,234	0,034*		

*p<0.05 ; Abbreviations: CWI: Cold Water Immersion, AST: Aspartate Aminotransferase

When the AST levels of the massage and cold water protocols were compared between the groups, it was observed that the massage application after CWI improved significantly according to the pre-test averages (p<0.05), while a statistically significant difference was obtained in the post-test averages compared to the CWI of the massage application (p <0.05).

Table 4. Comparison of the differences in LDH levels of the massage and cold water ımmersion of study group

Group	n	Pre test X̄±Ss.	Intermediate Test X̄±Ss.	Post test X̄±Ss.	Measurement*Group F	p
CWI	8	179.37±13.80	178.25±42.59	164.25±22.92	1,121	0.036*
Massage	8	180.37±18.46	190.12±16.98	169.80±22.94		
Between Groups						
z		2,126	1,815	3,126		
p		0.620	0.038*	0.022*		

*p<0.05; Abbreviations: CWI: Cold Water Immersion, LDH: Lactate Dehydrogenase

It was determined that there were significant differences at the p<0.05 level for the LDH variable between the measurement values of massage and CWI (p<0.05). Among the study groups of CWI and massage for the LDH variable; A significant difference was found for the mid-test

and post-test values (p<0.05). No significant difference was found for the pre-test values (p>0.05).

Table 5. Comparison of the differences in LDH levels of the massage and cold water ımmersion of control group

Group	n	Pre test X̄±Ss.	Intermediate Test X̄±Ss.	Post test X̄±Ss.	Measurement*Group F	p
CWI	8	187,25±15,91	210,21±13,44	170,42±17,61	1,422	0,044*
Massage	8	148,22±12,61	192,11±35,25	176,85±20,52		
Between Groups						
z		-2,364	-1,462	2,356		
p		0,840	0,046*	0,030*		

*p<0.05; Abbreviations: CWI: Cold Water Immersion, LDH: Lactate Dehydrogenase

In the comparison of the athletes participating in the study between the groups, it was determined that the intermediate test average was statistically significant compared to the average of the massage application after CWI, while a statistically significant difference was obtained in the posttest averages compared to the CWI of the massage application (p<0.05).

Table 6. Comparison of the differences in CK levels of the massage and cold water ımmersion of study group

Group	n	Pre test X̄±Ss.	Intermediate Test X̄±Ss.	Post test X̄±Ss.	Measurement*Group F	p
CWI	8	190.97±76.64	245.80±76.96	325.40±81.67	2,232	0.065
Massage	8	185.93±68.65	222.85±82.72	280.97±95.40		
Between Groups						
z		1,862	2,326	2,168		
p		0.009*	0.019*	0.076		

*p<0.05; Abbreviations: CWI: Cold Water Immersion, CK: Creatine Kinase

It was determined that there were no significant differences at the p<0.05 level for the CK variable between the measurement values of massage and CWI (p>0.05). Among the study groups of CWI and massage for the CK variable; A significant difference was found for the pre-test and mid-test values (p<0.05). No significant difference was found for the post-test values (p>0.05).

Table 7. Comparison of the differences in CK levels of the massage and cold water ımmersion of control group

Group	n	Pre test X̄±Ss.	Intermediate Test X̄±Ss.	Post test X̄±Ss.	Measurement*Group F	p
CWI	8	191,52±67,60	257.58±91,21	407,19±60,80	1,486	0,058
Massage	8	194,60±70,28	260,35±90,21	401,41±74,21		
Between Groups						
z		1,325	1,986	-1,865		
p		0,049*	0,055*	0,068		

*p<0.05; Abbreviations: CWI: Cold Water Immersion, CK: Creatine Kinase

While no statistically significant difference was observed in the comparison of the pre-, intermediate and post-test of the athletes participating in the study ($p>0.05$), the mean of the pre-test ($p=0.049$) and the intermediate test ($p=0.055$) compared to the CWI of the massage application protocol in the comparison between the groups was statistically significant. It was determined that there was a significant difference in terms of ($p<0.05$).

DISCUSSION

Muscle damage in athletes occurs after different loading methods. The type of exercise that causes muscle damage the most is methods that include eccentric muscle contractions (Proske and Allen, 2005; Banfi et al., 2010). When serum levels are examined, the damage is primarily observed in serum levels of Creatine Kinase (CK), Aspartate Aminotransferase (AST) and Lactate Dehydrogenase (LDH) (Güzel et al., 2007; Banfi et al., 2007; Nosaka et al., 1992).

When the literature is examined;

In a study investigating the muscle damage, performance and recovery parameters of tennis players during the 4-day tournament, it was determined that the LDH value increased by 15% after the tournament (Çakır and Şenel, 2017). In a study on the effect of muscle damage after intense exercise on 12 young professional football players for the determination of muscle damage, it was observed that LDH and CK values increased (Hazar et al., 2011). In a study on markers of muscle damage after endurance training and amino acid supplementation, it was determined that after 90 minutes of exercise, LDH levels increased 4 hours later and returned to normal after 24 hours (Greer et al., 2007). CK, AST, LDH levels were determined to be higher in the measurement 6 hours after the high-intensity rugby exercise. These enzyme levels of the same athletes reached normal levels only after 24-48 hours (Takeda, 2014). There are other studies in which AST, LDH and CK levels, which are markers of muscle damage, reach their maximum values between 4-6 hours after exercise and within 24 hours, and return to normal within a maximum of 48 hours (Clarkson et al., 2006; Banfi et al., 2010).

In a study conducted on 20 male futsal players to investigate the effects of cold water immersion on muscle damage, it was determined that AST, LDH and CK parameters were lower in the cold water immersion group, which shortened the recovery time. In the measurements 24 hours after the cold water immersion, it was determined that the AST and CK levels of the experimental group were lower than the control group in all (Çakır, 2017). When the difference between the groups was examined in the study on the effect of cold water immersion on recovery, AST and LDH levels were statistically significant ($p<0.05$), while no significant difference was found in CK levels (Bleakley et al., 2012). When the effect of passive, active and contrast water bath application on recovery was investigated, it was determined that the most effective method was the contrast water method (Coffey et al., 2004). In another study, no significant difference was found between the data on active recovery, cold water immersion and cold compression therapy (Chan et al., 2016). In the study conducted on 41 male athletes from football, volleyball and rugby players, the athletes were divided into 4 groups and different recovery methods were applied to each group. Enzyme values, which are a marker of muscle damage, were measured for up to 24 hours in the athletes who were applied hot water immersion, cold water immersion, passive rest and contrast water therapy methods. It was concluded that cold water immersion and Contrast water had a greater effect on recovery (Pournot et al., 2011).

It has been stated that the half-time in blood lactate level after massage application is higher compared to active and passive rest (Medbo and Tabata, 1993). In another study conducted on 30 athletes, it was reported that there was a decrease in fatigue and a significant effect on performance after massage (Robertson et al., 2004; Lane and Wenger, 2004). In the study on the effect of massage on muscle damage, AST, ALT, CK, LDH rates were determined from blood samples taken immediately after training, 3 hours, 48 hours and 72 hours. It was determined that there was a statistically significant difference in AST, CK, LDH and ALT levels between the groups that received and did not receive massage (Korkmaz, 2019). In a study conducted on 19 football players to examine the effect of massage on muscle damage after weight training, it was observed that CK levels improved up to 30% compared to the group that was not massaged (Korkmaz, 2019). In the study, which was applied on thirteen rugby

players and investigated the recovery effects with cold water immersion, hot water therapy and massage, it was determined that the CK level of the cold water immersion group had a greater decrease (Banfi et al., 2007).

Before reaching the final results, considering the universe of the athletes, the analysis of the athletes participating in this study for a certain age group and the evaluation of the athletes only with man volleyball players were determined as a limitation of the research. It was determined that cold water immersion and massage produces effects on reducing muscle damage. However, massage, which is one of the recovery methods applied after high-intensity exercise, was defined to be more effective than cold water immersion in reducing muscle damage. When the general performance of the groups was examined, It was seen that massage provided less muscle damage and therefore more performance improvement in recovery than other groups. When the blood values of the groups were compared from the pre (initial) test to the post-test, It was concluded that the positive change in the massage was more than the other groups.

Conflict of interest

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

Ethics Committee

The study was approved by the local university Non-Interventional Clinical Research Ethics Committee (Date: 16.04.2021, Number: E-14010876, Meeting number: 2021/05-16)

Author Contributions

Planned by the authors: Study Design, Data Collection, Statistical Analysis, Data Interpretation, Manuscript Preparation, Literature Search. Authors have read and agreed to the published version of the manuscript.

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RESEARCH ARTICLE

Examining the Effect of 8-Week Educational Games on Gross Motor Skills in Children with Autism

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Abstract
Families with autistic children expect their children to be self-sufficient and to play games like normal children. However, it appears that there are few initiatives and scientific research in our nation that would emphasize the importance of physical activity-based educational games in order to overcome this problem. The study's goal was to look at the impact of educational games on the development of gross muscular motor skills in people with autism. The study comprised 11 boys aged 10 to 12 who had never previously engaged in an educational game program on a regular basis. Measurements were gathered from the participants twice: once before the 8-week instructional gaming program and once after it ended. The control group received no instructional game software. The SPSS package application was used to perform statistical analysis on the data. There was a significant difference between the experimental group's pre-test and post-test results in hand grip, medicine ball throwing, speed, flexibility, sit-up, and balance ($p<0.05$). As a result, at the end of eight weeks, the educational game program based on physical activity and exercise had a positive influence on the gross motor abilities of children with autism. It may be recommended in this regard to further extend and promote educational game programs, as well as to include educational games in the education programs of children with autism.

Keywords
Autism, Educational Game, Motor Skills, Physical Development

INTRODUCTION

Autism is defined as a complicated neurodevelopmental illness marked by limited (Apa, 2013) and repetitive behaviors in social and communication abilities, and it has become increasingly common in recent years, with 1 in every 44 children being affected (Maenner et al., 2021). The causes of autism have yet to be discovered. As a result, its origin could not be determined. A framework for autism diagnosis has been developed through scientific research. Autism is a chronic neurological and psychiatric disorder that impairs the quality of life for people with the disease and their parents who are responsible for their care. Various therapy approaches used by families with autistic children over the years, as well as the efforts they made toward their recovery, have failed to produce results. However, in recent years, studies indicating that physical activities improve mental and physical health in people with autism (Baptista and Janz, 2012; Mikkelsen et al., 2017) have given families with autistic children hope.

Scientific studies on the benefits of physical activity for disabled people show that it has a significant impact on the physical, emotional, and social well-being of both healthy and impaired people (Aydemir et al. 2020). Physical activity is stated to be a greater need for disabled individuals in terms of providing them with a sense of success and pleasure, being at peace with their disability,

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struggling, and providing positive gains in social communication, in addition to its positive effect on the affective and psychomotor development problems of disabled individuals. Appropriate physical and motoric development is an unavoidable requirement for participation in physical activities, and activities modified for impaired individuals should be prioritized; the goal is to make physical and motoric features compatible with physical activity standards (Polat, 2019).

Physical activity-based educational activities can help children with autism improve their quality of life by enhancing their basic motor abilities, decreasing behavioral issues, assuring balance, acquiring hand-eye coordination, and communication skills. The multi-media and interactive features of educational games will aid not only in the development of motor skills but also in sociability. The physical and motoric development afforded by educational games will contribute to the general health of the autistic individual by increasing self-confidence and a sense of success. Autism and other disability groups must plan physical activity programs that take into account the limitations of individuals with autism, their living standards, their families' expectations, and the belief that they should be treated as individuals in society. In light of this information, the study looked at the impact of educational games on the development of major motor skills in people with autism.

MATERIALS AND METHODS

This study followed ethical standards and received approval from the Frat University's Non-Interventional Research Ethics Committee with reference number (March 23, 2023, session number 2023/05-22). 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. Patients diagnosed with autism by psychiatrists and attending a special education and rehabilitation center in Elazig, 11 boys aged 10-12 who had never consistently engaged in any educational gaming program before, took part in the study. The experimental group had six persons and the control group had five people. Educational games were applied to the experimental group for 60 minutes a day, 3 days a week, for 8 weeks. As a result of the preliminary performance tests, a homogeneous grouping was made as much as possible within the framework of the limitations determined and foreseen. The special education expert and psychologist working in the unit were also consulted when identifying the children with autism who would be involved in the study. Before beginning to work with autistic children, institutional managers, instructors, and students' families were interviewed, the study was explained, and the appropriate approvals were secured. The study was carried out in a special education and rehabilitation center, in halls equipped with appropriate flooring, heat, light, and sound insulation for educational games. Measurements were also made in these halls. Before starting the educational games, dynamic warm-up and stretching movements were performed for the first 10 minutes. In the main segment, educational games were played for 40 minutes. To round up the one-day educational game program, 10 minutes of static relaxation and cooling activities were conducted following the educational game. Measurements were gathered from the participants twice: once before the 8-week instructional gaming program and once after it ended.

Prerequisites for children with autism to participate in the study

Children with autism are between the ages of 10-12. Families provide voluntary consent forms. Ability to carry out given commands. Not reacting unnecessarily to touch. No other disability. Having the ability to hold the toilet. To determine these prerequisite skills, information was obtained from their instructors and families.

Educational games to be played by the experimental group in the study

Movements in autistic children must be very repetitious in order to achieve progress. As a result, one instructive game was played each week. Eight instructive games were played and completed in total. Eight educational games were chosen with age group and developmental features in mind (Aynacıyan, 2020).

Collection of Data

Height Measurement

The participants were measured for height while standing barefoot with their heads upright, using a meter, and the values obtained were entered in cm on the participants' form.

Body Weight Measurement

Participants were asked to wear t-shirts and shorts while their body weight was determined. Body weights were determined in kilograms (kg) using an electronic scale**.**

Body Mass Index (BMI) Calculation

The body mass index values of the participants were determined by the body mass index formula.

Standing Long Jump

Participants began by standing behind the line (feet shoulder-width apart, toes not touching the line). He executed the jump by stooping down, generating strength by moving his arms backwards and then forwards, then supported himself with his legs after being told he could. The distance in centimeters between the limbed person's end point and starting point, which was the shortest between the location where he jumped and the point of his fall, was measured (Urlu, 2014).

Right- and Left-Hand Grip Strength

In a standing position (feet shoulder-width apart) and looking directly forward, the participant squeezed the dynamometer with maximum effort, with the upper arm hanging straight down and the forearm positioned at a 180-degree angle. The tester was instructed to do the test by saying, "Are you ready?" and "Now squeeze with all your strength." The participant was careful not to shake the dynamometer, no matter how hard he tried, and neither a change in the original body position nor contact of the hand with the body was permitted during the experiment. After the value was written, the dynamometer was reset, and after a 30-60 second rest was given with the same hand between trials, the participant was prepared for the next trial (Özer, 2013).

Medicine Ball Throw

The competitor stood at the line-drawn starting point and threw the medicine ball forward over his head in a throw-in stance. The first location at which the medicine ball made contact with the ground was determined, and the distance from this point to the beginning position was measured in centimeters (Urlu, 2014; Yan, 2007).

20m Sprint

With the use of lines and skittles, a straight track with clearly defined starting and finishing places has been built. It began when the participant was prepared. The time began when he passed the starting line and ended when he reached the finish line (one leg was sufficient) (Çıplak et al. 2020).

Sit-Reach Test

If the participant sat on the ground for an extended period of time, his legs were straight and the bottom of his foot was put on the bottom of the sit-and-reach test platform. The apparatus on the box was moved forward with both hands while maintaining the beginning posture. The number advanced by waiting for 2 seconds was recorded as a result of yawning (Özer, 2013).

Sit Up Test

The participant was instructed to sit on the mat and lie back, with his hands clasped around his neck, his feet bent at a 90o angle, and his feet touching the mat. Then he was instructed to lie on his back with his shoulders on the mat. He sat down with his elbows forward in order to acquire a comfortable take-off position. The subject was instructed to do as many sit-ups as he could in 30 seconds, which began when he was ready, and the number of sit-ups he could complete was recorded.

Flamingo Balance Test

Participant is 50 cm long, 4 cm tall, and 3 cm wide. For one minute, stand on a wide wooden balancing beam. He attempted to maintain his equilibrium throughout. Time is halted when the equilibrium is interrupted (if he lets go while gripping his foot, falls off the board, touches the ground with any part of his body, etc.). The timer restarted when the individual restored his balance by climbing on the balancing beam. This pattern was repeated for one minute. When the time was up, each effort by the participant to retain balance (after falling) was counted and recorded as a score at the end of the test when one minute was over (Deforche et al., 2003).

Analysis of Data

The SPSS package application was used to perform statistical analysis on the data. As descriptive statistics, mean, standard deviation, percentage, and frequency distribution approaches were used. The data was normality tested and parametric tests were used for the data that was found to be normally distributed. The "Paired Samples t" test was used in the study to compare within groups. The threshold for statistical significance was set at $p<0.05$.

RESULTS

When Table 1 is assessed, it is monitored that the average age of the control group is 11.6 minimum height is 133 cm and the maximum is 159 cm. The minimum body weight is 26.5 kg and the maximum body weight is 40 kg. years, the average height is 143.20cm, and the average body weight is 34.10 kg. The youngest participant in the control group is 11 years old, while the oldest is 12 years old. It is seen that the

Table 1. Analysis results showing age, height and body weight values of the control group

Variable	N	Mean	Minimum	Maximum
Age (years)	5	11,6	11	12
Height (cm)	5	143,20	133	159
Body Weight (kg)	5	34,10	26,50	40

When Table 2 is scrutinized, it is seen that the average age of the experimental group is 11.17 years, the average height is 145.83cm, and the average body weight is 35.33 kg. The youngest participant in the experimental group is 10 years old, while the oldest is 12 years old. It is seen that the minimum height is 135 cm and the maximum is 160 cm. The minimum body weight is 28 kg and the maximum body weight is 45 kg.

Table 2. Analysis results showing age, height and body weight values of the experimental group

Variance	N	Mean	Minimum	Maximum
Age (year)	6	11,17	10	12
Height (cm)	6	145,83	135	160
Body Weight (kg)	6	35,33	28	45

When Table 3 is examined, no significant difference was detected between the pre-test and post-test scores of the control group in hand grip, medicine ball throwing, speed, flexibility, shuttle and balance ($p>0.05$).

Table 3. Analysis results showing control group gross motor skill measurement values

		Pre Test	Post Test		
Measurement	**N**	Mean±Sd	Mean±Sd	**T**	**P***
Hand Grip	5	18,56±10,19	18,45±9,45	,362	0.735
Medicine Ball Throw	5	241,40±101,62	240,2±97,59	,673	0.121
Speed Test	5	8,74±0,75	8,78±0,74	-,395	0.713
Flexibility	5	21,40±15,04	21,72±14,66	1,233	0.285
Shuttle	5	4,80±0,84	5±0,71	-,535	0.621
Balance	5	19,11±9,14	18,97±8,89	,467	0.665

When Table 4 is analyzed, a significant difference was detected between the pre-test and post-test scores of the experimental group in hand grip, medicine ball throwing, speed, flexibility, shuttle and balance ($p<0.05$).

Table 4. Experimental Group Gross Motor Motor Skill Measurement Values Analysis Results

		Pre Test	Post Test		
Measurement	**N**	Mean±Sd	Meant±Sd	**T**	**P***
Hand Grip	6	11,47±6,19	12,75±6,48	-6,559	0.001
Medicine Ball Throw	6	197±58,41	250,5±55,53	-4,995	0.004
Speed Test	6	8,63±0,84	7,65±0,96	6,411	0.001
Flexibility	6	19,17±7,25	22,5±7,34	-5,423	0.003
Shuttle	6	3,83±0,75	5,83±0,98	-7,746	0.001
Balance	6	14,08±6,01	15,41±6,02	-9,053	0.000

DISCUSSION

Individuals with autism have difficulty using gross muscular motor abilities when compared to their typically developing counterparts. The utilization of large muscle groups varies. Fat is defined as the inability to display large and small muscle talents as well as a lack of intramuscular coordination. Individuals with autism have more difficulties in aspects such as speed, flexibility, balance, and gait when compared to their typically developing peers (Kars et al. 2020; Kara et al. 2019; Yarımkaya et al. 2017; Yanardağ et al. 2009).

The effect of educational games on the development of big motor skills in people with autism was investigated in this study. According to the findings of the study, 8 weeks of exercise and physical activity-based educational activities increased gross muscular motor skills in children with autism. There was a significant link found between pre-test and post-test hand grip, medicine ball throwing, speed, flexibility, shuttle, and balance scores.

When the literature was reviewed, it was found that children with autism who participated in physical education, exercise, and movement training programs improved their social skills, gained mobility, and achieved physical and social growth through educational games (Derer, 2018; Alp and Çamlıyer, 2018). The benefits of an 8-week educational play program on children with autism were studied, and it was discovered that the play program offered a general improvement in children with autism and reduced potentially troublesome behaviors (Tezcan and Sadik, 2018). In another study, it was found that adapted game-supported physical education programs improved motor skills in children with autism (Akin and Alp, 2019). In a study that looked at the influence of sports training on basic motor abilities in children with autism, it was discovered that after sports training, they could do several actions that they couldn't accomplish before (Elaltunkara, 2017). 25 studies were analyzed in a comprehensive meta-analysis research on the importance of physical education and sports in children with autism. According to the findings of the study, physical education, educational gaming programs, and movement training programs improved motor skills (Kaya and Alp, (2022). These findings, as disclosed by scientific methods, support the findings of our study. It is seen that children with autism who leave a sedentary lifestyle behind and participate in exercise programs show physical development. It can be said that exercise programs and educational games have an effect on the development of gross motor skills.

Conclusion

As a result, it has been determined that educational games focused on exercise and physical activity improve the gross motor skills of children with autism. Regular and structured use of exercise-based educational games will improve the physical development and quality of life of people with autism. Given the literature and our findings, it is advised that educational game programs be expanded and disseminated, as well as educational games be included in the education programs of children with autism, in order to protect and continue the development of children with autism.

Appreciation

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Conflict of Interest

No conflict of interest is declared by the authors.

Ethics Committee

The study protocol was approved by the Ethics Committee of the Institute of Health Sciences of Firat University (Ethics Committee Approval: 2023/05-22).

Author Contributions

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

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RESEARCH ARTICLE

The Impact of Training Program Utilizing Elastic Bands on Selected Physical and Skill Variables among Volleyball Players

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Abstract
This study aimed to explore the impact of a training program using elastic bands on selected physical and skill variables among volleyball players of Palestine Technical University – Kadoorie. Twenty male volleyball players were selected, their arithmetic average age was 20.45 years, and they were divided into two groups, (10) players for the pre-training test (control) and (10) players for the post-training test (experimental). The experimental group participated in an elastic band training program for two months**.** The data were analyzed using the statistical analysis program SPSS, and this was done by t-test to determine the differences between the pre- and post-measurements and the equivalence between the experimental and control group. The results indicated that there were statistically significant differences in the post-measurement between the experimental and control groups for selected physical and skill variables among the volleyball players, in favor of the experimental group. The percentage and p values of change in these measure variables tests were the Spiking (20.51%; p=0.011), Blocking (18.18%; p=0.001), Vertical Jump from Standstill (9.71%; p=0.033), Vertical Jump from Movement (5.37%; p=0.037), Medical Ball Throws from Overhead (2.81%; p=0.022), Medical Ball Throws from Chest (3.23%; p=0.001), and Push-Up (35.80%; p=0.001). This study concludes that elastic band training represents a promising evolution in the development of volleyball players, and is considered a comprehensive approach to improving their physical and skill attributes and enhancing their overall abilities on the court. This study recommended conducting additional research and applying elastic band training in the field of sports performance.

Keywords
Elastic Bands, Physical Variants, And Physical Skills, Ptuk Male Volleyball Game

INTRODUCTION

Improving one's physical qualities and honing one's skill sets are two of the most important objectives that athletes can pursue in the pursuit of reaching their full potential in their respective sports (Mamirzhon, 2023). A holistic approach to training is required for volleyball

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because it is a sport that is both dynamic and demanding. This type of training must address both the physical and skill-related aspects of the game (Rasuljon & Nomozbek, 2022). Within the framework of the Palestine Technical University - Kadoorie volleyball team, this paper investigates the potential influence of a suggested training regimen that involves the utilization of elastic bands on a variety of different physical and skill characteristics.

The efficacy of elastic band training in enhancing numerous volleyball-relevant physical qualities has attracted attention. Muscular strength, stamina, and fortitude are the pillars of an athlete's performance. Elastic bands can offer a unique type of resistance that challenges muscles throughout their entire range of motion, promoting balanced growth and reducing the risk of muscle imbalances (Sari et al., 2023). By replicating game-specific movements and enhancing proprioception, these bands also facilitate functional training (Tarigan et al., 2022). In addition, the bands can be tailored to meet the requirements of each individual, making them an excellent training aid for athletes of all fitness levels. This adaptability enables athletes to progressively increase their resistance, resulting in continuous strength and power gains (Nasrulloh et al., 2021). The Palestine Technical University volleyball team could considerably improve their vertical leap height, hitting power, and general agility by incorporating elastic bands into their training regimen.

Elastic band training has recently received a great deal of attention in the field of sports science due to its ability to improve a broad range of physical characteristics and skill components applicable to a variety of athletic disciplines (Ayyub et al., 2023). While the overwhelming majority of research on elastic bands has focused on contexts like strength training and rehabilitation, there is a growing interest in their application to sport-specific training, especially in dynamic sports like volleyball. This interest is fueled by the fact that elastic bands are relatively inexpensive and portable (Ibrahim, 2022). Improvement of Physical Traits Numerous studies examining the effects of elastic band exercise on an individual's physical characteristics have yielded encouraging results. The variable resistance profile of elastic bands stimulates muscles throughout the entire spectrum of motion, making them useful for developing physical strength (Yee, 2019). This unique characteristic promotes regulated muscle activation and reduces the risk of developing muscle imbalances in comparison to conventional weight training. Moreover, due to the progressive nature of elastic bands, athletes are able to continuously adapt to new challenges and increase the level of resistance they confront, resulting in ongoing strength gains (Biçer, 2021).

Volleyball players must also have the ability to maintain their energy levels for extended periods of time. Elastic band exercises, which emphasize eccentric and concentric muscle contractions, are intended to simulate the demands of sports that involve frequent and rapid changes in movement and direction. This training method improves muscular endurance and stamina due to the simulation of game-specific movements (Sari et al., 2023). Elastic band research has primarily focused on enhancing strength, which is essential for explosive volleyball activities such as spiking and jumping. The elastic properties of elastic bands enable athletes to generate force more rapidly, which in turn promotes rapid muscle contractions and neuromuscular adaptations. This can result in an increase in power output and vertical jump height, both of which are required for effective launching and blocking (Nasrulloh et al., 2021).

In addition to enhancing, one's physical attributes, elastic band training can enhance one's comprehensive skill set. This is an essential topic that requires additional research. Volleyball skills such as serving, striking, and blocking require exceptional timing, coordination, and precision. It is possible to incorporate elastic bands on purpose into a variety of skill-specific exercises in order to enhance these attributes. By utilizing bands during spiking exercises, for instance, players are forced to exert more effort during both the upward and downward portions of the motion. This results in stronger shocks and enhanced striking precision (Elsharnoby, 2022). Moreover, elastic band exercises provide a platform for neuromuscular adaptation, which trains muscles to contract at the appropriate moment and in perfect harmony with one another. This flexibility can result in improved coordination, agility, and overall skill execution, all of which are essential for effective volleyball performance. One of the most essential aspects of the game is its adaptability (Masel & Maciejczyk, 2022).

The psychological effects of elastic band training are a subject of increasing study. An additional area of interest is the dynamics of teamwork. Unique training techniques, such as elastic bands, can invigorate workouts. This prevents training from becoming monotonous and increases athletes' motivation. Athletes who are able to surmount the obstacles presented by elastic bands can increase their sense of accomplishment, self-confidence, and self-efficacy (Xu, 2019). In addition, elastic band training can help enhance team dynamics due to its group nature. Developing a sense of solidarity and unity among group members can be facilitated by engaging in a shared activity, overcoming obstacles together, and bearing witness to the progress of other group members. This enhanced team spirit can have a positive effect on communication, collaboration, and synergy on the playing field (Hammami et al., 2022).

Incorporation into Volleyball Practice although the potential benefits of elastic band training are evident, careful planning is required for its successful incorporation into volleyball training regimens. Several aspects, such as exercise selection, progression, and periodization, must be modified to meet the unique demands of volleyball (Sari et al., 2023). Trainers and sports scientists must collaborate to develop a comprehensive and well-balanced training program for athletes. This program should incorporate elastic band exercises as well as other training methods (Ayyub et al., 2023). The Palestine Technical University - Kadoorie volleyball team faces a multifaceted challenge in the realm of sports performance enhancement that incorporates both physical attributes and the refinement of skills. As the team seeks for optimal performance and competitive success, it must address the intricate interplay between the development of essential physical qualities and the refinement of complex skill sets. The inadequacy of the current training regimen to provide an all-encompassing solution to this problem may hinder the team's ability to reach their maximum potential on the court (Salameh & Nassar, 2023).

While the team engages in regular training sessions, the current approach may lack the diversity and specificity required to effectively target the physical attributes and skill components specific to volleyball. Absence of a customized and integrated training program may result in suboptimal gains in muscular strength, endurance, power, and agility, which are the foundations of effective performance. Moreover, the current training program may not adequately address the complexities of skill refinement, such as serving, spiking, and blocking, which require precise timing, coordination, and execution (Nassar, 2022). Additionally, it is important to consider the psychological and team cohesion components of training. A lack of novel and engaging training methods may contribute to a decline in player motivation and zeal. This may impact their confidence and perception of self-efficacy, which are crucial psychological factors that influence performance. In addition, the team's dynamics and sense of unity may not be optimal, which may hinder team spirit and collaborative efforts during matches (Salameh & Nassar, 2023).

In light of these obstacles, there is a clear need for a comprehensive and innovative training program that addresses the psychological and team cohesion aspects of performance enhancement. Such a program should include elements that cater to the specific demands of volleyball and provide a holistic approach that propels the volleyball team at Palestine Technical University - Kadoorie to peak performance. To ensure the team achieves its objectives and maintains a competitive advantage in the dynamic and demanding world of volleyball, it is essential to address these difficult obstacles.

This study is critical for furthering our understanding of volleyball-specific athlete performance enhancement, skill development, and novel training strategies. The importance of such study is underscored by its potential to improve athlete achievement, coaching efficacy, scientific knowledge, and the sports community as a whole. By addressing numerous dimensions of athlete development, this research has the potential to increase the performance of the Palestine Technical University - Kadoorie volleyball team and inspire beneficial improvements in the field of sports training and performance enhancement.

In light of the previous discussion the study aimed to investigate the following:

The impact of a training program using elastic bands on selected physical and skill variables among volleyball players of Palestine Technical University - Kadoorie.

The impact of the conventional program on selected physical and skill variables among

volleyball players of Palestine Technical University - Kadoorie.

The differences between the experimental and control groups in terms of selected physical and skill variables among volleyball players of Palestine Technical University - Kadoorie.

MATERIALS AND METHODS

The methodology of this study was carefully planned to analyze the influence of a proposed training program utilizing elastic bands on selected physical and skill variables among volleyball players at Palestine Technical University - Kadoorie. The study attempted to provide a complete view of the intervention's impacts by using a quantitative approach.

Participants

The study's participants were all male volleyball players from Palestine Technical University - Kadoorie's team. A purposive sampling strategy was used to ensure a representative sample of athletes with various skill levels and experience. Before giving informed consent to participate, participants were informed about the study's objectives, procedures, and potential risks.

A sample of (20) players was chosen and it was divided into two groups, (10) players for the pre-training test (control) and (10) players for the post-training test (experimental).

This study followed ethical standards and received approval from the Faculty of Physical Education and Sports Sciences, Palestine Technical University - Kadoorie with reference number (2023/20 from 1.2.2023-2.4.2023). 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.

Data Collection Procedure

Spatial and Temporal Context

Ethical permission and informed consent were obtained from the Scientific and Ethical Committee of the Faculty of Physical Education and Sport Sciences, Palestine Technical University- Kadoorie to conduct this study. Also, written informed consent was obtained from all participants before beginning to collect data related to the study.

The research was carried out on the campus of Palestine Technical University - Kadoorie, making use of its specific sports facilities and courts. The intervention lasted from February 10, 2023 through April 10, 2023. This timeframe corresponded to the second semester of the academic year 2022/2023.

Experimental Design

The study used a pre-test and post-test design, comparing the effects of the proposed elastic band training program to a control group that followed a traditional training routine. The experimental group participated in a planned training program that included elastic band workouts aimed at certain physical qualities and volleyball skills. The control group continued with their regular exercise schedule.

Skill Variables

Spiking Test:

According to (Zhou et al., 2020) spiking can be tested using the following steps:

A few meters from the net, place the participant in the attacking position. The player begins behind the assault line (3-meter line) and approaches using the standard footwork of the team. A setter or coach delivers a set to the striking zone of a player. The player executes a spike with the objective of sending the ball over the net and into a designated location on the opponent's court. The administrator of the test documents the number of effective spikes, their accuracy, and the landing zones of the ball.

Blocking Test:

According to (Zonifa, 2020) blocking can be tested using the following steps:

Position the participant at the net so that he or she is prepared for defensive blocking actions. A coach or teammate simulates real-game situations by performing assaults (spikes) from the opposite side of the net. The player attempts to intercept and redirect the spiking ball back to the opponent's side of the court by executing blocking movements. The administrator of the test records the number of effective blocks, the accuracy of blocks (in or out of bounds), and the position of the player relative to the net.

Physical Variables

According to (Masel & Maciejczyk, 2022; Salameh & Nassar, 2023; Zhou et al., 2020; Zonifa, 2020) the following tests can be tested using the following steps:

Vertical Jump from Standstill:

Place the athlete in a predetermined starting area. Request that the athlete stand with his or her the athlete to take a preparatory step or movement (approach). During the preparatory movement, instruct the athlete to bow their knees and swing their arms behind them. On the "go" signal, the athlete extends their hips, knees, and ankles to leap as high as possible vertically.

Medical Ball Throws from Overhead Test: Assessing Upper Body Power

Place the athlete in the designated location for throwing. Request that the athlete stand with feet shoulder-width apart and the medical ball held overhead. Instruct the athlete to engage their core muscles and hurl the medical ball with a swift, powerful motion forward and upward.

Medical Ball Throws from Chest Test: Evaluating Upper Body Explosiveness

Place the athlete in the designated location for throwing. Request that the athlete hold the medical ball with elbows bent and arms near to the body at chest level. Instruct the athlete to engage their core muscles and hurl the medical ball with a swift, powerful motion.

Push-Up Test: Evaluating Upper Body Strength and Endurance

Place the individual on the exercise mat in a prone position. Instruct the person to position their palms slightly wider than shoulder-width apart and in alignment with their chest. The feet should be near together or approximately hip-width apart, and the body should form a straight line from the head to the heels. Instruct the individual to lower their body until their chest is near to the mat by bending their elbows. The individual then pushes themselves up to the beginning position.

Statistical analysis

ankles shoulder-width apart. Tell the athlete to straighten their knees and swing their arms behind them. On the "go" signal, the athlete extends their hips, knees, and ankles to leap as high as possible vertically.

Vertical Jump from Movement

Place the athlete in a predetermined starting area. Before executing the vertical leap, instruct

Quantitative data collecting includes employing approved techniques to measure specified physical and skill variables. Pre-test measures were taken prior to the intervention, and post-test measurements were taken at the conclusion of the training period. Statistical analysis of the data was performed, checked, coded, and entered into the statistical program Statistical Package for the Social Sciences (SPSS) (version 24, IBM, USA). Where data related to physical and skill training (Spiking, Blocking, Vertical Jump from Standstill, Vertical Jump from Movement, Medical Ball Throws from Overhead, Medical Ball Throws from Chest, Push-Up) were analyzed and processed for the pre and post-tests. This data was analyzed using descriptive statistics (arithmetic mean, standard deviation, skewness, coefficient of torsion). In this context, using the (Independent Samples t-test) and (Paired Samples t-test) the data obtained were analyzed to determine the differences in the pre-and post-measurements and the ratio between the experimental and control groups, thus determining statistical significance on priority at $\alpha \leq 0.05$.

Study Sample Characteristics

Data was collected regarding the characteristics of the participating players, which were as follows: age, weight, and height. The number of participants reached 20 volleyball players, whose ages ranged between 18 and 23 years. While the weights of the participating players reached (57-99) kg, and their heights ranged between 180 and 200 cm, as shown in Table 1. The participants also underwent a set of physical and skill training, which is shown in Table 2.

Table 1. The characteristics of the study sample according to the variables of age, height, and body weight. (N = 20)

Variable	Measuring Unit	Arithmetic Mean	Standard Deviation	Skewness
Age	Year	20.45	1.432	-0.426
Weight	Kg	77.45	11.161	0.255
height	cm	1.8630	0.0515	1.205

It is evident from Table 1. That the results of skewness indicate that it is close to zero. These results indicate the achievement of homogeneity between the members of the study sample and their subjection to a normal equilibrium distribution, where the values of the torsion coefficient of the age, weight and height variables came between (-3 and +3).Therefore, the study sample individuals were randomly divided into two groups, the first group (experimental) is trained using the proposed training program with Elastic bands, the second controlled group is trained in the traditional (normal) method, and the arithmetic average for the ages of the study sample is (20.45 years) and that the average weight of the students in the study sample is (77.45 kg) and that their average height is equal to (186.3 cm).

Table 2. The arithmetic means, standard deviations, the lowest and largest value and the torsion coefficient of the variables (age, weight, height) and the physical and skill variables of male volleyball players (n = 20)

Variable	Measurement Unit	Lowest Value	Largest Value	Arithmetic Mean	Standard Deviation	Coefficient of Torsion
Age	Year	18	23	20.45	1.432	-0.490
Weight	kg	57	99	77.45	11.161	-0.216
Height	cm	180	200	186.3	5.151	-0.490
Spiking	Degree	5	13	8.55	2.038	0.466
Blocking	Frequency	5	8	6.35	0.745	0.082
Vertical Jump from Standstill	cm	37	57	51.60	4.358	0.103
Vertical Jump from Movement	cm	61	73	66.70	4.219	-1.387
Medical Ball Throws from Overhead	MTR	5.76	6.30	5.9845	0.14749	-0.002
Medical Ball Throws from Chest	MTR	4.96	5.45	5.1585	0.11833	0.760
Push-Up	Frequency	8	14	10.35	1.348	2.322

It is clear from the results of Table 2. that the torsion coefficients of the total study sample in the variables (age, weight, and height) and the physical and skill variables ranged between (-3, +3) (Bougie & Sekaran, 2019), meaning that there is homogeneity in these variables for the total sample of the study.

RESULTS

First: The results related to the study's first hypothesis, which was "There are statistically significant differences at a significance level (α≤ 0.05) in the effect of the conventional program on selected physical and skill variables among volleyball players of Palestine Technical University - Kadoorie for the control group, between the pre-test and post-test means, in favor of the post-test mean" Therefore, in order to ensure the validity of this first hypothesis and examine it, a (paired samples t-test) was used, and the results of Table 3 show that.

Table 3. The results of the first hypothesis (n = 10)

	Dependent Variables	Pre-Measurement (N=10)		Post-Measurement (N=10)		T-Value	Sig.	Change %
		M	SD	M	SD			
Physical Tests	Vertical Jump from Standstill	51.00	5.869	52.10	7.015	2.898	0.002	2.11%
	Vertical Jump from Movement	67.90	3.635	68.70	3.773	6.000	≤0.001	1.16%
	Medical Ball Throws from Overhead	5.950	0.0946	6.140	0.1231	7.052	≤0.001	3.09%
	Medical Ball Throws from Chest	5.150	0.0946	5.239	0.0706	7.679	≤0.001	1.70%
	Push-Up	9.90	0.994	11.30	1.494	4.118	0.003	12.39%
Skill Tests	Spiking	8.20	1.989	9.30	1.947	11.00	≤0.001	11.83%
	Blocking	6.60	0.699	7.20	0.919	3.674	0.005	8.33%

Values are presented as mean (M), standard deviation (SD), * The tabular value of (T) at the level of significance (α≤ 0.05) = 2.09, * The tabular value of (T) at the level of significance (α≤ 0.01) = 2.86

Second:

The results related to the study's second hypothesis, which was "There are statistically significant differences at a significance level (α≤ 0.05) in the effect of a training program using elastic bands on selected physical and skill variables among volleyball players of Palestine Technical University - Kadoorie for the experimental group, between the pre-test and post-test means, in favor of the post-test mean" Therefore, in order to ensure the validity of this first hypothesis and examine it, a (paired samples t-test) was used, and the results of Table 4 shows that.

Table 4. The results of the Second hypothesis (n = 10)

	Dependent Variables	Pre-Measurement (N=10)		Post-Measurement (N=10)		T-Value	Sig.	Change %
		M	SD	M	SD			
Physical Tests	Vertical Jump from Standstill	52.20	2.201	57.70	3.129	7.342	≤0.001	9.53%
	Vertical Jump from Movement	65.50	4.601	72.60	3.978	13.498	≤0.001	9.78%
	Medical Ball Throws from Overhead	5.95	0.1048	6.259	0.1852	8.516	≤0.001	4.94%
	Medical Ball Throws from Chest	5.179	0.127	5.414	0.0999	8.448	≤0.001	4.34%
	Push-Up	10.80	1.549	17.60	1.174	17.493	≤0.001	38.64%
Skill Tests	Spiking	8.90	2.132	11.70	1.829	21.000	≤0.001	23.93%
	Blocking	6.10	0.738	8.80	0.422	17.676	≤0.001	30.68%

Values are presented as mean (M), standard deviation (SD), * The tabular value of (T) at the level of significance (α≤ 0.05) = 2.09

Third

The results of the third hypothesis which states that "There are statistically significant differences at a significance level (α≤ 0.05) in the post-test measurement between the experimental and control groups for selected physical and skill variables among volleyball players of Palestine Technical University - Kadoorie, in favor of the experimental group" and in order to test this hypothesis an independent samples t-test was carried out as shown in table (5).

Table 5. The results of the third hypothesis (n = 20)

	Dependent Variables	Control group (N=10)		Experimental group (N=10)		T-Value	Sig.
		M	SD	M	SD		
Physical Tests	Vertical Jump from Standstill	52.10	7.015	57.70	3.129	2.305	0.033
	Vertical Jump from Movement	68.70	3.773	72.60	3.978	2.250	0.037
	Medical Ball Throws from Overhead	6.0830	0.1231	6.259	0.1852	2.502	0.022
	Medical Ball Throws from Chest	5.239	0.0706	5.414	0.0999	4.523	≤0.001
	Push-Up	11.30	1.494	17.60	1.174	10.484	≤0.001
Skill Tests	Spiking	9.30	1.947	11.70	1.829	2.842	0.011
	Blocking	7.20	0.919	8.80	0.422	5.004	≤0.001

Values are presented as mean (M), standard deviation (SD), * The tabular value of (T) at the level of significance (α≤ 0.05) = 2.09, * The tabular value of (T) at the level of significance (α≤ 0.01) = 2.86

DISCUSSION

The reported findings give a detailed review of the effects of two separate training interventions - a traditional training program and a proposed training program employing elastic bands - on the physical and skill characteristics of volleyball players. These findings illustrate the important contributions each training strategy made to the players' performance, as well as the advantages of the proposed elastic band training above the conventional approach. The results of our study confirmed as the another step in proving the effective role of elastic band training on young volleyball players. This has been indicated by recent studies that confirm the importance of this

training and its impact on the youth group (Aloui et al., 2019; Hammami et al., 2022).

The results show that the standard training program resulted in considerable gains in numerous physical and skill characteristics for the control group. We are able to notice from the results of Table No. (3) that there is statistically significant difference at the level of significance ($\alpha \leq 0.05$) in the effect of the conventional training program on some physical and skill variables of the volleyball players for the control group, where the percentage change for the physical and skill tests was (Spiking (11.83%), Blocking (8.33%), Vertical Jump from Standstill (2.11%), Vertical Jump from Movement (1.16%), Medical Ball Throws from Overhead (3.09%), Medical Ball Throws from Chest (1.70%), Push-Up (12.39%). These improvements, albeit varying in size, demonstrate the effectiveness of the traditional training program in improving the players' spiking accuracy, blocking proficiency, jumping abilities, upper body strength and power, and overall physical fitness. These results are consistent with the findings of (Ayyub et al., 2023; Elsharnoby, 2022; Ibrahim, 2022; Sari et al., 2023; Tarigan et al., 2022). These results show that many physical and skill variables of the volleyball players in the control group were significantly affected by the traditional training program. The percentage improvements in the players' performance across spiking, blocking, jumping, throwing, and push-ups show that the program helped them improve in some important areas of their skills, possibly improving their overall performance on the volleyball court. On the contrary, some studies mentioned that there are many trainings, such as variable resistance training that includes elastic band training, eccentric training, postural sway, and strength training, all of these are training that young people undergo and work to improve the level of their athletic performance in playing volleyball beyond those skill developments in their performance that were achieved by traditional training (Hammami et al., 2022; Elsharnoby, 2022; Suchomel et al., 2018).

We are able to notice from the results of Table 4 that there is statistically significant difference at the level of significance ($\alpha \leq 0.05$) in the effect of the proposed training program using elastic bands on some physical and skill variables of the volleyball players for the experimental group, where the percentage change for the physical and skill tests was Spiking (23.93%), Blocking (30.68%), Vertical Jump from Standstill (9.53%), Vertical Jump from Movement (9.78%), Medical Ball Throws from Overhead (4.94%), Medical Ball Throws from Chest (4.34%), Push-Up (38.64%). And these results are consistent with the findings of (Elsharnoby, 2022; Ibrahim, 2022; Nasrulloh et al., 2021; Nassar, 2022; Sari et al., 2023; Tarigan et al., 2022). These results show that the elastic band-based training program that was suggested had a statistically significant and favorable effect on a number of physical and skill variables for the volleyball players in the experimental group. In addition, the results showed that the highest percentage of change related to physical and skill tests was for the push-up exercise, followed by the blocking, and finally the vertical strike. This indicates that applying the training program using elastic bands has a clear and effective impact over a short period on these physical skills among young players. This result is consistent with the evidence provided by some studies confirming that exercises based on the application of elastic bands have contributed significantly to improving and developing the physical variables associated with the skill of push-up exercises, blocking, and vertical striking in the volleyball (Fang et al., 2023; Aloui et al., 2021; Ataee et al., 2014; Elsharnoby, 2022). The program's success in boosting the players' ability in important areas is shown by the sizable percentage changes in performance across spiking, blocking, jumping, throwing, and push-ups, which help to improve their overall performance on the volleyball court.

We are able to notice from the results of Table No. (5) that There are statistically significant differences at a significance level ($\alpha \leq 0.05$) in the post-test measurement between the experimental and control groups for selected physical and skill variables among volleyball players of Palestine Technical University - Kadoorie, in favor of the experimental group, where the percentage change for the physical and skill tests were Spiking (20.51%), Blocking (18.18%), Vertical Jump from Standstill (9.71%), Vertical Jump from Movement (5.37%), Medical Ball Throws from Overhead (2.81%), Medical Ball Throws from Chest (3.23%), Push-Up (35.80%). These results are consistent with the findings of (Elsharnoby, 2022; Ibrahim, 2022; Nasrulloh et al., 2021; Sari et al., 2023; Tarigan et al., 2022; Xu, 2019; Yee, 2019).

Furthermore, a study conducted by Hamami et al. reported that there were significant interactions and improvements in the performance of the vertical and horizontal jump among volleyball players in the experimental group two months after they underwent a training program that included elastic band training compared to the control group (Hamami et al., 2022). Conversely, Aloui et al. found no significant change or interactions in vertical and horizontal jumping performance after undergoing elastic band training for one month and a half in young players participating in their study (Aloui et al.,2019). Although there was a significant improvement in the jumping performance of the participating players after undergoing the rubber band training, they showed a slight improvement in the performance of medicine ball throws from overhead and chest (2.81%, 3.23%). This may be due to the fact that good performance in volleyball depends on the players' ability to perform movements such as throwing and jumping with rapid force (Fathi et al.,2019; Nunes et al.,2021). The statistically significant differences that were in the experimental group's favor were the outcome of a successful interaction of skill-specific drills, progressive overload, targeted training, encouraging coaching, and a happy training atmosphere. The volleyball players made notable improvements across a wide range of physical and skill characteristics as a result of this dynamic synergy. The outcomes demonstrate the intervention program's unquestionable success in maximizing the athletes' capacities and raising the bar for their performance. This is consistent with what has been confirmed by many recent studies on the importance of elastic band training and its effective role in improving many physical skills among volleyball players (Hammami et al., 2022; Zouita et al., 2023; Mascarin et al., 2017).

Finally, the findings from both training treatments highlight the potential for targeted and structured training programs to positively improve physical and skill factors in volleyball players. However, the proposed elastic band training program was especially effective in eliciting considerable improvements in many performance indicators. This was consistent with a several study where they demonstrated that elastic band training that athletes undergo improves and enhances their muscular, strength development, medicine ball throw (Lopes et al., 2019; Fang et al., 2023; Elsharnoby,2022). These findings have practical implications for coaches and players looking to optimize training protocols, and they highlight the importance of introducing innovative training modalities like elastic bands for greater athletic performance.

Conclusion

The findings of this study provide a comprehensive overview of the effect of two distinct training programs on the physical and skill attributes of volleyball players. Several aspects of player performance, including spiking accuracy, blocking proficiency, jumping abilities, upper body strength, and general physical fitness, were significantly enhanced by the conventional training program. These accomplishments demonstrate the significance of traditional training methods in fostering player development.

The proposed elastic band training program, on the other hand, resulted in statistically significant and observably superior gains across all examined metrics. In the experimental group, spike force, blocking efficiency, explosive jumping ability, upper body strength, and muscular endurance improved significantly. These findings highlight the specific advantages of incorporating elastic band training into the routines of volleyball players, highlighting its capacity to boost their performance to new heights.

When the experimental and control groups are explicitly compared, the superiority of the elastic band training method is reinforced. Across the board, statistically significant differences in favor of the experimental group were observed, highlighting the all-encompassing nature of the enhancements attained through this innovative training strategy.

In conclusion, while traditional training methods have their benefits, the advent of elastic band training represents a promising evolution in the development of volleyball players. It provides a comprehensive approach to improving players' physical and skill attributes, thereby enhancing their overall court abilities. These results call for additional research and application of elastic band training in the field of sports performance, indicating a promising future for this novel approach in volleyball and potentially beyond.

Recommendations

Several recommendations can be made to enhance the training and performance of volleyball players based on the study's findings and

outcomes. These recommendations cover a broad range of training, coaching, and player development-related topics:

Given the significant benefits observed in the experimental group as a result of the proposed elastic band training program, it is advised that coaches and trainers incorporate elastic band exercises into their regimens. Elastic bands are a versatile and efficient tool for targeting specific muscle groups, enhancing explosive power, and enhancing overall strength and stamina.

Each athlete should have a training regimen that is tailored to their individual requirements and goals. By analyzing an athlete's strengths and weaknesses, coaches are able to create individualized training plans that target areas in need of development, resulting in more well-rounded and capable athletes.

The efficacy of elastic band training and the standard training program in increasing vertical leap demonstrates the significance of explosive power exercises. Emphasis should be placed on plyometric drills, lower body strength training, and dynamic motions in order to improve the players' ability to generate force promptly and effectively.

As evidenced by the development of spiking and blocking skills, skill-specific drills should continue to be emphasized in training. These drills aid in the improvement of technique, timing, and coordination, all of which are necessary for the successful execution of crucial volleyball actions.

Conflict of Interest

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

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Ethics Committee

The current study involving human participants was approved and obtained ethical permission no. (2023/20 from 1.2.2023-2.4.2023) by the Scientific and Ethical Committee of the Faculty of Physical Education and Sports Sciences, Palestine Technical University - Kadoorie. Written informed consent was also obtained from all participants in the current study.

Author Contributions

The authors accomplished this study by making significant contributions including designing the study according to the formulation of its objectives. AFAN, IZ prepared the draft and carried out the study design; AFAN, AI, and NAR collected the data; AFAN, AD, and BMOA performed the statistical analysis of the data; AFAN, and MRK interpreted the data; and all authors of the manuscript performed the literature search and collaborated on the manuscript critical review and editing. All authors were contributors and responsible for the content of the manuscript and approved the version submitted for publication.

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RESEARCH ARTICLE

Distraction Osteogenesis by Ring Fixator in Post Traumatic Tibial Bone Loss

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Abstract
Background: Reconstructing segmental bone loss defects presents a significant challenge within the field of orthopedics. The purpose of this study is to assess the clinical and radiological results of using the Ilizarov technique for tibia reconstruction following traumatic bone loss. Methods: This study was a prospective study involving 30 patients who experienced tibial bone loss in the diaphysis or metaphysis following trauma. These patients were treated with a ring fixator (Ilizarov) from March 2021 to February 2023. Unfortunately, five patients were lost to follow-up, leaving a cohort of 25 patients who were observed for a duration ranging from 9 to 12 months. Results: The current study involved 25 patients with post-traumatic tibial bone loss. The age range was 14 to 48 years, with a mean age of 28.4±8.8 years. Among the cases, 18 had a moderate defect (72%), which was significantly higher than those with a minor defect (20%) ($P \leq 0.05$). Deformity was less than 7° in most cases (96%), while only one case had deformity greater than 7° (4%) ($P \leq 0.05$(. Leg length discrepancy was less than 2.5 cm in the majority (96%), with only one case having a 3 cm length discrepancy (4%) ($P \leq 0.05$). By the end of the follow-up period, all patients showed perfect union, enabling them to engage in daily activities post-operatively. Conclusion: The success of corticotomy and solid docking relies on well-vascularized bone and soft tissue. Soft tissue compromise at the corticotomy site can hinder healthy tissue regeneration.

Keywords
Distraction Osteogenesis, Ring Fixator, Tibial Bone Loss

INTRODUCTION

Bones have an inherent ability to naturally heal after an injury. However, in specific critical-sized defects, the bone's self-healing capacity is insufficient, necessitating medical intervention (Dimitriou et al., 2011).

Various methods are accessible for addressing these defects, including the widely accepted autogenous bone grafts, allografts, bone graft substitutes, and vascularized fibular bone grafts. Nevertheless, it's important to note that all these techniques come with their own set of limitations (Nauth et al., 2011).

Signs of clinical issues, whether vascular or related to soft tissue, only become evident when shortening exceeds 2 cm (Edwards, 1983). Treating tibial bone and soft tissue defects, particularly those larger than 5 cm, resulting from high-energy trauma or non-union debridement, poses a substantial challenge for orthopedic surgeons regarding both limb reconstruction and soft tissue coverage. The Ilizarov method has brought about a significant transformation in the management of these injuries, to the extent that some experts consider it the benchmark for addressing tibial bone defects through distraction

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osteogenesis (Fürmetz et al., 2016, Zhang et al., 2018).

The Ilizarov technique is valuable in various clinical scenarios, spanning across pediatric and adult patients, even though its most common application remains the correction of limb length disparities and complex deformities (Foster et al., 2012, Dickson et al., 2015).

In comparison to alternative methods for rectifying posttraumatic angular deformities, such as intramedullary nails, plate fixation, and osteotomies, the Ilizarov method has more straightforward surgical objectives. Surgeons are primarily responsible for ensuring stable fixation for each bone segment and performing an osteotomy (Marcellin-Little, 1999).

The alignment of the limb is determined while the patient is under anesthesia and not bearing weight, which introduces an element of unpredictability in terms of the functional and cosmetic results of the surgery. This unpredictability may necessitate additional procedures to achieve full deformity correction (Marcellin-Little, 1999).

The aim of this prospective study was to evaluate clinical and radiological outcome of ilizarov technique for reconstruction of tibia in post-traumatic bone loss.

MATERIALS AND METHODS

Study Design

In a prospective study spanning from March 2021 to February 2023, 30 patients with tibial bone loss in the diaphysis or metaphysis, following trauma, were treated using a ring fixator (Ilizarov). Unfortunately, five patients were lost to follow-up, leaving 25 patients who were tracked for a duration ranging from 9 to 12 months. Of these, 10 patients received their treatment at Beni Suef University Hospital, while the remaining 15 were treated at Nasser Institute Hospital.

This study followed ethical standards and received approval from the Faculty of Medicine Beni-Suef University with reference number (FMBSUREC/03012021/04.09.2023). 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.

Inclusion criteria were patients under 50 years old with post-traumatic tibial fractures, including 10 patients with bone defects resulting from the initial trauma and 15 patients with defects arising from repeated debridement following septic and aseptic nonunion. **Exclusion criteria were** patients over 50 years old, those with neurovascular insufficiency, individuals with pathological fractures due to bone tumors, and those with comorbidities that might interfere with anesthesia or healing, such as cardiac issues or uncontrolled diabetes.

The clinical assessment involved a thorough history, general and local physical examinations, with a particular focus on the condition of the skin and soft tissues in areas where transosseous wires and screws were applied. Laboratory investigations included CBC, ESR, CRP, and routine preoperative tests.

Radiological assessments consisted of plain x-ray views from the anterior-posterior and lateral perspectives, computed tomography, and a CT scanogram to evaluate limb length in cases of bone loss.

Operative planning:

The operative planning phase encompassed anesthesia, the patient's positioning on the operating table, the application of a tourniquet, and preoperative landmarks, and surgical procedures.

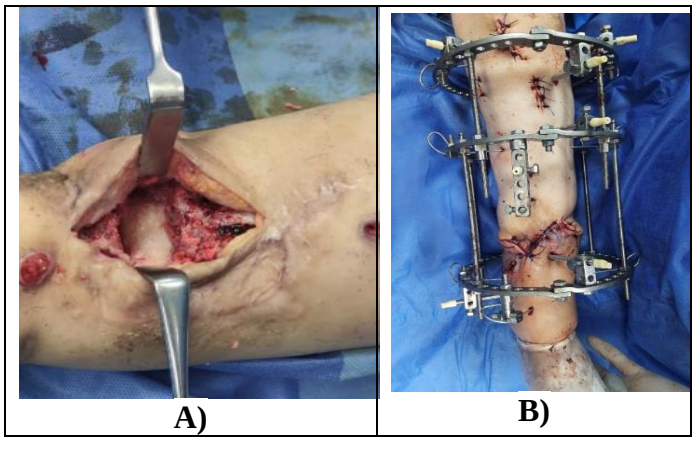
Surgical technique:

The surgical technique involved the resection of necrotic bone until bleeding, known as the "paprika sign," was observed **(Fig. 1 A)**. The area was irrigated with saline, and the defect length was assessed based on Robinson et al.'s classification (Robinson et al., 1995). If the fibula was intact, a proximal reference wire was positioned perpendicular to the mechanical axis of the tibia and connected to the proximal ring, while the distal reference wire was aligned parallel to the ankle joint and connected to the distal ring. The middle bone segment was secured with wires to the middle ring, and half-pins were used to enhance stability in each segment.

Tibial alignment was checked using imaging. Shortening was carried out while monitoring the vascularity of the dorsalis pedis and tibialis posterior. If there was a short distal bone segment, the ankle joint was spanned, and an osteotomy was performed at the metaphyseal-diaphyseal junction

using a pre-drilled hole (corticotomy). The periosteum was preserved and closed after osteotomy. In one case where the fracture was close to the ankle joint, the foot was included in the frame to prevent equinus contracture and enhance osteosynthesis stability. Acute bone shortening, up to 3 cm, was performed without complications, using a T or Z-shaped incision to avoid skin issues during closure (Fig. 1 B).

For lengthening, distraction was initiated at a rate of one millimeter per day after a latency period of 10 days, and daily cleaning with saline was performed. At the end of the follow-up period, bone and functional outcomes were assessed using the Association for the Study and Application of the Method of Ilizarov (ASAMI) scoring system (Testa et al., 2020).



A) B)

Figure 1. A) Paprika sign and B) Z shape incision

Statistical analysis

Historical data, basic clinical examinations, and outcome measures were collected and subsequently coded, entered, and analyzed using Microsoft Excel software. The data was then transferred to Statistical Package for the Social Sciences (SPSS version 21.0) for further analysis. Qualitative data were represented in terms of numbers and percentages, while quantitative data for continuous groups were expressed as mean ± standard deviation. To determine the significance of differences, the following tests were employed: for qualitative variables, the Chi-square test (X2) was used to assess differences and associations, while for quantitative independent groups, the t-test was employed. A significance level of <0.05 indicated statistically significant results.

RESULTS

The study group comprised 25 patients with post-traumatic tibial bone loss, consisting of 20 males (80%) and 5 females (20%). The patients' ages ranged from 14 to 48 years, with an average age of 28.4±8.8 years (Table 1).

Table 1. Demographic data of the study group

Demographic data		**Study group** (n=25)
Sex	Males	20 (80%)
	Females	5 (20%)
Age (year)		28.4±8.8 / 14-48

Data were presented as mean ± standard deviation (SD), number (%).

In the context of osteomyelitis, a significant majority of cases showed no postoperative deep infection (96%), whereas only one case (4%) experienced an infection (P ≤ 0.05) that was successfully resolved through surgical debridement (Table 2).

Table 2. Postoperative deep Infection in the study group.

Postoperative Deep Infection	**Study group** (n=25) N	%
Yes	1	4
No	24	96
Chi square	21.160	
P-value	< 0.0001*	

*P ≤ 0.05 is considered significant

In terms of deformity, a significant majority of cases (96%) exhibited deformities of less than 7°, while only one case (4%) showed a varus deformity exceeding 7° (P ≤ 0.05). Notably, the patient with the varus deformity expressed satisfaction with the outcome (Table 3)

Table 3. Deformity in the study group

Deformity <7 °	**Study group** (n=25) N	%
Yes	24	96
No	1	4
Chi square	21.160	
P-value	< 0.0001*	

*P ≤ 0.05 is considered significant

In terms of leg length discrepancy, a significant majority of cases (96%) had a difference of less than 2.5 cm, while only one case (4%) had a discrepancy of 3 cm (P ≤ 0.05). It's worth noting that this discrepancy did not affect

Table 4. Leg length discrepancy (LLD) in the study group

LLD <2.5 cm	Study group (n=25) N	%
Yes	24	96
No	1	4
Chi square	21.160	
P-value	< 0.0001*	

*P ≤ 0.05 is considered significant

A significant majority of cases (96%) did not experience a loss of ankle motion, while only one case (4%) had a stiff ankle (P ≤ 0.05). The issue in this case was attributed to a short distal tibial bone segment, leading us to utilize a spanning ring for long-term support. By the end of the follow-up period, the patient had achieved full bone union and chose not to undergo further operations (Table 5).

Table 5. Loss of ankle motion in the study group

Loss of ankle motion	Study group (n=25) N	%
Stiff	1	4
No	24	96
Chi square	21.160	
P-value	< 0.0001*	

*P ≤ 0.05 is considered significant

There was an insignificant association between ASAMI and Robinson classifications for orthopedic limb defects in the study group (P-value = 0.3676) (Table 6).

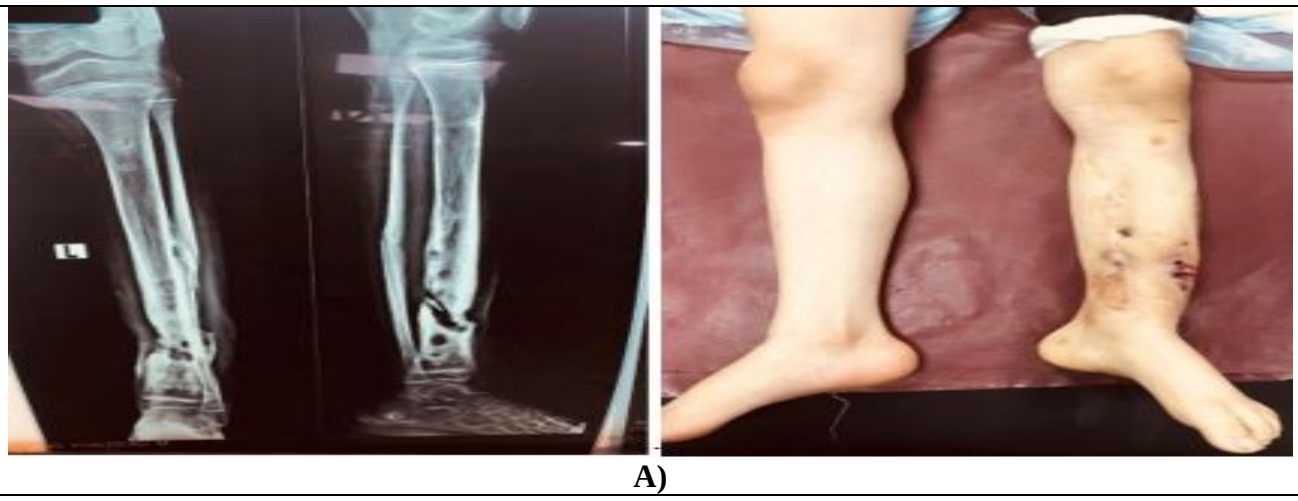
Table 6. Relation between ASAMI classification and Robinson classification defect in the study group

ASAMI classification	Robinson classification defect			
	Minor (<2.5cm)		Moderate (2.5-10cm)	
	N	%	N	%
Excellent	7	100	16	88.9
Good	0	0	2	11.1
Chi square	0.812			
P-value	0.3676			

No significant relation was found between ASAMI classification and Robinson classification defect (P.>0.05).

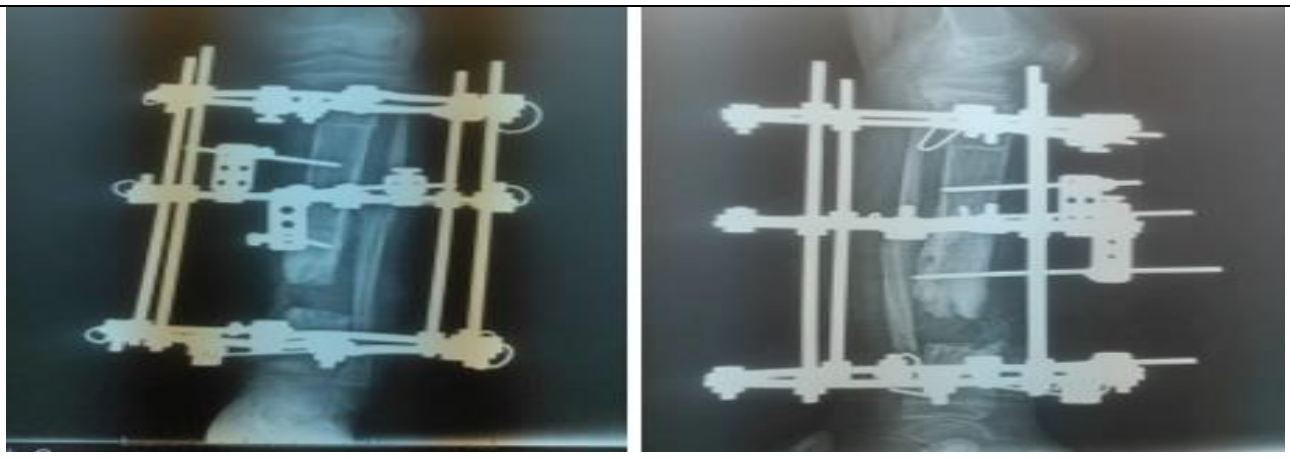
Case Presentation

We describe a 14-year-old male patient with a 4 cm left tibia defect classified as moderate per the Robinson classification. This bone defect resulted from post-infection nonunion debridement after the failure of a previous plate and screws procedure. The treatment approach involved single-level bone transport using the Ilizarov technique following bone debridement, with a distraction rate of 0.25 mm every 6 hours per day for six weeks until the docking site was achieved. The patient was followed up for a duration of 9 months, and the outcome, as per the ASAMI Classification, was rated as excellent (Fig. 2,3,4)

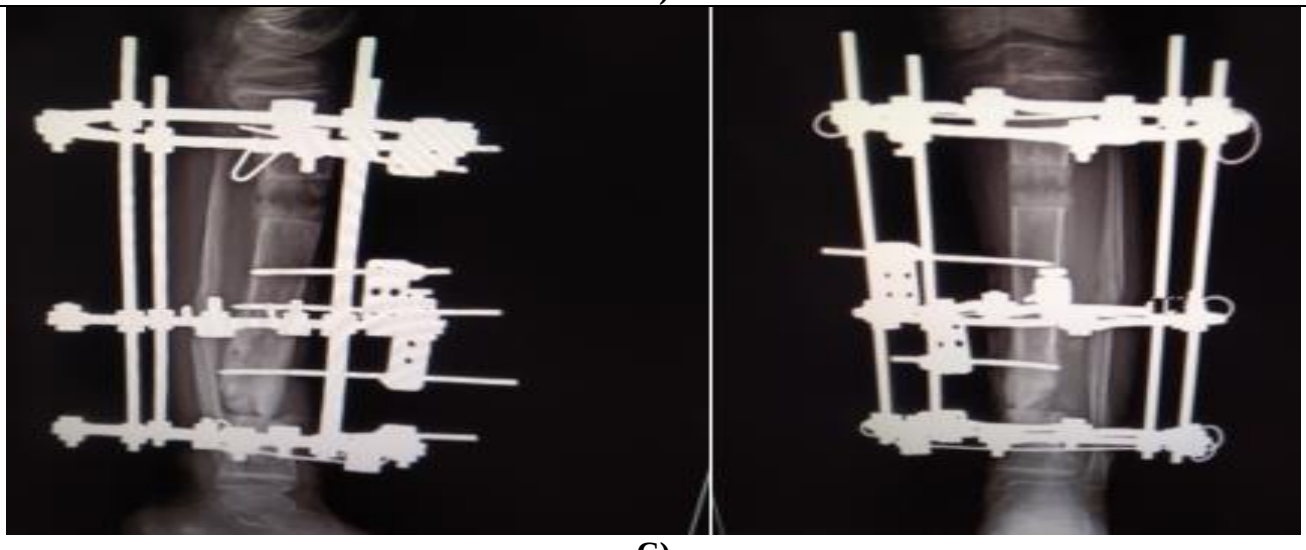


A)

Figure 2. A) AP and lateral X-rays of left distal tibia infected nonunion with sequestrated bone, left one clinical photo.



B)



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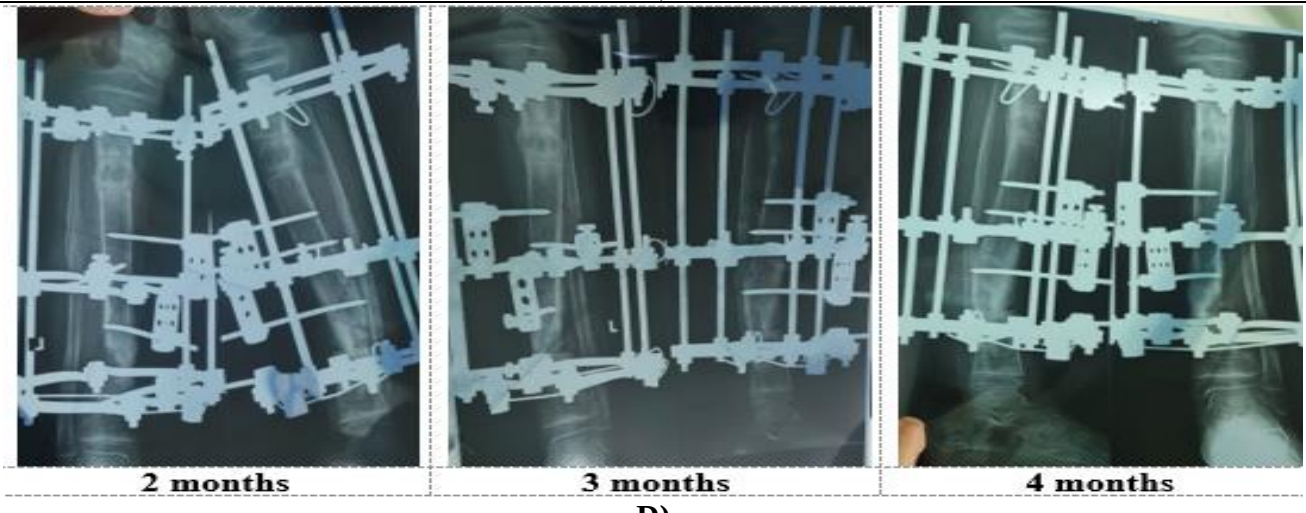

D)

Figure 3.
B) AP and lateral postoperative X-rays of lift distal tibia with single level bone distraction after bone debridement using ring fixator.
C) X-rays of postoperative follow up at 1 month post bone distraction left tibia with single level bone transport.
D) X-rays of postoperative left tibia with bone distraction.

E)

F)

Figure 4.
E) Full weight bearing with flexion knee and mobile ankle joint.
F) AP and lateral X-rays of left tibia with single bone distraction follow up post removal of ilizarov level and single level bone distraction

DISCUSSION

Segmental bone loss remains a persistent challenge for orthopedic surgeons, particularly in the context of trauma, often resulting from open fractures and infections. The tibia, in particular, is the most commonly affected site in cases of traumatic bone loss, primarily due to its limited soft tissue coverage, which increases the risk of open fractures and bone extrusion in high-energy injuries. While there are several surgical methods available for addressing these complex cases, a lack of consensus or specific guidelines for comprehensive management continues to be a notable issue, leading to potential obstacles in achieving favorable long-term functional outcomes due to the relatively high occurrence of complications and subsequent reoperations (Adamczyk et al., 2020).

In our study, our patient group consisted of 10 individuals who experienced post-traumatic tibial bone loss resulting from initial trauma. Among these, eight patients underwent bone transport with an Ilizarov ring fixator to address moderate bone loss ranging from 2.5 to 10 cm, while the remaining two patients opted for acute bone shortening with gradual lengthening using an Ilizarov fixator to manage minor bone loss, measuring less than 2.5 cm. The differentiation between these approaches was based on the Robinson classification for bone defects. For patients with post-traumatic bone loss due to infected nonunion, our study included 15 cases. Ten of them were treated with bone transport

employing an Ilizarov ring fixator to address moderate bone loss (2.5 - 10 cm), while the remaining five patients underwent acute bone shortening with gradual lengthening via an Ilizarov fixator to manage minor bone loss, again categorized according to the Robinson classification.

In comparison, a study by Sen C et al. focused on 24 cases of post-traumatic tibial bone loss with moderate bone defects, addressing them through bone transport with the Ilizarov method (Sen et al., 2004). Meanwhile, Krappinger D et al. examined 15 cases with larger post-traumatic tibial bone defects, ranging from moderate to severe loss, which were also managed using the Ilizarov method (Krappinger et al., 2013).

In our study, all patients achieved successful union at the docking site. This was achieved through various techniques, including bone marrow injection in seven patients, refreshing bone ends with bone compression in six patients, and the use of iliac bone graft in two patients. In contrast, in Magadum MP et al.'s research, they found that only one patient experienced nonunion (Magadum et al., 2006). In our own study, the timing of Ilizarov frame removal after achieving union varied, ranging from 6 to 11 months. This duration decreased when we employed acute compression with gradual lengthening and the bifocal bone transport technique. However, the effectiveness of this approach was limited in cases where there was an insufficient amount of proximal or distal bone segments available for a double-level osteotomy, along with the challenge of ensuring adequate soft tissue coverage. The timing for frame removal increased as the size of the bone defect and the chosen technique in the study became more extensive. In contrast, Sen C et al. reported a mean external fixation duration of 7.1 months (range 3-10) due to their use of the bifocal bone transport technique. The follow-up period for our patients ranged from 9 to 12 months.

By comparison, Sen C et al. conducted a study with a longer follow-up duration, extending to 18-60 months, and Magadum MP et al.'s study had a follow-up period of 39 months (Magadum et al., 2006). This difference in follow-up duration could be attributed to the complexity of cases and the need for multiple surgeries in the patients.

In our study, both bone and functional outcomes were evaluated using the ASAMI scoring system. The results revealed excellent outcomes in 23 cases (92%), which was significantly higher than the percentage of cases with good outcomes (8%) ($P \leq 0.05$). These findings were consistent with Sen C et al.'s study, where 21 patients achieved excellent results, and three had good results (Sen et al., 2004). Furthermore, in our study, the majority of patients did not experience deep infections (96%), with only one case suffering from a deep infection (4%) ($P \leq 0.05$), which was successfully resolved through surgical debridement. In contrast, Magadum MP et al.'s study reported a higher rate of postoperative infections, with 21 patients experiencing minor pin tract infections during the treatment period, involving an average of 5 pin sites per patient. Four patients developed moderate to severe pin tract infections (Magadum et al., 2006).

Additionally, in our study, most patients had leg length discrepancies of less than 2.5 cm (96%), with only one case having a 3 cm difference (4%). This discrepancy did not significantly affect their daily activities, and the patient declined further surgical interventions. Dendrinos GK et al.'s study also successfully corrected deformities and length discrepancies to less than 7 degrees and 2.5 centimeters, respectively (Dendrinos et al., 1995). Moreover, in our study, at the end of the follow-up period, the majority of cases had angulations of less than 7° (96%), with only one case having an angulation exceeding 7° (4%) ($P \leq 0.05$), and this patient expressed satisfaction. In contrast, Magadum MP et al.'s study reported two patients with minor residual deformities (Magadum et al., 2006).

Finally, in our study, most cases showed no loss of ankle motion (96%), with only one case experiencing a stiff ankle (4%) ($P \leq 0.05$). This issue was attributed to a short distal tibial bone segment, which led us to use a spanning ring for long-term support. By the end of the follow-up period, the patient had achieved full bone union and declined further surgical interventions. These findings were consistent with Magadum MP et al.'s study, where one patient had a 10° fixed flexion deformity but still maintained the ability to perform daily activities postoperatively (Magadum et al., 2006).

Conclusions

The success of both corticotomy and solid docking hinges on well-vascularized segments of bone and soft tissue. When the soft tissue is compromised at the intended corticotomy site, the development of healthy regenerate tissue may be impeded. Severe open fractures with a wide zone of injury are frequently linked to inadequate soft tissue coverage at the injury site.

Conflict of Interest

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

Ethics Committee

This study followed ethical standards and received approval from the Faculty of Medicine Beni-Suef University with reference number (FMBSUREC/03012021/04.09.2023).

Author Contributions

The authors accomplished this study by making significant contributions including designing the study according to the formulation of its objectives. AGM, AABAS prepared the draft and carried out the study design; AGM, AMS and HGHG collected the data; AGM, AABAS and HGHG performed the statistical analysis of the data; AGM, AABAS and HGHG interpreted the data; and all authors of the manuscript performed the literature search and collaborated on the manuscript critical review and editing. All authors were contributors and responsible for the content of the manuscript and approved the version submitted for publication.

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RESEARCH ARTICLE

Correlation Between Direction of Prolapsed Intervertebral Disc (PIVD) And Lumbar Vertebral Alignment

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Abstract

Purpose: The purpose of this research was to establish a link between direction of a prolapsed intervertebral disc (PIVD) and lumbar vertebral alignment. **Methods:** This cross-sectional study included 102 participants with prolapsed intervertebral discs in the lumbar segment and lumbar vertebral mal-alignment of both sexes between the ages of 30 and 50 who had undergone MRI and X-ray for the lumbo-sacral spine. The Numerical Pain Rating Scale (NPRS) was used to assess outcome, MRI scans were used to determine the direction and amount of PIVD, and lumbar spinal alignment was assessed using X-rays in the AP and lateral views. SPSS version 26.0 was used for statistical analysis. **Findings:** Among the 102 participants, The study found that only 2.94% of 102 participants had Prolapsed Intracranial Disc Disease (PID) at the L1-2 level, with many on multiple levels. Prolapsed intervertebral discs were prevalent in 46.07% of individuals, with scoliosis in 33.33%, exaggerated lumbar lordosis in 4 subjects, and anterolisthesis in 20.59%. The study found a significant correlation between posterocentral and anterolisthesis, biforaminal and flatback, right paracentral and left paracentral prolapse and scoliosis ($p<0.0001$), with biforaminal direction being particularly significant for anterolisthesis and retrolisthesis ($p=0.0050$, 0.0014). The lumbosacral angle had a mean value of 31.79, and the mean of pain on rest was 1.99±1.38 and during activity was 5.51±1.66. **Conclusion:** It concluded that there was a significant relationship between the direction of prolapsed intervertebral disc (PIVD) and lumbar vertebral alignment.

Keywords
Anterolisthesis, Lumbar lordosis, Lumbosacral angle, Pain, Scoliosis

INTRODUCTION

A herniated lumbar disc, commonly referred to as a lumbar disc herniation (LDH), is a typical cause of sciatica, low back pain, and radicular limb discomfort. It is described as a localised displacement of disc material outside of the intervertebral disc space that causes myotomal or dermatomal discomfort, weakness, or numbness (Kreiner et. al., 2014, Vander , 2010).

A heterogeneous set of musculoskeletal illnesses known as low back pain (LBP) affects 65-85% of people worldwide (Satpute et. al., 2019; Ozturk et. al., 2006). LBP has become a more complicated and multidimensional issue in the second decade of the twentieth century, with rising prevalence, time frame, expenses, and rising severity and co-morbid conditions (Shinde & Bhende, 2023; Shinde et. al., 2022) It also appears to be expanding globally at this time. Bad posture can

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cause muscle imbalance, which leads to a dysfunctional connection between different parts of the body (Avaghade et. al., 2023).

The most frequent differential diagnoses for LBP are lumbar disc herniation (LDH) and degenerative disc degeneration (Amin et. al., 2017). One of the most common musculoskeletal conditions is lumbar prolapsed intervertebral disc (PIVD) or herniation, which affects 10% of the population (de Carvalho et. al., 2016; Thakeray et. al., 2010; Gadiya et. al., 2016). There are numerous physical and social factors for low back pain, which contribute to the 92% incidence of PIVD in the Indian population (Ranganatha et. al., 2020). LDH was found most commonly at the L4-L5 region (40%), followed by the L5-S1 region (36.8%), the L2-L3 region, and the L1-L2 region (each contributing 13.2%) (Takatalo et. al., 2011). There are reports of a 5% to 18% prevalence of recurrent LDH (Kapetanakis et. al., 2019). A significant portion of clinically significant herniation attacks occur in persons between the ages of 30 and 50, but they can also happen in adolescents and the elderly, with a 2:1 male to female ratio (Andersen et. al., 2019; Jordan et. al., 2009). According to studies, LDH is present in 24–27% of asymptomatic individuals (Harper & Klineberg, 2019; Jensen et. al., 1994). LDH is most frequently idiopathic, however it can also develop as a result of trauma or physiological disc degeneration brought on by ageing (Zhang et. al., 2023). Other risk factors for lumbar disc herniation include obesity, smoking, diabetes, connective tissue disorders, and genetic predisposition (Sharrak & Khalili , 2022).

A number of changes in the intervertebral disc, such as a decrease in water retention in the nucleus pulposus, an increase in the ratio of type 1 collagen in the nucleus pulposus and inner annulus fibrosus, and the deterioration of collagen and extracellular material, all contribute to lumbar disc herniation (Al Qaraghli & De Jesus, 2023). The nucleus pulposus shifts through the annulus fibrosus, typically posteriorly, resulting in stenosis or narrowing of the central canal and mechanical compression of the thecal sac or accompanying nerve roots (Zhang et. al., 2023). The main signs and symptoms of LDH are low back discomfort spreading to the back of the thigh and leg, numbness and paraesthesia in the appropriate dermatome, weakness, and depressed reflexes in the appropriate myotome (Wang et. al., 2014). The manner a patient presents can vary depending on where the herniation is in respect to the thecal sac and nerve roots. Patients with central stenosis who have lumbar disc herniations that are pressing posteriorly on the thecal sac may experience neurogenic claudication. Additionally, pain is made worse by walking, standing, and with lumbar extension, and it is made better by truncal flexion or rest. In the most severe disc herniations, the thecal sac can become critically stenotic, leading to cauda equine syndrome, which presents with symptoms like acute urinary retention, faecal or urinary incontinence due to overflow incontinence, saddle anaesthesia, and sexual dysfunction (Wu & Cruz, 2022; Davis et. al., 2023). Additionally, sciatica may result from lumbar/pelvic muscular spasm impinging a lumbar/ sacral nerve root (Davis et. al., 2023). A herniated intervertebral disc is discovered in about 85% of sciatica sufferers (Ropper & Zafonte, 2015). Long distance driving, manual labour, carpentry, barbering, and office work increase the risk of LDH in middle-aged working men.

The protrusion of the disc material may be posterocentral or central, posterolateral, paracentral, foraminal, anterior, or anterolateral, and it may also alter the symptoms. The posterior longitudinal ligament experiences posterior central protrusion, which may be the source of low back pain. A rip in the longitudinal ligament, which results from postero-lateral prolapse, harms the growing nerve root. Pain on trunk flexion, sensory deficits, muscle weakness, altered reflexes, or decreased lumbar lordosis are all symptoms of both central and foraminal pain. Anterior or anterolateral disc prolapse is relatively uncommon and is characterised by symmetrical or asymetrical discomfort that is felt across the L4-5 region or may radiate to the buttock or thigh and worsens with extension. A protective accentuation of the lumbar lordosis is a clear symptom (Kotwal & Mittal, 2020).

Patients with LDH may experience paravertebral muscle soreness, scoliosis, trunk shift, and imbalanced spinal sagittal alignment, which can cause a variety of issues for both individuals and society. The emergence of these symptoms may lead to specific changes in the sagittal and coronal shapes of the spine (Wu et. al. 2019). The pathogenesis of lumbar spine illnesses as well as the health-related quality of life in both paediatric and adult populations are significantly

and measurably impacted by the sagittal alignment of the lumbar spine. With ageing and degenerative disorders, the sagittal alignment of the lumbar spine might shift (Berven & Wadhwa, 2018). Patients with lumbar illness may experience chronic low back pain as a result of abnormal sagittal spinal alignment (Endo et. al., 2010). These aberrant spinal alignments include scoliosis, spondylolisthesis, hypolordosis, and hyperlordosis. According to earlier research, significant fat infiltration of the paravertebral muscles and LDH are typically present together, and muscular disease can also cause scoliosis (Wang et. al., 2022). The development of an upright, bipedal posture and gait depends on lordosis in the lumbar spine, a peculiar characteristic of the human spine (Berge, 1998). Studying the pathophysiology of lumbar developmental and degenerative disorders requires an understanding of lumbar lordosis as well as the link between lumbar lordosis, pelvic incidence, and balance or alignment of the spine (Berven & Wadhwa, 2018). Spondylolisthesis is defined as the anterior slippage of one vertebral body with respect to the adjacent vertebral body that results in mechanical or radicular symptoms or pain, whereas retrolisthesis is defined as the backward slippage of one vertebral body on another that has also been linked to back pain and function impairment (Tenny & Gillis, 2023; Shenoy et. al., 2019).

The incidence of LDH has increased as society and modern lifestyles have changed. LDH results in substantial medical costs in addition to a decreased quality of life. It has been demonstrated that living with LDH costs the patient and society a lot of money (Pourahmadi et. al., 2016). The literature has a number of studies on lumbar spine sagittal alignment and lumbosacral morphology (Antoniades et. al., 2000). In other words, any disc herniation may result in changes in lumbosacral morphology. On the other hand, LDH may develop as a result of changed lumbosacral morphology. However, the relationship between the direction of PIVD and lumbar alignment has received little attention, and to our knowledge, no study has been done that simultaneously examines the lumbar alignment and the direction of PIVD. The objective of the study was to clarify the relationship between the direction of PIVD and the alignment of the lumbar vertebrae. The research hypothesis was to evaluate the correlation between direction of prolapsed intervertebral disc (PIVD) and lumbar vertebral alignment.

MATERIALS AND METHODS

Particpants

A total of 102 participants of both sexes were randomly chosen for this cross-sectional study, which was conducted using the computerised SPSS software. Participants had to be between the ages of 30 and 50. The study included about 61 women and 41 men. Participants who had undergone MRI and X-ray for the lumbo-sacral spine and had been diagnosed with prolapsed intervertebral disc in the lumbar segment with lumbar vertebral mal-alignment were eligible to participate in this study. This study did not include participants who had undergone spinal fusion and fixation. This study complied with ethical standards and received approval from the Institutional Ethical Committee of Krishna Vishwa Vidyapeeth, KIMSDU, under reference number (Protocol Number 615/2022-2023). The participant gave informed consent along with the volunteer form covering study details, risks, benefits, confidentiality, and participant rights. The study prioritized the rights and welfare of the participant in the design, procedures, and confidentiality measures, strictly adhering to the ethical principles of the Declaration of Helsinki.The goal of the study was explained to the participants, and they were informed about the procedure. Each was evaluated for pain using the Numerical Pain Rating Scale (NPRS), the direction and level of PIVD were observed in MRI images, lumbar spinal alignment was evaluated by observing X-rays in the AP and lateral views, and observations were made. A correlation of the findings from each was performed to establish a relationship between them.

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).

Direction and level of the prolapse

This was observed on MRI. The disc material may protrude in a number of orientations, including the posterolateral, paracentral, right- and left-paracentral, biforaminal, anterior, and

anterolateral. Although rather uncommon, a prolapsed in the anterior direction is possible (Kotwal & Mittal, 2020)

Lumbar spinal alignment in the Anteroposterior (AP) and lateral view

Scoliosis was evaluated from an AP perspective and graded using Cobb's method. The upper border of the highest vertebra in the scoliotic curve and the lower border of the lowest vertebra in the scoliotic curve are both crossed by a straight line. Cobb's angle is the angle created by a perpendicular from these lines. Scoliosis is categorised into three grades: grade 1 for angle between 10° and 20°, grade 2 for angle under 40°, and grade 3 for angle above 40°. In the lateral view, spondylolisthesis, retrolisthesis, and lordosis were visible.

Spondylolisthesis and retrolisthesis was calculated with the Tillard's equation and graded using the Meyerding classification. The classification system divides slip into five grades: 0% to 25% is Grade I, 25% to 50% is Grade II, 50% to 75% is Grade III, 75% to 100% is Grade IV, and greater than 100% is Grade V. A line is drawn through the posterior wall of the superior and inferior vertebral bodies and measuring the translation of the superior vertebral body as a percentage of the distance between the two lines. This line is considered the displacement of vertebra over adjacent vertebra as numerator over the denominator which is length of the vertebral body below. Grades I and II are generally considered low-grade slip, whereas Grades III, IV, and V are considered high-grade slip (Koslosky & Gendelberg, 2020).

Lumbosacral angle (LSA)

The LSA angle was used to assess lumbar lordosis in lateral view. The angle produced by the superior surface of the sacrum and the horizontal surface is known as the LSA. LSA is normally between 40° and 45°. A higher LSA causes hyperlordosis, while a lower LSA causes flatback/hypolordosis (Okpala, 2014).

Statistical analysis:

The statistical analysis was carried out manually and with SPSS version 26.0 for Windows (SPSS Inc.,Chicago, IL, USA) of the statistics programme. The acquired data was statistically evaluated using descriptive statistics like mean, percentage, and standard deviation, p value calculation of direction of PIVD and lumbar alignment. 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 102 participants with PIVD. According to statistical analysis the correlation between PIVD and lumbar vertebral alignment was seen.

Table1. Demographic variables

		Gender		Total (n)	No. of participants (%)
		Male	Female		
Age (Years)	30-35	13	11	24	22%
	36-40	3	8	11	12%
	41-45	7	12	19	19%
	46-50 yrs	18	30	48	47%
Occupation	Farmer	8	5	13	12.7%
	Homemaker	0	39	39	38.2%
	Desk job	14	7	21	20.6%
	Doctor	2	2	4	3.9%
	Dentist	4	2	6	5.9%
	Nurse	1	4	5	4.9%
	Construction	5	2	7	6.9%
	Driver	7	0	7	6.9%

Interpretation

The table 1 interpret that 47% of participants with PIVD were aged 46-50 years, with 39% being women and 18 men. The majority of the participants were housewives, with 38.2% being housewives. Other occupations included desk workers, farmers, construction workers, drivers, dentists, nurses, and doctors. The study also revealed that a significant number of participants were housewives, drivers, dentists, nurses, and doctors.

Table 2. Occurrence of level of PIVD

Level of PIVD	Number of participants
L1/2	0
L2/3	0
L3/4	6
L4/5	34
L5-S1	20
L2/3+ L3/4	3
L2/3+ L4/5	2
L2/3+ L5-S1	1
L3/4+ L4/5	9
L3/4+ L5-S1	2
L4/5+L5-S1	10
L1/2+L3/4+L4/5	1
L2/3+L3/4+L4/5	4
L2/3+L4/5+L5-S1	1
L3/4+L4/5+L5-S1	7
L1/2+L2/3+L3/4+L4/5	1
L1/2+L2/3+L3/4+L4/5+L5-S1	1

Interpretation

Table 2 depict that only 2.94% of 102 participants had Prolapsed Intracranial Disc Disease (PID) at the L1-2 level, compared to 68.62% at the L4-5 level, 41.2% at the L5-S1 level, 33.3% at the L3-4 level, 12.74% at the L2-3 level, and 41.2% at the L5-S1 level. Many people have PIVD on multiple levels, with 60 patients having a PIVD at a single level. The majority of PIVDs occurred at the L4/5 and L5-S1 levels in 10 participants and the L3/4 and L4/5 levels in 9 participants.

Interpretation

Table 3 interprets that prolapsed intervertebral discs were most common in the posterocentral and biforaminal directions in 46.07% of 102 individuals. Scoliosis was present in 33.33% of the participants, with 12 having convexity to the right and 22 having convexity to the left. Exaggerated lumbar lordosis was reported in 4 subjects, while decreased lordosis was seen in 66. Anterolisthesis was observed in 20.59% of the subjects, while retrolisthesis was observed in 11.

Table3. Distribution of direction of PIVD and lumbar alignment

Direction	Number of participants	Lumbar spinal alignment	Number of participants
Posterocentral	20	Scoliosis with convexity towards right (Grade I)	5
Biforaminal	30	Scoliosis with convexity towards left (Grade I)	13
Right paracentral	3	Flatback	32
Left paracentral	13	Hyperlordosis	3
Anterior	1	Anterolisthesis (Grade I)	6
		Anterolisthesis (Grade I)	4
Posterocentral+ Biforaminal	8	Retrolisthesis (Grade I)	0
Posterocentral + right paracentral	7	Scoliosis with convexity towards right (Grade I) + flatback	5
		Scoliosis with convexity towards right (Grade I) + flatback	1
Posterocentral + left paracentral	7	Scoliosis with convexity towards left (Grade I) + flatback	7
		Scoliosis with convexity towards left (Grade II) + flatback	2
Biforaminal + right paracentral	3	Flatback + anterolisthesis (Grade I)	8
		Flatback + anterolisthesis (Grade II)	1
		Flatback + anterolisthesis (Grade III)	1
Biforaminal + left paracentral	3	Flatback + retrolisthesis (Grade I)	10
Right paracentral + left paracentral	2	Scoliosis with convexity towards right (Grade I) + flatback + anterolisthesis (Grade I)	1
Posterocentral + biforaminal + right paracentral	1	Scoliosis with convexity towards right (Grade I) + hyperlordosis + anterolisthesis (Grade I)	1
Posterocentral + biforaminal + left paracentral	2	Scoliosis with convexity towards left (Grade I) + flatback + anterolisthesis (Grade I)	1
Posterocentral + right paracentral + left paracentral	2	Scoliosis with convexity towards left (Grade I) + flatback + retrolisthesis (Grade I)	1

Table 4. P value of correlation between direction of PIVD and the lumbar spinal alignment

Direction of PIVD / Spinal Alignment	Posterocentral	Biforaminal	Right Posterolateral	Left Posterolateral	Anterior
Scoliosis with convexity towards right	0.5521 (NS)	0.5599 (NS)	<0.0001***	0.0117*	0.7169 (NS)
Scoliosis with convexity towards left	0.1550 (NS)	0.0176*	0.8868 (NS)	<0.0001***	0.6025 (NS)
Flatback	0.9142 (NS)	<0.0001***	0.4538 (NS)	0.0946 (NS)	0.4629 (NS)
Hyperlordosis	0.8740 (NS)	0.3932 (NS)	0.7053 (NS)	0.8453 (NS)	0.8411 (NS)
Anterolisthesis	<0.0001***	0.0050**	0.7160 (NS)	0.0229*	0.0490*
Retrolisthesis	0.4986 (NS)	0.0014**	0.4356 (NS)	0.1197 (NS)	0.7300 (NS)

NS= not significant ; ***= extremely significant ; **= very significant ; *= significant

Interpretation

Table 4 shows that a significant correlation between the posterocentral direction of PIVD and anterolisthesis, biforaminal direction of PIVD and flatback, right paracentral direction of prolapse and scoliosis with convexity towards the right, and left

paracentral direction of prolapse and scoliosis with convexity towards the left (p<0.0001). The biforaminal direction of PIVD was found to be very significant for anterolisthesis and retrolisthesis (p=0.0050, 0.0014). However, the correlation between posterocentral direction of prolapse and scoliosis with convexity towards the right, biforaminal direction of prolapse and scoliosis with convexity towards the right, and anterior direction of prolapse and scoliosis with convexity towards right and left was not significant (p=0.5221, p=0.5599, p=0.7169, p=0.6025). The correlation between the biforaminal direction of PIVD and scoliosis with convexity towards the left was also significant (p=0.0176). The study highlights the importance of understanding the correlations between PIVD and various conditions.

Table 5. Lumbo-Sacral Angle (LSA) and pain

	Mean + SD
LSA	31.79 ± 11.02
Pain at Rest	1.99 ± 1.38
Pain on Activity	5.51 ± 1.66

Interpretation

Table 5 depicts the mean value of the lumbosacral angle was 31.79 with a standard deviation of 11.02. The pain assessment was carried out by using VAS scale during rest and during activity. The mean of pain on rest was 1.99±1.38 and during activity was 5.51±1.66.

DISCUSSION

The purpose of this study was to investigate and determine the relationship between PIVD and lumbar vertebral alignment. The study comprised 102 participants (61 women and 41 men), aged 30 to 55 years, who had undergone MRI and X-ray for the lumbosacral spine and had been diagnosed with PIVD and lumbar vertebral malalignment. According to Zhang et al. 2023, lumbar disc herniation most usually develops between the ages of 30 and 50. In his study, Fromayer stated that the average age of patients suffering from LDH and eventually undergoing surgery is 42 years (Zhang et. al., 2023). Brinjikji et al. (2015) conducted a systematic review of patients diagnosed with spinal degeneration in asymptomatic populations ranging in age from 20 to 80 years, concluding that imaging evidence of degenerative spine disease is common in asymptomatic individuals and increases with age (Brinjikji et. al., 2015). According to the findings of our study, the age group of 46 to 50 years, with 30 women and 18 males was found to be the most usually impacted, and around 39 females were housewives.

Despite what some studies claim, disc bulge is more commonly detected at the L4-5 and L5-S1 levels (Demirel et. al., 2017) Furthermore, approximately 70 patients in our study exhibited PIVD at the L4-5 level, while approximately 42 participants had PIVD at the L5-S1 level. Markku (1986) conducted a study with the goal of identifying risk groups and developing causal hypotheses, and concluded that in men, the risk of being hospitalised due to herniated lumbar disc or sciatica was lowest in professional and related occupations, significantly higher in all other groups, and highest among blue-collar workers in industry and motor vehicle drivers. The variation in risk between occupational groupings of women was less pronounced but remained noticeable. However, risk was strongly linked with self-assessed strenuousness of job in women but not in men (Heliovaara, 1987) According to the findings of our study, participants who were housewives or worked at a desk were the most likely to have PIVD.

In the year 2016, a systematic review of literature on risk factors for recurrent lumbar disc herniation was conducted with the goal of investigating the existing evidence on risk factors for recurrent LDH (rLDH). According to this study, smoking, disc protrusion, and diabetes were all predictors of rLDH. Due to the scarcity of literature, further data from high-quality observational studies is required to further study risk factors for Rldh (Huang et. al., 2016). A 2016 study titled "Lumbosacral morphology in lumbar disc herniation a chicken and egg issue" measured intervertebral disc angles (IDA), lumbar lordosis angle (LLA), lumbosacral lordosis angle (LSLA), lumbosacral angle (LSA), and sacral tilt (ST) on

lumbar magnetic resonance imaging. In addition, this study demonstrated no correlation between lumbosacral alignment and LDH, despite variations in IDA according to the grade and amount of disc herniation (Coskun et. al., 2016).

Another study conducted in 2018 called "Sagittal alignment of the lumbar spine" revealed that the correlation between lumbar lordosis and pelvic incidence is a major predictor of the pathophysiology of lumbar developmental and degenerative disease. Realignment goals in the spine compromised by degenerative disease or deformity must prioritise restoration of lumbo-pelvic parameters. The majority of lumbar lordosis occurs between L4 and S1, and restoring lordosis in the lower lumbar spine is especially crucial to avoid junctional failure and adjacent segment degeneration (Berven & Wadhwa, 2018). Okpala (2014) conducted study to determine the average value of this angle in our population. This study indicated that utilising the LSA, it is now possible to have an idea of the probable values at which to consider hypo-lordosis (below 15°)/hyper-lordosis (above 75°) in our community (Okpala, 2014). The findings of our investigation revealed that the mean value of LSA is 31.79±11.02.

In comparison with LDH without trunk shift and controls, LDH with coronal trunk shift has a more anterior shift of the C7 plumb line, less LL, and a more horizontal sacrum, according to Wu et al.'s 2019 study on the coronal and sagittal spinal alignment in lumbar disc herniation with scoliosis and trunk shift. In patients with disc herniation, correlation analysis revealed a discordant spinopelvic connection and a change in the compensatory model (Wu et. al., 2019) Our study's findings demonstrated that PIVD most frequently occurred in the posterocentral and biforaminal directions, each in 46.07% of subjects. The lumbar alignment also underwent numerous modifications, with 33.3% of participants having scoliosis and convexity to the left and right, 3.92% having hyperlordosis, 64.71% having hyperlordosis, 20.59% having anterolisthesis, and 10.8% having retrolisthesis. Additionally, the mean pain during activity was 5.51±1.66.and was 1.99±1.38 at rest.

With the rising frequency of lumbar disease among the working population as a result of long sitting and standing hours, there is also an increase in the financial burden placed on them as a result of costly studies. This leads to further delays in medical intervention and, as a result, a poor prognosis. A thorough physical examination must be combined with modern imaging to get an accurate diagnosis. Following a thorough postural examination, this study will allow the physical therapist to forecast the direction of the prolapsed disc in the lumbar segment. This study filled a knowledge gap by adding to the evidence that there is a considerable association between the direction of a prolapsed intervertebral disc and the alignment of the lumbar vertebrae.

This study has some limitations, including a small sample size and a dearth of male participants. It was limited to a single geographical area. The proposed time frame for the study was likewise rigorously adhered to. Data for lumbar spinal alignment with hyperlordosis and anterior orientation of prolapsed intervertebral disc were insufficient.

Clinical Implications

The relationship between PIVD orientation and vertebral alignment is crucial for patient management. It allows for treatment customization, enabling precise treatment plans based on the alignment of disc prolapses with vertebral misalignments. This knowledge also enhances prognostic capabilities, allowing for more informed treatment expectations and long-term management strategies. Additionally, it contributes to preventive medicine, identifying patterns indicating a predisposition for PIVD and specific vertebral alignments, enabling targeted interventions to reduce disc herniation risk. This study highlights the importance of thorough physical examination and modern imaging in diagnosing lumbar disease, especially in the working population.

Suggestions

Thorough research can be done by using validated measures such as the Roland-Morris Disability Questionnaire (RMDQ) and the Oswestry Disability Index (ODI) to standardise the assessment of functional disability, and enhance treatment outcomes. Tailored rehabilitation strategies can result from creative physiotherapy interventions that target specific PIVD directions and lumbar vertebral misalignments. By enabling people to take charge of their own spinal health, patient education and self-management techniques may be able to lessen the symptoms and recurrence of PIVD. Larger sample sizes and extended follow-up periods in longitudinal studies can shed light on the long-term effects of

physiotherapy treatments. Evidence-based guidelines for the management of spinal conditions related PIVD must be developed through collaborative research involving physiotherapists, radiologists, and biomechanical experts.

Conclusion

Prolapse was seen to occur on the same side as the convexity in cases with scoliosis. The posterocentral direction saw the most prolapsed discs in an anterolisthesis. Biforaminal prolapse was noticeably present in flatbacks. The prolpase in retrolisthesis was noticeably present in the biforaminal direction. The information for people with hyperlordosis and anterior prolapse is insufficient to make a comment. As a result, there was a significant relationship between lumbar vertebral alignment and the direction of PIVD.

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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 615/2022-2023.

Author Contributions

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

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RESEARCH ARTICLE

Overweight and Obesity among University Student: Cross Sectional Study Exposes Association with Food Habit and Physical Activity

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Abstract
This study aims to investigate the association between food habit, physical activity, and nutritional status in university students. Cross sectional study was conducted on 62 undergraduate university students (22 males, 40 females, 20.82 ± 2.52 years) enrolled from five departments. International Physical Activity Questionnaire-Short Form (IPAQ-SF) was used to measure physical activity level. Evaluation of food habit was collected through a validated Recommended Foods Score which has been adapted to measure diet quality in general with a focus on healthy food intake. Independent sample t-test and Mann-Whitney test were done to compare the measured variables between sport major and non-sport major student. Spearman correlation was performed to examine the association between measured variables. The results showed that more than one-fifth of total subjects (21%) were overweight. Food habit is associated with body mass index (p=0.005) and METs score (p=0.032). Lastly, physical activity was positively associated with BMI (p=0.004). From the findings it can be conclude that balance amount of healthy food and actively engage in physical activity can contribute to lower BMI, as well as maintain health and well-being. This also happens to adolescent population, include university students an age group which could be addressed to prevent several health problems.

Keywords
Adolescents, Food Pattern, Obesity, Overweight, Physical Activity, Recommended Food Score

INTRODUCTION

The prevalence of obesity in the world is increasing progressively during last few decades, especially among children and adolescents (González-Muniesa et al., 2017; Sholikhah & Tuah, 2021). The high prevalence presents in low and middle-income countries (LMIC) as well as in high-income countries (Jebeile et al., 2022). The incidence varies around the world, from less than 2% in Sub-Saharan Africa to more than 30% in the United States (WHO, 2017). It has been estimated that in 2030, about 1.35 billion and 573 million adults would have problem related to overweight and obesity, respectively (Romano et al., 2021). In Indonesia, obesity increases at all ages, where the result of Indonesian Basic Health Research reported a rise in obesity prevalence from 15.4% in 2013 to 21% in 2018 (Merino et al., 2017; Ministry of Health, 2018a).

Obesity and overweight are being the ultimate risk factors that contribute to the development of many non-communicable diseases

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(NCDs) such as hypertension (ca 6%), cardiovascular and heart disease (ca 16%), cancer (15%), diabetes mellitus (ca 10%), and other chronic diseases (Kok et al., 2023; Nugroho et al., 2020; Qadir et al., 2014). Most of the total population is now living in countries where being obese or overweight kills more individuals than being underweight (Berhanu et al., 2023). Approximately, around 3.4 million deaths occurred every year due to overweight or obesity (Henning, 2021), making obesity a real pandemic in 21st era (Villalobos, 2016).

The issues related with obesity affect population in general, including adolescents. An obese or overweight teenager hold higher risk of being obese/overweight during adulthood (CDC, 2018) and of developing aforementioned diseases (Yun et al., 2018). Although the onset and development of obesity are most evident during youth (Gan et al., 2011), university students also experience a crucial period when their life styles and behaviors are conducive to change in favor of gaining weight (Ganasegeran et al., 2012).

College weight gain happens during an individual entering university life, which is a critical transition period when the behavior and lifestyle of young adults including food habits are prone to change as they have freedom to choose what to eat (Yun et al., 2018). These populations are at greater risk of developing unhealthy eating practices with inadequate nutrient intake (Gan et al., 2011), which might affect their health in the future (Genena & Salama, 2017). Some of these practices include skipping breakfast, irregular meals, snacking, low intake of fruit and vegetable, as well as increased consumption of fried and processed food (Ganasegeran et al., 2012). Although these behaviors are considered temporary as a part of university life, the unhealthy habit and practice built up at this age tend to persist in later life (Scaglioni et al., 2018).

Apart from food habit, sedentary lifestyle and low physical activity also play a role on the increase of overweight and obesity in university students (Yun et al., 2018). Many public health efforts related to exercise have been formulated, including setting standard and guidelines on the level of physical activity (PA), provided guidance as well as suggestion on the duration, frequency, and intensity of PA (Bull et al., 2020). For example, CDC recommends that adults aged 18–64 years should practice thirty minutes of moderate to vigorous physical activity (MVPA) for at least five days a week, or preferable sixty minutes for more health benefits. However, late studies show that such efforts have been pointless, with Global Burden of Disease (GBD) reported that the level of inactivity globally has not changed from 2001 to 2016 (Grasdalsmoen et al., 2019).

Studying the physical activity among adolescents especially university students will aid in understanding the important relationship of PA with overweight and obesity. Investigation related to this matter have been done in past, however only few is known that also looked the relationship with food habit. Thus, this study was conducted to assess the association between overweight / obesity, food habit, and physical activity especially among university student in East Java.

MATERIALS AND METHODS

Study Design and Participants

This cross-sectional study was conducted among 62 undergraduate students in Universitas Negeri Surabaya. Data was collected during October to November 2022, where the samples were randomly chosen from students enrolled in sport major and non-sport major across five faculties. This study was approved by the Research Ethics Committee of Airlangga University with reference number 101/EA/KEPK/2023, and all procedures and protocol complied with the Helsinki World Medical Association Declaration on the ethical conduct of research involving human subjects. 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.

Baseline characteristic

Baseline characteristic data was collected using self-administered questionnaire comprised of general information such as demographic (age, sex, year in university, major, place of origin, living arrangement, mothers' education, physical activity or METs score, RFS points), and socio-economic (monthly allowance and father's occupation).

Food habit

specific for adolescents which was developed by Slater et al., (2003). The questionnaire was added food items consumed locally. It consisted of a list composed of 50 food items, whose frequencies of consumption were categorized in never, less than once a month, 1-3 times a month, once a week, 2-4 times a week, once a day, and ≥ 2 times a day. Such information was evaluated using the average of healthy diet score, which refers to the Recommended Foods Score (RFS). RFS is an instrument developed by Kant (2000) which aims to confirm the quality of the diet in general using FFQ, with focused on the intake of lean meats, fruits/vegetables, and low-fat dairy products (Table 1). In this study, we modified the RFS according to Indonesian diet. We gave one point for every food item that was consumed at least once a week, made it a total 50 point in maximum score. Higher score of RFS indicating better diet quality.

Physical Activity

Physical activity was measured using International Physical Activity Questionnaire-Short Form (IPAQ-SF) that was developed by Craig et al (2003). The physical activity score was obtained from the METs-minutes/week which is the sum of walking activity, moderate activity, and vigorous activity in duration (minutes) and frequency (days), which was then multiplied by the value of each METs. The multiplication results were then classified into three categories: mild (< 600 METs minutes/week), moderate (600-3000 METs minutes/week), and severe (> 3000 METs minutes/week).

Nutritional Status

Dietary habit data was collected through a validated food frequency questionnaire (FFQ)

Nutritional status was obtained through anthropometric measurements. Bodyweight was measured using an electronic scales with accuracy 0.1 kg (Omron HN-289, Osaka, Japan) and height using portable stadiometer (Seca 213, Seca Ltd., California, US) with a level of accuracy of 0.1 cm. Body mass index (BMI) was then calculated from weight divided by the square of height (kg/m^2), and nutritional status was classified into categories proposed by Ministry of Health, (2018b): (1) very thin (< 17 kg/m^2); (2) thin (17.0 – 18.4 kg/m^2); (3) normal (18.5 – 25.0 kg/m^2); (4) overweight (25.1 – 27.0 kg/m^2); (5) obesity (> 27 kg/m^2).

Data Analysis

All data were presented descriptively as mean and standard deviation or frequency and percentage. Normal distribution was checked using Saphiro-Wilk test. Independent sample t-test and Mann-Whitney test were done to compare the measured variables between sport major and non-sport major student. Lastly, Spearman correlation was performed to examine the association between nutritional status, food habit, and physical activity. All statistical analysis was performed using SPSS 25 (IBM Corp. Armonk, NY) for Windows with significant level was set at 0,05.

RESULTS

Present study had a total of 62 students participated. Among them, 22 students (35.5%) were males and 40 students (64.5%) were females, with average age was 20.82 ± 2.52 years. The average of bodyweight and height are 60.44 ± 9.71 kg and 1.66 ± 7.58, respectively. Most of the students had normal BMI (59.7%) (Table 2).

Table 1. List of local food items adapted from recommended foods score

Group	Food	Total Item
Vegetables	Broccoli, spinach, cabbage, tomato, carrot, lettuce, corn or peas, zucchini, cucumber, okra, potato, basil, sweet potato, beetroot, boiled cassava, eggplant, morning glory, watercress, fern sprout	19
Fruits	Orange, pear or apple, watermelon, melon, lemon, banana, pineapple, strawberry, mango, papaya, guava, avocado, starfruit, grape, dragon fruit	15
Legumes	Mungbean, soybean, peanut, almond	4
Cereals	Oatmeal, rice	2
Dairy	Skimmed milk, yogurt, cheese, soya milk	4
Lean meats	Roasted (beef/chicken/fish), grilled (beef/chicken/fish)	6
Total		**50 points**

Table 2. Baseline characteristic of participants

Socio-demographic Characteristic	Value
Age (year), mean (SD)	20.82 (2.52)
Gender, n (%)	
Male	22 (35.5)
Female	40 (64.5)
Weight (kg), mean (SD)	60.44 (9.71)
Height (m), mean (SD)	1.66 (7.58)
BMI (kg/m^2), n (%)	
Underweight	10 (16.1)
Normal	37 (59.7)
Overweight	13 (21.0)
Obese	2 (3.2)
Year in university, n (%)	
First year	19 (30.6)
Second year	17 (27.4)
Third year	15 (24.2)
Fourth year	11 (17.7)
Major, n (%)	
Sport major	25 (40.3)
Non-sport major	37 (59.7)
Place of origin, n (%)	
Urban	29 (46.8)
Rural	33 (53.2)
Living arrangement, n (%)	
Living with parent	12 (19.4)
Dormitory/boarding house	41 (66.1)
Living alone	9 (14.5)
Father's occupation, n (%)	
Unemployed	4 (6.5)
Entrepreneur	24 (38.7)
Civil servant	11 (17.7)
SOE official	8 (12.9)
POE official	15 (24.2)
Mother's education status, n (%)	
Uneducated	1 (1.6)
Primary school	5 (8.1)
Junior high school	14 (22.6)
High school	25 (40.3)
College/university	17 (27.4)
Monthly allowance, n (%)	
< 500.000 IDR	19 (30.6)
500.000 – 1.000.000 IDR	31 (50.0)
> 1.000.000 IDR	12 (19.4)
METs, n (%)	
Mild	37 (59.7)
Moderate	17 (27.4)
Severe	8 (12.9)
RFS score, n (%)	
> 80th percentile	23 (37.1)
< 80th percentile	39 (62.9)

Most of the students involved in this study were freshmen (30.6%) coming from non-sport major (59.7%). More than half of the students (53.2%) were from rural area of East Java. Regarding living arrangement, 66.1% of students resided in university dormitory or boarding house. The majority of students had fathers who worked as entrepreneur (38.7%) and mothers with high school diploma (40.3%). In term of socio-economic characteristic, half of the students (50.0%) got 500.000 – 1.000.000 IDR as monthly allowance. Physical activity level which was presented as METs showed that more than half of the students were in mild category (59.7%) and most of them (62.9%) had RFS score < 80th percentile (Table 2).

From Table 3, it was found that age, height, and RFS score were not significantly different between sport major and non-sport major, with p=0.076, p=0.113, and p=0.215, respectively. The differences were found in bodyweight (p=0.048), BMI (p=0.029) and METs score (p=0.036) which sport major students had higher bodyweight and physical activity level, as well as had lower BMI compared to non-sport peers.

In term of all-group differences, bodyweight and BMI of non-sport major students were found to be significantly different compared to sport major and all subjects (p<0.05). But, METs score of non-sport major was only different with sport-major peers (Table 3).

Table 3. The difference of measured variables between sport and non-sport major students

Characteristics	Mean ± SD			Sig.
	All (n=62)	Sport Major (n=25)	Non-sport Major (n=37)	
Age	20.82 ± 2.52	21.05 ± 1.49	20.92 ± 1.93	0.076[a]
Bodyweight (kg)	57.40 ± 8.36	58.00 ± 14.66	55.83 ± 10.22*†	0.048[b]
Height (cm)	159.40 ± 5.24	161.24 ± 8.73	159.83 ± 8.08	0.113[a]
BMI (kg/m^2)	22.93 ± 2.68	21.95 ± 2.35	23.82 ± 3.08*†	0.029[a]
RFS score	30.25 ± 1.50	31.22 ± 1.85	31.90 ± 1.72	0.215[a]
METs score	972.50 ± 10.24	1024.77 ± 13.82	925.64 ± 12.15†	0.036[a]

Description: [a]analysed using Mann-Whitney test; [b]analysed using independent t-test
(*)Significantly different with all group (p ≤ 0.05). (†)Significantly different with sport major group (p ≤ 0.05).

Table 4. Correlation between food habit, physical activity, and body mass index

	BMI		RFS score		METs score	
	sig.	r	sig,	r	sig.	r
BMI	-	-	0.005*	-0.518	0.004*	-0.729
RFS	0.005*	-0.518	-	-	0.032*	0.625
METs	0.004*	-0.729	0.032*	0.625	-	-

Description: *significant at 0.05

Spearman test shows that food habit is significantly associated with body mass index, with p=0.005 and r=-0.518. The same result is observed in physical activity level which is found to had strong negative relationship with body mass index with p=0.004 and r=-0.729. Lastly, physical activity was positively associated with food habit assessed by RFS, with p=0.032 and r=0.625 (Table 4).

DISCUSSION

Present study revealed high frequency of overweight among university students, which was more than one-fifth of the total subjects. Previous investigation has also uncovered worrying profiles of overweight and obesity among the adolescents from different region of the country. A cross sectional study involving senior high school students across five big cities in Indonesia found that more than one-third of the sample was overweight (Sarintohe et al., 2022). In other hand, previous literature study reported the prevalence of overweight and obese students from 29 medical faculties across Indonesia was 35.5% (Diani et al., 2023) and the highest prevalence was found in medical students based in Jakarta (Azzahra et al., 2020).

These findings present that the nutritional status of adolescents, especially university students, becomes serious public health problem (Bulqini et al., 2021), since overweight and obesity developed in these age groups is often associated with the early onset of other chronic or non-communicable diseases such as diabetes mellitus, dyslipidemia and hypertension in future life (Coelho et al., 2012; Enes & Slater, 2010). Moreover, overweight and obesity in young people may lead to other long term health problems, such as the increased risk of morbidity, premature deaths, and disability in adulthood (Coelho et al., 2012).

It is well-understood that preserving a healthy lifestyle since younger age is important for obesity prevention (Jakobovich et al., 2023; Janicke et al., 2021), once numerous attributes of adulthood are achieved and/or associated with this age group, making it more important to involve determinant factors such as practice of physical activities and food habit into the investigation (Coelho et al., 2012; Mello et al., 2004). As for physical activity, it is important to highlight that its practice among children and adolescents should be repeatedly stimulated , because although the majority of health problems associated with physical inactivity or sedentary lifestyle will present only in later life, it is known that their onset can start and develop since childhood or adolescence (Dias et al., 2014).

Therefore, many studies were conducted to investigate the practice of physical activity, showing higher percentages of sedentarism in adolescents (Fadillah et al., 2021; Ziaei et al., 2022) which is in line with the result of present work. Present study found that overweight/obesity was associated with physical activity, where higher BMI was correlated with lower MET score. This finding was similar to previous study which showed negative correlation between BMI and physical activity in adolescents, where the higher of body mass index would lower the physical activity level, and vice versa (Correa-Rodríguez et al., 2017; López-Sánchez et al., 2019; Muharam, 2019). It could be implied that an increase in percentage of fat mass (%FM) which is observed by BMI might be responsible for a decrease in physical activity score (Dewi et al., 2021). This could lead to many serious problem in the future as lower physical activity level would cause numerous health disorders such as cardiovascular diseases, diabetes mellitus (Maulana et al., 2021; Ridwan et al., 2022; Sholikhah & Ridwan, 2021), and even could impact physical fitness thus affecting their performance at school or university (Hariyanto et al., 2023).

As for dietary habit, we found that body mass index was related with food intake assessed by RFS, corroborating the longitudinal study conducted by Wolongevicz et al. (Wolongevicz et al., 2010) where females with lower diet quality were more likely to become overweight or obese after 16-year of follow up. Other study also reported similar finding where the higher score of healthy food pattern, the lower was BMI of the adolescents (Gutiérrez-Pliego et al., 2016). Overweight and obesity is undoubtedly linked with food intake. Food intake is a complex thing in which diverse variables are combined, as it is built by a set of biological and social interactions mediated by the culture where it takes place such as belief, surrounding environment, the influence of friends and family, etc (Gutiérrez-Pliego et al., 2016). In many occasions, the university living environment placed students in a new and unfamiliar settings such as detachment from home and parents, new friends or roommates, and new campus life coming with more competing demands in academic life, which possibly make them struggle in adapting to this situation (Kabir et al., 2018). Thus, healthy food choice might not become first priority (Nelson et al., 2009) which motivates them to buy food that is convenience, fast, and inexpensive instead (Marquis, 2005). This phenomenon could also be seen in present study where majority of students had lower score of RFS, indicating low intake of healthy food.

Similar to diet quality in general, many researchers have documented an association between food pattern and physical performance in adults. Granic et al. (2016) in their prospective study found that healthy diet consisting of a high intake of nuts, fruits, fish, vegetables, cereals, and dairy products, has a prolonged effect on improving age-related physical performances. Considering that food pattern/habit and RFS are related, a higher score of it may indicate that adequate food intake of healthy nutrients is associated with various health benefits (Jeong et al., 2019). These findings suggest that the reduction of overweight and obesity risk may be possible through various strategies which optimize the nutrient quality of the individual's habitual

eating behavior, as well as promoting physical activity on university students.

Conclusion

We can conclude through this study, that the studied population shows a high prevalence of overweight, which is significantly associated with low level of physical activity and low quality of the healthy diet assessed by RFS. Balance amount of healthy food and actively engage in physical activity can contribute to maintain health and well-being. This also happens to adolescent population, include university students—an age group which could be addressed to prevent several health problems. Therefore, further research should be carried out to identify possible interactions between these factors and even other factors than those already investigated that may influence the occurrence of overweight in this age group, thus supporting the development of measures and strategies to control and fight obesity among the young generation.

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Conflict of interest

The authors declared to have no conflict of interest. In addition, no financial support was received.

Ethics Statement

The study was approved by Research Ethics Committee of Airlangga University with reference number 101/EA/KEPK/2023.

Author Contributions

Study Design, P and DY; *Data Collection*, EFY; *Statistical Analysis*, AMS; *Data Interpretation*, EFY and AMS; *Manuscript Preparation*, P and SHPP; *Literature Search*, DY. All authors have read and agreed to the published version of the manuscript.

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RESEARCH ARTICLE

Association Between Physical Fitness, Body Fat, BMI, and Physical Activity Level with Learning Outcomes in Elementary School Students

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Abstract
The main problem in achieving learning outcomes in physical subjects at the primary school level is very complex. This study aimed to investigate the relationship between physical fitness, body fat, BMI, and physical activity levels with physical education learning outcome in elementary school students. A cross-sectional study was conducted to answer the research questions. This study involved 27 students (Aged 10.82±0.79) from elementary schools in Malang City, Indonesia. Instruments to determine physical fitness include endurance (PACER Test), flexibility (V sit and reach), and strength (sit-ups and squat thrust), the Indonesian Physical Fitness Test was used to determine body fat and Body Mass Index (BMI), and Physical Activity Questionnaire for Children (PAQ-C) was used to determine physical activity levels. The research result showed that physical fitness, body fat, BMI, and physical activity level were closely related to learning outcomes (R of 0.821), but only physical fitness influences physical fitness (Sig. < 0.05), while body fat, BMI, and physical activity level had no effect. In conclusion, students with good physical fitness tend to get good learning outcomes, so the physical education curriculum must accommodate physical activities that can increase the physical fitness level of students. Future research on academic success factors needs to be investigated, especially schools need to promote movement-based activities to support academic success.

Keywords
Physical fitness, Pacer test, Physical activity, Obesity, Physical education, Learning outcomes

INTRODUCTION

Education is anticipated to have a significant influence on learning outcomes, particularly in terms of how students behave. This behavior change should encompass all the untapped potential within children that can be nurtured through education. Physical education, which is an important component of holistic education, is one part of this (Cereda, 2023). Through carefully organised physical, sports, and health activities, the goal is to promote physical fitness, motor skills, critical thinking abilities, social skills, logical reasoning, emotional stability, moral action, a healthy lifestyle, and an introduction to environmental consciousness (Bailey et al., 2009; Erfle & Gamble, 2015; Goudas & Magotsiou, 2009; Meyer et al., 2013; Özkan & Kale, 2023; Starc & Strel, 2012). Physical education holds great importance within the education system. Therefore, it is offered to foster the development of motor skills, physical capabilities, knowledge, reasoning abilities, appreciation for values (including mental, emotional, spiritual, and social attitudes), and the cultivation of habits that promote a healthy lifestyle, ultimately leading to

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well-rounded and comprehensive growth and development (Randall, 2013).

Learning outcomes are an indicator of students' success in participating in physical education lessons. Many studies report that learning outcomes can be achieved by students because of the success of the learning methods applied by teachers (Yu et al., 2021; Zacharis, 2011), students' motivation (Rafiola et al., 2020; Tella, 2007), and use of technology in learning (Khasanah & Hariyoko, 2023; Lee & Lee, 2021). Factors in achieving learning outcomes need to be explored so teachers, students, and parents can know clearly about the factors to further develop strategies based on the identified factors. This is important considering that each child has a different character and each learning method will produce a different impact on each student. Another research also revealed that physical activity, learning environment, and learning motivation are important factors in improving learning outcomes (Hasbullah et al., 2021). Firdaus et al. (2023) also reported that students who have a good body mass index (BMI) and physical fitness are not enough to get optimal learning results without high learning motivation.

Physical education develops cognitive, affective, and movement-based psychomotor aspects (McLennan & Thompson, 2015). The cognitive domain is concerned with how humans acquire, process, and apply knowledge. This is known as the "thinking" domain. Our attitudes, values, and emotions are all part of the affective domain. This is known as the "valuing" domain. The psychomotor domain is concerned with manual or physical abilities. This is the domain of "doing". All three must be addressed if unmotivated pupils who lack the motivation or ability to learn are to overcome barriers to learning and academic achievement (Dudley & Burden, 2020).

This study attempts to identify several variables that are assumed to have a close relationship to learning success in physical education subjects. Physical fitness, Body Fat, BMI, and Physical Activity Level are considered as several determining factors for learning success. Although several studies report that good physical fitness can influence the achievement of good learning outcomes (Nanda & Sari, 2021), however, it cannot be denied that other aspects can encourage students to improve their learning outcomes. A teacher who has limited information regarding the factors that cause student learning outcomes will not have a strategy to improve their learning outcomes. A student who has a good level of physical activity may not necessarily be able to complete the tasks given by the physical education teacher, nor do students with a tendency to be obese find it difficult to perform movement skills. It has been recommended that the treatment of obesity in young people should focus on environmental factors such as diet and physical activity that can be modified (Barlow & Committee, 2007), rather than focusing on excess weight and weight control.

Physical inactivity among children and adolescents is becoming a rising public health issue (Baldonado et al., 2022; Wyszyńska et al., 2020). In 2018, only between 20 and 40% of children aged 5 to 17 years in Europe met the WHO recommendation of 60 minutes of moderate to vigorous intensity physical activity every day (Aubert et al., 2018). Therefore, children with lack physical activity also have the potential to become overweight (Aquino & Reyes, 2022).

The studies that have been reported are only limited to factors that influence the achievement of student learning outcomes in Physical Education subjects which include aspects of movement skills (Aziz, 2014), cognitive, affective, and psychomotor aspects (Mirzeoğlu, 2014), and physical fitness (Agustin et al., 2021), yet there are still limited studies linking whether overweight, physical activity, and body mass index affect student learning outcomes in physical education.

So, this study seeks to investigate whether physical fitness Body Fat, BMI, and Physical Activity Level are considered closely related and contribute to the achievement of student learning outcomes in physical education subjects. This study involved elementary school students aged 9-12 years. These findings can be a key driver for teachers and schools in promoting fit, active, and healthy living in achieving student learning outcomes.

MATERIALS AND METHODS

Participants

This study was a cross-sectional study. This study involved an elementary school in Malang City, Indonesia, totaling 41 students, of which 14 students were not involved in data analysis because each student did not complete one of the tests, resulting in 27 students as participants (male = 12, female = 14). Participant categories are shown in Table 1.

This study was approved by the Research Ethics Committee of the State University of Malang with reference number No (LB.01.02/9/KE.114/2023), and all procedures and protocol complied with the Helsinki World Medical Association Declaration on the ethical conduct of research involving human subjects. 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.

Table 1. Participant characteristics

Variable	Total (n=27)			
	M	SD	Minimum	Maximum
Age	10.82	0.79	9	13
Body mass (kg)	37.10	9.53	24	62.3
Body height (m)	1.42	0.07	1.28	1.52
Body Mass Index (kg/m2)	18.32	4.66	13.64	31.79

Mean (M); Standard Deviation (SD)

This research seeks to measure physical fitness, body fat, body mass index (BMI), physical activity levels, and learning outcomes in elementary school students. Instruments used to measure physical fitness include endurance (PACER Test), flexibility (V sit and reach), and strength (sit-ups and squat thrust).

Body mass index and body fat using the Indonesian Student Fitness Test (Ministry of Youth and Sport, 2022). To determine the level of physical activity with the Physical Activity Questionnaire for Children (PAQ-C) (Kowalski et al, 2004). Physical fitness tests that refer to the Indonesian Student Fitness Test include the V-Sit Reach Test, Sit-ups for 60 seconds, Squat Thrust for 30 seconds, and Pacer Test.

Meanwhile, learning outcome data comes from physical education subject grades in the current semester. The measurement activities were carried out over 2 days in August 2023. On the first day, all participants filled out a form willing to take a series of tests. Next, all participants took a physical fitness test. On the second day, all participants filled out the PAQ-C questionnaire and measured Height, Weight, and Age.

Statistical analysis

The study seeks to determine the relationship between physical fitness, body fat, body mass index, level of physical activity, and learning outcomes in physical education subjects, so the data is analyzed using multiple linear regression to determine the relationship between variables both partially and simultaneously. In addition, normality test data was also carried out. The Statistical Package for Social Sciences (SPSS) software programme version 23.0 was used to analyse all data.

RESULTS

Table 2 presents the test results for physical fitness, body fat, body mass index, and physical education subject grades during the semester. The Physical Fitness Score was the result of a combined analysis of the V-Sit Reach Test, Sit-ups for 60 seconds, Squat Thrust for 30 seconds, and Pacer Test.

Table 2 showed that the average physical fitness score of number 2, which when translated based on the Indonesian Student Fitness Test guidelines, was included in the Fair category. The average body fat value of 0.66 showed that most were in the Normal category.

Meanwhile, the average Body Mass Index value was 18.32, which means that the majority of

participants were in the good (normal) nutrition category. Physical activity level data also showed interesting information, namely that students with moderate and low physical activity had the same composition (n=12) (Table 3).

Table 4 showed that the Adjusted R-value was 0.616, which meant that (physical fitness, physical activity, body fat, BMI, and physical activity level) affected the learning outcomes of PE subjects by 61.6%. Meanwhile, the rest (100-61.6=38.4%) was influenced by other variables besides physical fitness, physical activity, body fat, BMI, and level of physical activity. To find out whether physical fitness, physical activity, body fat, BMI, and level of physical activity partially influence learning outcomes in Physical Education subjects, it could be seen in Table 5.

Table 2. Data on physical fitness, body fat, body mass index, and physical education subject grades

Variable	Total (n=27)			
	M	SD	Minimum	Maximum
Physical Fitness	2	0.5	1.3	3.1
Body Fat	0.66	0.10	0.5	0.93
Body Mass Index (kg/m2)	18.32	4.66	13.64	31.79
Physical Education Subject Grade learning outcomes	84.6	2.6	80	89

Mean (M); Standard Deviation (SD)

Table 3. Data of physical activity level

Category	Frequency	Percentage (%)
Very high	0	0
High	3	11.12
Medium	12	44.44
Low	12	44.44
Very low	0	0
Total	27	100

Table 4. Coefficient of determination value

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.821[a]	.675	.616	1.635

a. Predictors: (Constant), Physical Activity, Body fat, Physical Fitness, BMI

Table 5. Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	78.899	3.905		20.207	.000
	Body Mass Index	.460	.755	.140	.609	.549
	Bodyfat	.860	.647	.318	1.330	.197
	Physical Fitness	3.644	.634	.802	5.747	.000
	Physical Activity	-.890	.508	-.229	-1.753	.093

a. Dependent Variable: Learning Outcomes

Based on Table 5, the only significance value < 0.05 was physical fitness, so only physical fitness influenced learning outcomes in physical education lessons. Meanwhile, BMI, body fat and physical activity did not have a significant effect. Table 6 showed that there is no difference in learning outcomes between male and female students.

Tabel 6. Independent Sampels T-Test

	t	df	p
Male - Female	-0.757	25	0.456

Note. Student's t-test

DISCUSSION

This research seeks to investigate the relationship between physical fitness Body Fat, BMI, and Physical Activity Level with student learning outcomes in physical education. The findings showed that physical fitness Body Fat, BMI, and Physical Activity Level had an influence on achieving learning outcomes, but partially, only physical fitness influenced students' achievement of learning outcomes.

The connection between physical fitness and overall health is well-established. Maintaining physical fitness can lower the chances of developing cardiovascular diseases, type II diabetes, and obesity (Hillman et al., 2008). Furthermore, it has been shown to positively impact mental health by reducing symptoms of depression, anxiety, and stress (Eveland-Sayers et al., 2009). The well-being of children and adolescents is greatly influenced by their physical fitness levels. Not only does it contribute to better brain function, cognitive abilities, and academic performance (Tomporowski et al., 2008), but it also raises concerns about the overall development of individuals worldwide.

Participating in numerous sports requires maintaining and increasing health-related physical fitness, which includes cardiovascular endurance, muscle strength and endurance, flexibility, and body composition (Chen et al., 2016; Ni & Yu, 2023), therefore the students who had good physical fitness, they would be able to follow the movement learning assigned by the teacher. Legarra-Gorgoon et al. (2023) conducted research in preschool children in Spain to investigate the relationship between basic motor competence (BMC) and physical fitness. Higher BMC was associated with better physical fitness in Spanish preschool children, according to his research. These findings highlight the critical role of basic motor skills in increasing physical activity in preschool children.

The thing that needed attention were students with a high Body Mass Index (BMI), which means being overweight can harm physical fitness, as in a study reported by Liu et al. (2023) on children aged 4-9 years in China. Schools must be promoters of healthy living through physical activity as outlined in the physical education curriculum. Physical activity has many health benefits, including better cardiovascular endurance, blood pressure, and reduced risk of future depression and heart attacks (Bushman, 2019). Schools are the main place to reach the majority of Indonesian children and provide them with physical opportunities. Some schools provide arenas for playing amidst the narrowing of empty land in urban areas.

Although the findings in this study showed that physical activity, BMI, and Body fat were not closely related to learning outcomes, other studies reported different results (Aziz, 2014; Firdaus et al., 2023; Hasbullah et al., 2021; Liu et al., 2023; Meyer et al., 2013; Rodriguez et al., 2020). This was caused by many factors, including part of the limitations of this study. This study did not observe the tests given to all students to achieve student learning outcomes. The learning outcomes obtained from the students could be in the form of physical fitness tests, working on questions, or even structured assignments. This needed to be observed further and to find out the indicators of student success in taking physical education lessons.

The conclusion of this study was the physical fitness indicators were very closely related to student learning outcomes in physical education lessons. The physical education curriculum must accommodate the needs of elementary school students to be more physically active and have ideal body composition. This was a major challenge for physical education subjects amidst the issue of physical activity in free time which most teenagers use to look at gadgets, television, and also to just lie down.

Conflict of Interest

The authors have declared no conflicts of interest.

Ethisc Committee

This study received permission from the Ethics Commission of the State University of Malang No 101/KEPK/2023

Author Contributions

Study design, SA, YNH; Data Collection, YNH, PW; Statistical Analysis, TDP, YNH, BAM, PD; Manuscript preparation, YNH, PW, TDP; Literature review, SA, YNH. All authors have read and agreed to the published version of the Manuscript.

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RESEARCH ARTICLE

Single Shot of Knee Intraarticular Injection of Platelets Rich Plasma versus Hyaluronic Acid Injections for Symptomatic Knee Osteoarthritis. An Observational Prospective Study

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Abstract
The aim of this study was to evaluate the effectiveness and safety of intra-articular PRP and HA in KOA patients. Methods: The current work was prospective randomized observational. Participants were divided into two groups. Group 1; 1 intra-articular PRP injection (15 mL) in 72 patients and Group 2; A single intra-articular injection of HA (80 mg/4 mL) was administered to 72 patients. All patients were evaluated before infiltration and 1, 3, 6, and 12 months after injection. Results: No significant difference was detected in the demographic distribution (gender and age) and Grade RT, Grade RL, Grade II OA and Grade III OA classifications of patients who received intra-articular PRP or HA injection for knee OA ($p>0.05$). Compared with the HA group WOMAC mean of 48.8 and $p<0.05$, there was no significant change in the PRP groups with the WOMAC mean of 68.9. At month 3, each group had significantly reduced overall WOMAC score compared to baselines in both groups. The mean WOMAC was 48.2 in the HA and 47.9 in the PRP group ($P<0.001$). At 6 months, the average WOMAC score of the PRP group was 39.4, while this rate was 56.3 in the HA group ($P<0.001$). The PRP group showed a steady improvement, while those treated with HA showed a rapid deterioration. At 12 months, the HA group's WOMAC scores (74.1) returned to baseline levels. The mean WOMAC of the PRP group was (58.9) ($P<0.001$). Conclusion: The overall PRP improvement outweighs HA injections

Keywords
Hyaluronic Acid, Intra-Articular, Platelet Rich Plasma

INTRODUCTION

A very common degenerative joint disorders is knee osteoarthritis (KOA) which slow articular cartilage damage, the synovial inflammation of the membranes, and alterations in the bones beneath the cartilage characterize (**Malemud, 2015**). Osteoarthritis of the knee affects 10–18% of people, and if left untreated, it can cause considerable physical impairment (**McDonough and Jette, 2010**). According to one study, the probability of lower limb impairment which KOA causes is at least 40% in older individuals (Johnson and Hunter, 2014), and KOA is a top 10 disability cause (**Neogi, 2013**). Since the mid-twentieth century, knee OA has increased (**Wallace et all., 2017**).

Patients usually receive several treatments in an attempt to halt the advancement of the disease; yet, there is no medications have to slow or stop of KOA. The focus of current therapies is to a great extent on the remission of the symptom to reduce the pain and increase function recovery (**Fonsi et all., 2020**). Both nonpharmacological and pharmacological methods are being used as a nonsurgical option (**Ferreira et all,. 2018**). Diet

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and exercise are the two nonpharmacological therapies that are commonly advised, although they are not always implemented. Nonsteroidal anti-inflammatory drugs (NSAIDs), duloxetine, topical NSAID acetaminophen, opioids, can relieve symptoms (**McAlindon et all., 2014**) Currently less Invasive interventions get bigger attention, like steroid, hyaluronic acid (HA), injections of platelet-rich plasma (PRP) and injections of stem cells.

Intra-articular injections, as a less invasive cure for KOA, has been found to be safe and efficacious (**Cook & Smith, 2018**). While traditional conservative methods such as NSAID treatment primarily target symptoms including pain and inflammation, alternative procedures including HA or PRP intraarticular application for the stimulation of the endogenous producing HA, promoting cellular metabolism and regenerating tissue and stopping cartilage tissue catabolism (**Filardo et all., 2012**) have been shown to improve cellular metabolism and tissue regeneration. Chondrocytes, synoviocytes, and fibroblasts production of HA, a high-molecular-weight glucosamine is significant to the knee joint viscoelasticity and lubrication (**Chen et all., 2019**). The concentrations of HA in osteoarthritic knees have been found to be lower. Increasing data suggests that HA enhances joint functions, alleviate pains, and reduce analgesic doses (**Zhang et all., 2018**). HA is involved in the dissipation and lubricating of traumatic energy (**Tascıoglu and Öner, 2003**). IA-HA reduces OA pain-related nerve impulses. The use of exogenous HA raises endogenous proteoglycan and hyaluronic acid synthesis (**Moreland, (2003**). On chondrocytes, HA is connected to CD44 and inhibits the IL-1action, which decreases MMP-1, 2, 3, 9, and 13 (**Julovi activitieset all., 2004**). The hyaluronan mediated motility (RHAMM) receptor binds to HA, which may be beneficial for chondroprotection (**Karna et all., 2008**). The generation of nitric oxide in the synovium is also suppressed & IA-HA has been shown to slow aggrecan degradation (**Peng et all., 2010**). IA-HA therapy reduces TNF-a, IL-1, IL-6, IL-17, MMP-13, and Nf-kB by inhibiting numerous inflammatory pathways via Toll-Like Receptors (**Yatabe et all., 2019**). IA-HA has effects on the sub-chondral bone and its aberrant metabolism (**Campo et all.,2011**). In OA knee joints, IA-HA concentration and molecular weight are lower than normal (**Hiraoka et all., 2011**). Molecular weight, concentration, HA sources (HA which is derived from biological fermentation vs. that derived from avian), dose (how many injections and intervals), estimated impact length of time, cross linkages, and additional formulations are all factors to consider while using it (**Dahl et all., 1985**).

Growth factors, particularly platelet-rich plasma (PRP) injection, have piqued people's attention in the last ten years due to their ability to heal tissue lesions and preserve normal tissue structure (**Migliore et all. 2016**). Autologous blood centrifugation produces a high platelet concentration of PRP (**Milants et all., 2018**). After platelets degranulate, releasing many growth aspects and cytokines helps in hastening producing cartilage matrix, reducing synovial membrane inflammation, and improving cartilage repair (**Mishra et all., 2012**). PRP is frequently utilized in musculoskeletal disorders including rotator cuff tears, patellar tendinopathy, lateral epicondylitis, and osteoarthritis due to its regeneration and anti-inflammation (**Anitua et all., 2007**). Yet, whether (PRP vs. HA) is the most effective for knee OA is still controversial. In an PRP meta-analysis versus HA for KOA (**Di Sante et all., 2006**).

Performed PRP intra-articular injections to viably treat KOA, yet according to some studies, PRP was not better than HA in effectiveness. However, (**Di et all., 2018**) some research works failed to prove that PRP is better than HA clinical improvement. Clinical Guidelines of the American Academy of Orthopaedic Surgeons stated that HA injection does not cure KOA, whrereas PRP injection is “not advised for or against” (**Filardo et all., 2015**). The OA Research Society International (OARSI) (**McAlindon., 2014**) proves HA injections to treat KOA but not PRP injections. According to Campbell (**Campbell et all., 2015**) PRP injections could trigger local adverse responses than HA in comprehensive examinations of an overlapping meta-analysis. There were many past meta-analyses (**Dai et al., 2017; Xu et al., 2017; Shen et al., 2017**) which state that PRP injection cause no more adverse effects than HA injections. The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), the well known in assessing evaluating pain, stiffness, and physical functions in arthritis studies or the visual analogue scale (VAS) for the quantification of the pain severity (**Filardo et all., 2012; Cerza et all.,2012**). In these studies, PRP positively

impacts regenerating biological cartilage in spite of the results of inhomogeneous (**Guermazi et all., 2004**). The current work assessed effectiveness and safety of intra-articular PRP and HA in those who suffer from KOA.

MATERIALS AND METHODS

Participant

This study was approved by the Research Ethics Committee of the State Al-Iraqia Med School with reference number No (1311-1-10-2021), and all procedures and protocol complied with the Helsinki World Medical Association Declaration on the ethical conduct of research involving human subjects. 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 current work is prospective randomized observational. Patients with knee discomfort who could be suitable were pre-screened. the ethical committee of Al-Iraqia Med School approved the study. All methods were performed based on the ethical committee of Al-Iraqia Med School guidelines and regulations.

Patients who completed informed consents and met the criteria to be included into two groups in a 1:1 ratio.

A commercial computer-generated randomized list which is a blind randomization assisted program was used to assign patients into groups. Patients in group 1(platelet-rich plasma (PRP)) received one autologous PRP injection intra-articularly. Patients in group 2 (hyaluronic acid) got one hyaluronic acid injection intra-articularly. The primary result was to change from the pain baseline, which WOMA for an Arab population determines (**Kayo et all., 2009**) at one year. From February 2018 to May 2020, 144 patients (88 females and 56 males) with symptomatic, radiologically with approved knee OA (Kellgren-Lawrence grades II–III) were included in this research. Over age 50, swelling, a persistent discomfort history, and/or some motion in the knee joint were all criteria for inclusion. X-ray pictures in anteroposterior and lateral projections were used to validate clinical and radiologic evidence of knee OA (Kellgren-Lawrence grades II–III). Post-traumatic knee osteoarthritis, oncological, endocrine (gout, diabetes), autoimmune (rheumatoid arthritis) and acute/chronic infectious diseases, blood clotting disorders (thrombocytopenia, coagulopathy) and previous interventions on the knee joint were all excluded .

Group1; 72 patients were injected with 1 PRP intra-articular injections. The blood drawn was 15 mL. For infiltration, noncommercial double syringe PRP Kit was used with 1 mL anticoagulant (sodium citrate). We centrifuged Citrated blood at 3000 rpm for 10 min. Pure PRP solution 3-5 mL was produced from the plasmatic fraction for the injection of Intra-articular PRP. Group 2; 72 people received single intra-articular injections of cross-linked HA (80 mg/4 mL).

The injections were performed by the physicians who had involved in this study. For both groups alcohol or an iodine-based antiseptic disinfected the skin prior to the injection. Both groups employed the superolateral infiltration technique, confirmed as the safest and most effective to ensure intra-articular drug penetration. A popliteal cushion was used to locate the patient was in a supine posture with the slight bending of the knee. The patella's medial, lateral, and superior margins were always marked. A superolateral approach was used after local anesthesia with lidocaine chlorohydrate, where we inserted the needle at an approximate 45 angle toward the medial joint knee line until accessing the "soft spot" in the middle of the femur-patella, adjacent the line junction through the lateral patellar edges and the line through the superior patella pole. The patients were observed for 10 to 15 minutes after the infiltration to verify if there were any adverse responses.

All physicians followed these instruction guidelines while they doing the injections for both group. Physical activity was not restricted as part of the post-injection regimen for both groups and all patients in both groups were advised and monitored not to use any analgesic drugs during the study and no special physiotherapy programs were advised. All of the patients were assessed prior to the infiltration as well as 1, 3, and 6 and a year after injection. In terms of safety, all patients in both groups were followed for any adverse events during and after the injections, and these were all reported. Western Ontario and McMaster

(WOMAC) osteoarthritis index questionnaire helped in assessing pain, articular stiffness, and functional restrictions. The same physicians were in charge of this stage.

Statistical analysis

The study used the statistical Package for the Social Sciences Version 22.0 (SPSS) for the data entry to calculate P value, means and standard deviations. Continuous variables were reported as mean ± standard deviation. The Mann-Whitney U test was used as appropriate for univariate analysis and the Bonferroni test for multiple comparisons.

RESULTS

A total of 144 consecutive patients, treated for knee OA between 2018 and 2020, were included into this study. Of them, 72 patients (50%) received PRP injections while 72 (50%) received HA injections. Baseline characteristics are outlined in Table 1, showing. It was determined that there was no significant difference in the mean ages of the PRP and HA groups ((61.80±10.2), (62.54±10.4), respectively (p>0.05). Grade values of PRP and HA groups were respectively (Grade RT (1.56 ± 0.49), Grade RL (1.54 ± 0.50) and HA; Grade RT (1.29 ± 0.45) and Grade RL (1,26 ± 0,44). It was determined that there was no significant difference (p>0.05). The total of Grade II OA in the PRP and HA group was 64, and the total in the Grade III OA group was 80.

Table 1. Demographic distribution of patients who underwent intra-articular injections of PRP or HA for knee OA.

Variables	PRP Group	HA Group	Z-Value	P-Value*
	n = 72 (%50)	*n = 72 (%50)*		
Females	45	42		
Mean age (years)	61,80±*10,2*	*62,54±10,4*		*>0.05*
Male	27	30		
Mean age (years)a	64,18±*9,1*	*59,63±9,3*		*>0.05*
OA Grade	PRP (1,55 ± *0,50)*		-,257	.797
OA Grade	HA (1,55 ± *0,49)*		-,655	.512
OA Grade RT	1,56 ± *0,49*	1,54 ± *0,50*	-1,582	.114
OA Grade RL	1,29 ± *0,45*	1,26 ± *0,44*	-,910	.363
Grade II OA	31	33		
Grade III OA	41	39		

PRP: platelet-rich plasma; HA: hyaluronic acid; OA: osteoarthritis; RT:Right; RL: Left; *Bold values are statistically significant.

While the scores in the PRP and HA WOMAC groups were close to one at the beginning (72.84 ± 8.83; 76.31 ± 10.14), significant differences were detected after the first month (p<0.001*). At 3 months, the overall WOMAC scores of both groups decreased significantly compared to baseline values (PRP (47.94 ± 15.00), HA (48.22 ± 14.80, respectively). The groups' difference was statistically significant (P< .001*) at this time point.

At 6 months, a reversal of the pattern was noted, with continued improvement in patients treated with PRP and slight deterioration in those treated with HA, as shown in Tables 2 and 3. WOMAC mean PRP (39.44 ± 14.00), HA (56.34 ± 10.10, respectively). A statistically significant difference was detected between the PRP and HA groups (P < .001*)

Table 2. Mean Western Ontario and McMaster (WOMAC) scores of the PRP and HA groups at baseline and follow-up periods within the group

Variables	WOMAC *PRP Group*	*P-Value**	WOMAC *HA Group*	*P-Value**
Baseline	72,84 ± *8,83*		76,31 ± *10,14*	
WOMAC 1 months	69,90 ± *9,49*		48,84 ± *16,71*	
WOMAC 3 months	47,94 ± *15,00*	*<0.001**	48,22 ± *14,80*	*<0.001**
WOMAC 6 months	39,44 ± *14,00*		56,34 ± *10,10*	
WOMAC 12 months	58,94 ± *13,29*		74,11 ± *9,95*	

*PRP: platelet-rich plasma; HA: hyaluronic acid; WOMAC: Western Ontario and McMaster *Bold values are statistically significant.*

As seen in Figure 3, Tables 2 and 3, while a steady improvement was observed in the PRP group, a rapid deterioration was seen in the HA treatment group at 12 months PRP (58.94 ± 13.29), HA (74.11 ± 9,95), respectively). WOMAC scores of most participants in the HA group decreased to baseline values. Both groups show statistically significant differences (P < .001). In terms of safety, 12 adverse events were observed during the study; these were all in the immediate postinjection period; 7 of these were 5 in the HA and PRP groups, respectively. Adverse effects were mostly minor and equal across groups. Infiltration-related discomfort was the cause of adverse events in the HA group and f PRP group, all of which were self-limiting within a few hours of injection without the need for further intervention.

Table 3. Mean Western Ontario and McMaster (WOMAC) scores between PRP and HA groups at baseline and follow-up periods

Variables	**WOMAC *PRP/ HA Group***	***Z-Value***	***P-Value****
Baseline	72,84 ± *8,83*	*-2,432*	
WOMAC 1 months	69,90 ± *9,49*	-7,169	
WOMAC 3 months	47,94 ± *15,00*	-,194	*<0.001**
WOMAC 6 months	39,44 ± *14,00*	-6,896	
WOMAC 12 months	58,94 ± *13,29*	-6,721	

*PRP: platelet-rich plasma; HA: hyaluronic acid; WOMAC: Western Ontario and McMaster *Bold values are statistically significant.*

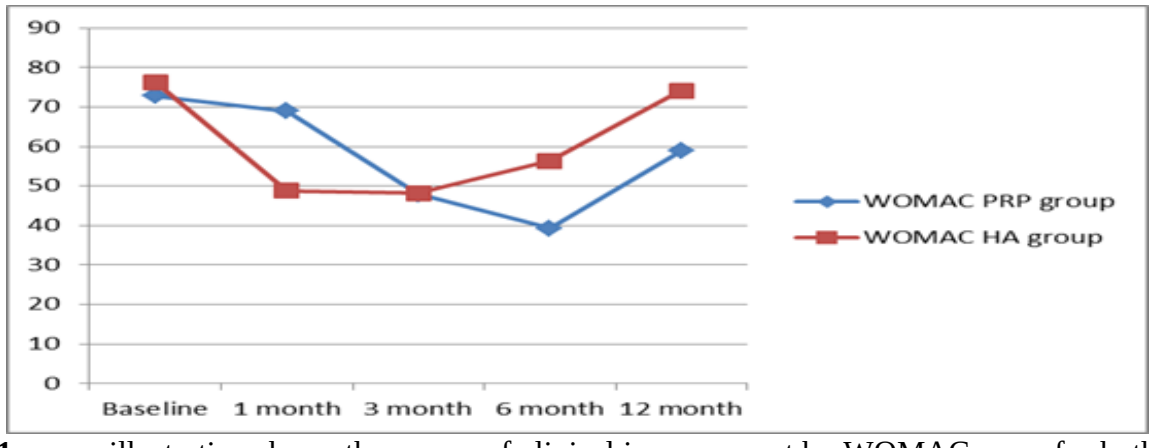

Figure 1. curve illustration shows the course of clinical improvement by WOMAC score for both PRP & HA group at baseline and through period's interval of follow up

DISCUSSION

The design of this study as randomized comparative study with one years of follow-up and applied on such a high number of patients make this study as one of the most available evidence on PRP application for knee osteoarthritis. The findings of this randomized study show that the single platelets rich plasma intra-articular injections were more effective than 1 single injection of HA in the reduction of knee pain and stiffness impring physical functions in those with knee OA for long term follow up but in short term length of times HA injections was significantly better.

The biochemical changes generated by HA therapy increases the synovial fluid's protecting, lubricating, and shock-absorbing properties. Furthermore, this treatment technique has no inflammatory side effects, which is a significant benefit (**Vaquerizo et all., 2013**), in fact, HA has been shown to have an active anti-inflammatory or chondroprotective action. I A-HA therapy reduces TNF-a, IL-1, IL-6, IL-17, MMP-13, and Nf-kB by inhibiting numerous inflammatory pathways via Toll-Like Receptors (**Di et all.,2018; Filardo et all.,2015**). The sub-chondral bone and its aberrant metabolism are also affected by IA-HA (**Hiraoka et all., 2011**). In OA knee joints, IA-HA concentration and molecular weight are lower than normal (**Dahle t all., 1985**). Molecular weight, concentrations, HA sources (HA which is derived from biological fermentation vs. that derived from avian), dose (how many injections and intervals),

estimated impact length of time, cross linkages, and additional formulations are all factors to consider while using it (**Migliore et all.. 2016**). and this could explain the earlier improvement in HA over PRP group, figure 1. There has been only one previous study about arthroplasty delay involving PRP by **Turajane et al**. (**2017**) including 60 patients. They compared intra-articular injections of autologous activated peripheral blood stem cells (AAPBSC) with PRP added growth factors, and HA along with arthroscopic mesenchymal stem cells versus the same combination without the added growth factors versus only intra-articular HA. They found that AAPBSC groups performed better than HA alone; however, they concluded that further research on the matter is required. Our study demonstrated a statistically significant difference in delaying knee arthroplasty favoring patients treated with autologous knee intra-articular injections of PRP versus high-molecular-weight HA. There have been some reports indicating.

PRP improves cartilage degeneration by stimulating mesenchymal proliferation, migration, and differentiation of stem cell into articular chondrocytes based on the preclinical study. PRP enhances cartilage regeneration by inhibiting inflammatory cytokines and changing the degree of enzymatic expression, which slows the course of KOA (**Di et all., 2018**). Furthermore, multiple clinical studies and systematic reviews have shown that PRP can relieve osteoarthritic symptoms including pain, stiffness, and function loss up to a year after injection (**Filardo et all., 2015**). In **Vaquerizo et al**, (**2013**) they concluded that PRP injections shows safety and significantly superiority of HA in initial and secondary efficacy analyses both at 24 and 48 weeks (**Huang and Tsai 2021**), with more significant clinical development, reduction of patients' pain and joint stiffness and physical functions, in terms of basal levels in patients with knee OA, these results agree with our study findings especially regarding the use of single shot of HA, but although in **Vaquerizo et al.,** (**2013**) they compared multiple PRP injections to single HA injection, also Huang study conclude that a single cross linked-HA injections shows more safety and effectiveness for 26 weeks in patients having knee OA by the comparison of the multiple injections of linear-HA (**Duymus et all., 2017**), in addition to that ,the manufacturer recommendations of our HA used was single injection, and so we used to compare single injection of both to quantify the native efficacy of single PRP injection in term of safety and length of time of clinical improvement and this could be attributed to the decline in the curve of clinical improvement In PRP group toward the end of our study(figure 1) although it was still better than HA group nevertheless this might suggest the necessity to evaluate the need of multiple PRP injections in some patients for better outcomes.

Surprisingly, several research have looked at the PRP and HA therapeutic effectiveness in treating KOA. Duymus et al. (**2019**) examined the effectiveness of PRP against HA intra-articular injections. In treating mild–moderate knee OA, they discovered that PRP injection showed more effectiveness than HA injections. The use of PRP might give at least a year of pain-free everyday activities. Examined the differences between PRP and HA in treating KOA and found that a leukocyte-poor PRP intra-articular injections higher function healing for at least 12 months in those with mild-to-moderate knee osteoarthritis.

It should be stated that other confounding variables, such as weight, physical activity, other concurrent medications, and so on, were not taken into account for the patient selection criteria, potentially resulting in bias that might alter the study's outcome. In numerous clinical investigations, however, PRP injection failed to outperform HA injection in terms of effectiveness. Filardo et al. (**2015**) discovered that individuals who had PRP injection had no better clinical outcomes than those who received HA injection and this was actually similar to what we noticed in first 6 months follow up length of time(figure 1). Regarding safety, the adverse effects which noticed during the study were mostly minor and evenly distributed among the groups (P 13.810). The discomfort associated with the infiltration was the cause of adverse events in the HA group and f PRP group and all were self-limiting by a matter of several hours post the injection without the need for further intervention and so both types of injections could be regarded safe therapies if done correctly as long as there are no negative effects that worsen the patient's health. Finally, we observed that less than 25% of PRP group still had significant clinical improvement in contrast to less than 5 % in HA group and almost most of them were grade II OA changes.

Conclusion

This study showed that PRP intra-articular knee injections compared to HA reduced the likelihood of knee arthroplasty in grade II to grade III knee OA patients. A significant improvement in pain was found in the PRP group at 6 months and later compared to the HA group. Similarly, a statistically significant improvement was detected in the WOMAC general score at the 6th month and at the last follow-up. An overall trend towards improvement in WOMAC was observed at 12 months. Our results suggest that PRP may be an effective treatment for patients with grade II to grade III knee OA. In short-term functional recovery, intra-articular HA injections are more effective than PRP injections in treating KOA. Furthermore, PRP injection outperformed that of HA in the long-term pain alleviation and improved functions. Additional RCTs are needed to determine the best PRP and HA dosages and intervals.

Conflict of Interest

The authors have declared no conflicts of interest.

Ethisc Committee

This study was approved by the Research Ethics Committee of the State Al-Iraqia Med School with reference number No (1311-1-10-2021), and all procedures and protocol complied with the Helsinki World Medical Association Declaration on the ethical conduct of research involving human subjects.

Author Contributions

Study design, DMA, SAAAL; Data Collection, DMA, SAAAL, WFAQ, YDRRA; Statistical Analysis, DMA, YDRRA; Manuscript preparation, DMA, SAAAL, YDRRA; Literature review, DMA, SAAAL. All authors have read and agreed to the published version of the Manuscript.

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RESEARCH ARTICLE

Assessment of Alterations in Gait Parameters of Chronic Total Knee Arthroplasty – An Observational Study

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Abstract
Purpose of the Study: This research investigates postoperative gait alterations in individuals aged 50 and above who underwent total knee arthroplasty (TKA) at least one year ago. The study aims to fill existing gaps in literature by comprehensively assessing various gait parameters and understanding the persistent changes in mobility following TKA. **Materials and Methods:** Conducted as an observational study, 30 TKA subjects were assessed using Kinovea software for gait parameters, including cadence, speed, step length, step width, stride length, and knee flexion angle. Statistical analysis with MS Excel compared obtained values with established norms. **Results:** Significant gait parameter alterations were observed in post-TKA subjects. These changes include decreased cadence, walking speed, step length, and stride length, along with variations in knee flexion angle. Approximately 36.67% of participants exhibited alterations in these parameters, highlighting the need for further understanding of mobility challenges post-TKA. **Conclusion:** This study contributes vital insights into the persistent impact of TKA on gait parameters, emphasizing the complexity of postoperative mobility changes. The observed alterations highlight the importance of tailored rehabilitation programs to enhance functional independence and address long-term gait concerns in this patient population.

Keywords
Gait, Total Knee Arthroplasty, Gait Parameters, Physiotherapy

INTRODUCTION

Gait, in simple terms, refers to the way a person walks (Kharb et al. 2011). When individuals walk, their bodies must bear the load, provide assistance for movement, and maintain balance to achieve the desired walking pattern. Proper body posture is crucial to align with this gait. Due to the significant influence of mobility on a patient's autonomy, efforts are made to preserve this capability despite substantial limitations (Rana et al. 2016). Therefore, studying the gait cycle which represents a cyclic pattern of movement during walking becomes important (Kharb et al. 2011). Gait cycle starts with one foot's heel striking the ground and ends when the same heel touches the ground again (Levangie et al. 2011).

The knee, one of the most injured joints in the human body, bears a significant portion of the total body weight during walking. When the knee joint is severely damaged and conventional treatments are ineffective, total knee arthroplasty (TKA) is necessary. TKA is a cost-effective and reliably successful procedure, particularly for arthritis, the most common indication (Pachore et al. 2013). It provides reliable outcomes for grade 4 degenerative osteoarthritis, alleviating pain and

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improving the quality of life (Broatzman et al. 2011; Insall et al. 1985; Varacallo et al. 2018).

Research indicates that patients with osteoarthritis experience gait parameter alterations due to pain, stiffness, and reduced range of motion (Rana et al. 2016). These changes persist after TKA, although inconsistencies in results exist, indicating a need for further investigation (McClelland, 2007). As the body is a kinetic chain, the knee serves as a connection between the hip and ankle joints (Karandikar and Vargas, 2011). Increased severity of osteoarthritis leads to biomechanical changes in the hip, knee, and ankle joints (Astephen et al. 2008).

Surgeons typically use specific criteria as indications for TKA, considering factors such as severe daily pain, frequent rest pain, daily transfer pain, and extensive joint space damage observed in radiographs (Mancuso et al. 1996). The knee joint, divided into three compartments (medial, lateral, and patellofemoral), is commonly treated with TKA for grade 4 osteoarthritis, where all three compartments are replaced with monolithic femoral and tibial components. Single-compartmental conditions can be managed through partial knee arthroplasty (PKA) using various implants (Lange et al. 2017; Varacallo 2018).

Knee implants can be either cemented or non-cemented with most being cemented, while others attach directly to the bone without cement. Non-cemented designs rely on bone growth into textured or coated implant surfaces, often modified with hydroxyapatite to enhance bonding. Stainless steel is not used in knee replacement implants due to its limited ability to withstand corrosion over time within the human body. It is better suited for temporary applications such as fracture plates and screws. While cobalt-chromium alloys, tough and biocompatible, are widely used despite potential metal particle release (Aherwar et al. 2016). Titanium and its alloys, including Ti6Al4V, are popular for knee implants due to their biocompatibility, corrosion resistance, and lower density, mimicking natural joints and reducing complications. Tantalum, a flexible and biocompatible pure metal, is used in Trabecular Metal for bone in-growth (Levine et al. 2007). Polyethylene, common in tibial and patellar components, has improved wear resistance through materials like Ultra Highly Cross-Linked Polyethylene (UHXLPE) (Chakrabarty et al. 2015). Zirconium alloy, combined with an all-plastic tibial component, offers a potentially longer-lasting and biocompatible alternative, addressing concerns for nickel-allergic patients. Oxinium is oxidized zirconium. It combines ceramic and metallic properties, providing durability with reduced friction, potentially outlasting traditional materials like cobalt-chromium alloys in knee implants (Mehjabeen et al. 2018). Material choice depends on patient needs, preferences, and surgeon expertise, with continuous advancements in the field (Carr et al. 2009).

Physiotherapy after TKA is crucial for preventing complications arising from bedrest and regaining joint mobility and muscle strength. It includes teaching safe ambulation and transfers, reducing pain and swelling in the early post-surgery phase, and improving joint range of motion, muscle strength and endurance. Physiotherapy aims to boost mood, reduce anxiety, and restore full knee function for a return to normal activities, ensuring functional independence. While physiotherapy typically lasts for three months, patients are then gradually transitioned to a home-based protocol. However, as patients become more comfortable with daily activities, many discontinue the exercise routine, emphasizing the need to study changes in gait parameters 1 to 2 years after total knee arthroplasty (Hardy et al 2007).

MATERIALS AND METHODS

This was an observational study carried out in which alterations in gait parameters after total knee arthroplasty were assessed.

Participants

Our study, planned as a cross sectional research, included 30 subjects with the age of 50 years and above and who have undergone TKA at least 1 year ago (Figure1). Individuals were chosen based on specified criteria for inclusion and exclusion which is given below. 2 subjects aged between 55-59, 7 subjects aged between 60-64 years, 12 subjects aged between 65-69 years, 9 subjects aged between 70-75 years (Table 1). Out of 30, 19 subjects were male and 11 subjects were females. Out of 30, 6 had bilateral TKA, 15 had right and 9 had left TKA done. Out of 30, 4 subjects had a BMI ranging betweeb 20-24 (normal BMI), 5 subjects had BMI between 25-29 (overweight), 12 subjects had a BMI between 30-

34 (obese grade 1) (Table 1). Average height of the participant males was 165 cm and that of female participants was 152 cm. Out of 30, 6 subjects had undergone TKA 12 months ago, 9 had undergone 12-18 months ago, 8 subjects had undergone TKA 18-24 months, 7 subjects had undergone TKA 24-30 months ago at the time of assessment.

The participating subjects were informed about the study protocol, their rights, and the associated risks of participation before providing written informed consent. This observation was conducted on humans. The observational study was accepted by Institutional Human Ethics Committee of Krishna Institute of Medical Sciences, "Deemed to be University," Karad (Protocol number-617/2022-23). The study was carried out in accordance with the recommendations of the Declaration of Helsinki. Additional precautions were taken by the investigator(s) to protect the volunteers in this study. The selected subjects were asked to walk for a fixed distance of 3 meters and the time required to complete the distance was recorded using a stopwatch.

Data collection tool

Software named kinovea was used to measure the gait parameters. Kinovea serves as a specialized video analysis tool tailored for sports. It offers features such as capturing, slowing down, comparing, interpreting, and measuring motion in videos. The tool includes a chronometer for measuring time spans and tools like line, angle, and goniometer for measuring distances and angles. Precision is enhanced by the ability to zoom in, and measurements are conducted with subpixel accuracy, ensuring detailed and accurate analysis. Cadence was measured by counting the number of steps walked per minute by slowing the frame rate and counting the steps covered by the participants. Speed was calculated by dividing the distance covered by the subject by the time taken to cover it. Step length was measured by pausing the video and then by using the tool 'line' in the software, the distance between the heel of one foot to the heel of the other foot was measured. Stride length was calculated by multiplying the step width by 2. Knee flexion angle during early swing phase of the gait cycle was measured by pausing the video at early swing phase of the gait cycle and the tool 'angle' available in the kinovea software was used where it uses goniometer to measure the angle (Puig et al. 2019). Subjects were asked to dip feet in the water and walk. Step width was measured at the assessment place by measuring the horizontal distance between midpoint of the heel of one foot to the corresponding point of another foot from the obtained footprints. The obtained values were compared with the normal standard values.

Inclusion criterion

Subjects post total knee arthroplasty.
Subjects who have undergone TKA at least one year ago.
Subjects with unilateral or bilateral TKA.
Both male and female subjects.
Subjects with age above 50 years.

Exclusion criteria:

Any other major injury to lower limb

Statistical analysis

It was done using MS excel and instat statistics software. One sample t-test was used to find out the p values of obtained findings. It was done using MS excel and instat statistics software. One sample t-test was used to find out the p values of obtained findings. The findings are summarized in a table/graph format. The analysis was done using the kinovea software and the values were analyzed using the software MS Excel and in stat.

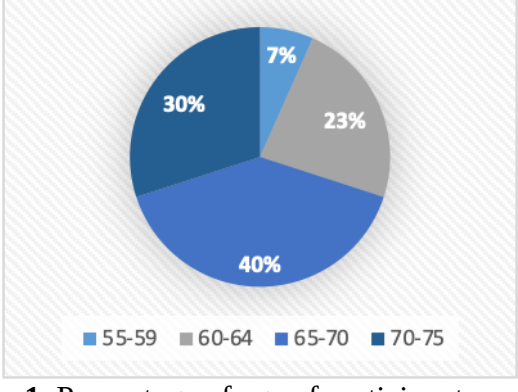

Figure 1. Percentage of age of participants

RESULTS

Table 1. Demographic data

	Total Number	Mean±SD
Age(Years)	30	67.13±5.07
BMI (kg/m2)	30	29.83±4.06

Interpretation- Cadence was measured and it was observed that 5 subjects had a cadence below

the considered normal range (90 steps/min) (p<0.0001, Table 2).

Cadence (steps/min)	Count of Patient
70-74	1
75-79	0
80-84	1
85-89	3
90-94	11
95-99	8
100-104	6
Grand Total	**30**

Interpretation- Speed was measured using the kinovea software. It was observed that 6 subjects had a considerable decrease in the speed i.e., < 0.80 m/s (p<0.0001, Table 3).

Table 3. Speed

Speed (m/s)	Count of Patient
<0.65	0
0.66-0.70	2
0.71-0.75	1
0.76-0.80	3
0.81-0.85	2
0.86-0.90	9
0.91-0.95	6
>0.95	7

Table 4. Step length

Step Length (cm)	Count of Patient
<30	0
31	1
32	0
33	1
34	2
35	1
36	2
37	2
38	2
39	3
40	5
41	3
>41	7
Grand Total	**30**

Interpretation- Step length was assessed using the kinovea software. The unit of measurement was centimeter (cm). It was observed that total 4 subjects that is 1 subject with 31 cm step length, 1 with 33 cm step length, and 2 subjects were with 34 cm step length had a considerable decrease in step length. As 35 cm is considered normal step length (p<0.0001, Table 4).

Table 2. Cadence

Table 5. Step width

Step Width (cm)	Count of Patient
<4	0
4	0
5	0
6	0
7	5
8	10
9	9
>10	6
Grand Total	**30**

Interpretation-Step width was measured while recording the video, the subjects' sole was dipped in water and then the patient was asked to walk. The foot marks left behind on the ground were used to measure the step width. It was observed that none of the subjects had a considerable decline in the step width i.e., <7cm (p<0.0001, Table 5).

Table 6. Stride length

Stride length (cm)	Count of Patient
<65	0
67	1
68	1
69	1
70	2
71	1
72	1
73	0
74	2
75	1
76	1
77	4
78	3
79	5
>80	7
Grand Total	**30**

Interpretation-Stride length was measured using the software kinovea. This was done by pausing the recorded video and then using the tools in the software to measure the distance between the heel of one foot and the heel of the other foot. It was observed that 5 subjects had an altered stride length i.e., less than 70 cm. (p<0.0001, Table 6).

Interpretation-Knee flexion angle in swing phase of gait cycle was assessed using the software kinovea. The recorded video was paused with the subjects' knee in early swing phase and using a tool in the software the angle formed at the knee joint was measured. It was seen that majority Interpretation-It was observed that 5 subjects had a decline in their cadence. Along with all the subjects with decreased cadence 1 more subject had a drastic decrease in his walking speed. Including few of the subjects with altered cadence and speed, 2 more subjects showed a decrease in step length. Stride length and step width were seen altered in the few of the subjects who had alterations in their cadence, speed and/or step length. Along with these 8 subjects, 3 more subjects had a decreased knee flexion angle in early swing phase of gait cycle (Figure 2, Table 7).

Table 7. Knee flexion angle in early swing phase

Knee flexion angle in early swing phase	Count of Patient
<40	0
40-45	1
46-50	2
51-55	6
56-60	14
>60	7
Grand Total	**30**

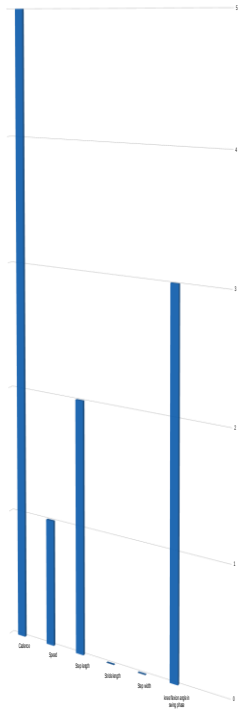

Figure 1. Count of subjects with parameters changed

Table 8. Count of subjects with parameters changed

Parameters	Count of Patient
Cadence	5
Speed	1
Step length	2
Stride length	0
Step width	0
Knee flexion angle in early swing phase	3
Grand Total	**11**

It can be concluded that 36.67% (11 out of 30) ($p<0.0001$) subjects had some kind of alteration in gait parameters.

Table 9. Altered gait parameters

	Total number	Mean±SD	P values
Cadence	30	94.33± 6.89	<0.0001
Speed	30	0.88 ±0.08	<0.0001
Step length	30	39.1± 3.50	<0.0001
Step width	30	8.1±1.68	<0.0001
Stride length	30	77.7±6.28	<0.0001
Knee flexion angle in early swing phase	30	56.76±4.77	<0.0001

DISCUSSION

This study unfolds a comprehensive investigation into the intricate alterations in gait parameters among individuals who underwent Total Knee Arthroplasty (TKA) at least one year ago. This study aims to provide an in depth understanding of the multifaceted impact of TKA on walking dynamics, exploring aspects such as structural modifications, muscle strength, and functional outcomes.

Structural changes introduced during TKA have a profound influence on various gait parameters. These modifications can manifest as a decrease in the knee flexion angle, subsequently resulting in a reduction in step length. In this study, alterations in step length were observed in four subjects, suggesting a potential compromise in the overall stride during walking. Reduced step

length contributes to a decrease in stride length, aligning with the changes in both parameters. This intricate relationship between structural modifications and their consequences on gait parameters is consistent with existing literature, indicating the persistence of altered gait parameters even after the initial postoperative period (Bączkowicz et al., 2018). A comprehensive understanding of these changes necessitates an assessment of the entire gait cycle (Andersson et al., 1981).

The reduction in cadence, contributing to a decline in walking speed, underscores the complex interplay between various gait parameters (McClelland, 2007). The research suggests that the walking pattern persists from before surgery, even though there is an early reduction in pain during walking after total knee arthroplasty (Otsuki et al., 1999). This complex relationship between structural changes and gait alterations highlights the multifaceted nature of the impact of TKA on walking dynamics.

Reduced quadriceps and hamstring muscle strength post-TKA significantly contribute to alterations in gait parameters (Schache et al., 2014). The impact extends beyond the operated limb, evidenced by a progressive decrease in strength in the non-operated lower limb (Yoshida et al., 2012). The reduced muscle strength is evident in the quadriceps, knee flexion angle, and a heightened fear of falling. These factors together contribute to a decreased walking speed following total knee arthroplasty (Pua et al., 2017). Also there is risk of tibial component loosening which might contribute to decreased gait speed (Hilding & M.B., 1996) The intricate interplay between alterations in structure and muscle strength underscores the nuanced character of gait changes following total knee arthroplasty (TKA).

Knee flexion angle during the early swing phase serves as a crucial indicator of joint mobility and overall biomechanics during walking. The observed alterations in nine subjects suggest potential limitations in knee joint movement post-TKA. While the procedure aims to restore joint function, variations in the flexion angle indicate persistent challenges in achieving optimal gait mechanics. Stiffer knee during walking increases the risk of contralateral TKA in patients who have undergone unilateral TKA which can be related to increased load on the contralateral knee hence it is important to have normal gait and symmetrical weight bearing post TKA which further increases the need for continuation of physiotherapy visits after the typical rehabilitation is over. (Ritter et al., 1994).

Despite the initial correction of static knee alignment and a decrease in the peak varus angle during gait six months post-TKA, these improvements tend to diminish over time. A correlation between the dynamic varus angle increase and adduction moment elevation from 6 months to 1 year suggests evolving biomechanical challenges (Orishimo et al., 2012). Biomechanical alterations in the knee and ankle were detected after total knee arthroplasty (Levinger et al,. 2013). Improving knee biomechanics is important as its associated with improved quality of life in post TKA patients (Naili et al., 2017). Even one year after undergoing surgery, a significant number of TKA patients exhibit no enhancement in their walking compared to pre-operative conditions (Rahman et al., 2015). These findings emphasize the need for continued monitoring of gait parameters to guide post-operative rehabilitation and formulate effective approaches to enhance mobility in these individuals.

Speed, an essential component of gait analysis, demonstrated a significant decrease in six subjects. A slower walking speed may impact daily activities and compromise functional independence, emphasizing the need for targeted interventions to address this decline. While showcasing improvement, those who experienced total knee arthroplasty (TKA) still displayed a reduced walking pace in comparison to the control group. The diminished gait speed observed after bilateral TKA was associated with suboptimal improvements in knee biomechanics. To boost walking speed, it is advised to integrate exercises that strengthen the quadriceps and aim for an expanded range of motion during walking (Ro et al,. 2017). Participating in physical activity improves walking performance for individuals who have had total knee arthroplasty (Taniguchi et al,. 2016). These findings support the study by (Bonnefoy-Mazure et al. 2017), where improvements in walking speed were observed one year post-surgery.

This study also recognized the role of pain in influencing gait dynamics. It was observed that some patients experience some degree of pain following TKA. The observed pain-related gait alterations manifest as a rigid knee gait, valgus

alignment during walking, and TKA components slightly internally rotated (Planckaert et al., 2018). These factors contribute to elevated patellofemoral forces, potentially explaining unexplained pain. Understanding the degree of pain-related gait alterations is crucial for tailoring interventions that address both pain management and gait improvement in the post-TKA period. Greater comorbidity and the existence of pain in other joints in the lower extremities or spine consistently negatively affected the numerical outcomes obtained for gait parameters (Kramers-de Quervain, et. al., 2012).

This integrated analysis of gait parameters demonstrated that 36.67% of subjects experienced alterations following TKA. This highlights the importance of comprehensive rehabilitation strategies that go beyond pain relief and structural corrections, emphasizing the optimization of gait dynamics. Also it was seen that patients are reluctant to adhere to rehabilitation exercises beyond the typical physiotherapy period, particularly in the second year post-surgery. This reluctance poses challenges for sustaining long-term rehabilitation efforts and may contribute to lasting difficulties observed six months post-TKA, as noted by (Bade et al. 2010). Consequently, it is crucial to develop strategies that enhance patient adherence to rehabilitation exercises and encourage long-term engagement with rehabilitation protocols.

Conclusion

In conclusion, this study provides essential insights into the persistent impact of TKA on gait parameters, shedding light on the complex interplay between structural changes, muscle strength, and functional outcomes. The observed alterations highlight the importance of tailored rehabilitation programs that extend beyond the typical physiotherapy period, emphasizing the need for sustained efforts in maintaining optimal gait mechanics.

Future research in the field should focus on interventions that promote long-term patient adherence to rehabilitation exercises, strategies for minimizing pain-related gait alterations, and approaches for optimizing biomechanics to improve overall quality of life in individuals post-TKA. This attempt can pave the way for more personalized and effective therapeutic strategies, ensuring that TKA patients achieve not only joint restoration but also long-term functional recovery comparable to individuals without knee issues. As the field progresses, continued exploration of the interplay between structural changes, muscle strength, and gait alterations will undoubtedly contribute to the refinement of rehabilitation strategies, promoting an integral approach to post-TKA care. The integration of emerging technologies, such as wearable sensors and advanced imaging techniques, may offer new approaches for assessing and addressing gait parameters in a more nuanced and personalized manner.

Moreover, an exploration of psychosocial factors influencing adherence to rehabilitation exercises and long-term engagement with rehabilitation protocols is needed. Understanding the patient's perspective, motivations, and potential barriers to adherence can help in the development of targeted interventions that match with individual needs and preferences. Collaborative efforts between healthcare professionals, researchers, and patients can contribute to the co-creation of rehabilitation programs that are not only evidence-based but also patient-centered, encouraging a sense of ownership and empowerment in the recovery journey.

Additionally, a longstanding perspective in studying post-TKA gait alterations could provide valuable insights into the course of changes over an extended period. Long-term follow-up assessments, spanning several years post-surgery, would enable the identification of trends, potential fluctuations, and the durability of interventions. This extended timeframe would also facilitate the exploration of age-related factors, comorbidities, and lifestyle influences that may intersect with post-TKA gait dynamics.

In the area of biomechanics, advancements in technology continue to offer exciting possibilities for refining gait analysis methodologies. Integration with artificial intelligence and machine learning algorithms may enhance the interpretation of complex gait patterns, allowing for more specific and individualized insights. The combination of biomechanical assessments with other modalities, such as neuroimaging or genetic profiling, could open new avenues for understanding the underlying mechanisms shaping post-TKA gait alterations Moreover, collaborative efforts across institutions and international research networks can facilitate the merging of data from diverse

populations. A broader and more diverse dataset would enhance the generalizability of findings and contribute to a more particular understanding of the factors influencing post-TKA gait dynamics across different demographics, cultural contexts, and healthcare systems.

In conclusion, this study serves as a stepping stone in understanding the complexities of post-TKA gait alterations. As we travel across this evolving scenario , embracing a multidimensional and patient-centered approach is essential. By addressing the multifaceted nature of post-TKA gait alterations and continuously refining our understanding through ongoing research, we can step forward to optimizing rehabilitation strategies, promoting enhanced functional outcomes, and ultimately improving the overall quality of life for individuals post-TKA.

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Conflict of İnterest

Authors declare no conflict of interest.

Ethics Statement

The interventional study was accepted by Institutional Human Ethics Committee of Krishna Institute of Medical Sciences, "Deemed to be University," Karad (Protocol number-617/2022-23).

Author Contributions

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

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RESEARCH ARTICLE

The Suppressor Effect of Presenteeism in The Relation Between Gaming Addiction and School Engagement Among Children

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Abstract
The purpose of this study was to investigate the impact of presenteeism on the correlation between gaming addiction and school engagement among secondary school students. The participants of the study comprised 300 children aged between 12 and 16 who were in secondary schools in the Aegean region in Türkiye. The mean age of the children was 13.52 (SD = 0.65). The study will use the 'Computer Game Addiction Scale for Children (CGAD)' to measure children's addiction to computer games, the 'Child-Adolescent Presenteeism Scale (C-APS)' to measure presenteeism levels in classroom, and the 'School Engagement Scale (SAS)' to measure school engagement. The analyses were conducted using the SPSS 23 software package at significance levels of .05 and.01. Pearson product-moment correlation analysis was used to determine the relationships between variables, and multiple regression analysis was used to determine the predictive power of variables for each other. The results of both Pearson correlation and bootstrapping showed a negative relationship between gaming addiction, presenteeism, and school engagement. Furthermore, a positive correlation was observed between presenteeism and game addiction. The regression analyses also found similar results. To better understand developmental differences in anxious emotion variance during childhood and adolescence, it is important to disaggregate aspects of anxious emotions and pay attention to potential suppressive effects.

Keywords
Game Addiction, Presenteeism, School Engagement

INTRODUCTION

In today's age of information technologies, technological developments occur so rapidly that the generation gap between parents and children is quite large. It is even possible to see this difference between siblings. To understand this difference, it would be appropriate to make "computer children" and tablet (android) children analogies. In Turkiye, the term "computer children", which is used for firsth and middle adults, has turned into the term "tablet (android) children", which is used for primary and secondary school students. It is indisputable that this transformation has both positive and negative effects on the individual and society. Computer/tablet games can cause addiction after a while for children who do not have the opportunity to play natural, traditional and classic games such as tip cheese, tip cheese, dreidel etc.

There is no mention of internet addiction in the main section of the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5). However, the additional section includes the subject of "internet game addiction", which is planned to be classified in the future. The only technological addiction included in the DSM-5-TR is the "Internet gaming disorder" (IGD) defined by Young (2009) as the sub-category of Internet addiction. Based on the criteria of gambling disorder in DSM-5 (APA, 2013), Internet gaming

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disorder is defined as a usage situation in which the person remains dehydrated, hungry and sleepless for a long time, up to 8-10 hours a day and up to 30 hours a week (Şakiroğlu and Akyol, 2018). The diagnostic criteria of IGD defined in the DSM-5-TR (APA, 2022) are as follows: a) the mind constantly being occupied with Internet games b) deprivation symptoms c) gradual increase of the time spent on Internet games d) decrease of control throughout Internet gaming e) continuing to play Internet games (Pontes and Griffiths, 2016: 2-3).

According to Gruesser and Thalemann (2006), computer game addiction is the type of behavioral addiction in which users prefer to play the games rather than do other activities or routines, postpone their duties because they are playing the games, and confuse the games with real-life situations (Horzum, 2011). In recent years, computer game addiction has started to be treated as a psychological problem in the scientific world by associating it with various psychological problems (Kuss, 2013; Reiterer, 2010). It is stated that children who play computer games pathologically have reduced interactions with their peers or the quality of these interactions decreases (Aydın, Oflu, and Yalçın, 2021; Colwell and Kato, 2003). Some of the children and young people who play computer games have reached or exceeded the addiction level by exaggerating the fun activity. (Reiterer, 2010; Thalemann, 2010). It can now be said that they are not just a player but also an addict. People who have a compulsive addiction to computer gaming begin to postpone the important things in their daily life. As the dose of procrastination increases, these players become unable to function in daily life and among family and society (Chip Online, 2014; Vollmer, Randler, Horzum, and Ayas, 2014). Many studies have shown that education, social environment, family, real-virtual separation, and auto control are among the most important factors that trigger the relationship between pleasure, violence, gender characteristics, time control, and computer game addiction (Basha, 2021; Chiu, Lee and Huang 2004; Charlton and Danfort, 2007; Griffiths, Davies and Chappell, 2004; Oggins and Sammis, 2012). Game addiction causes social and/or emotional problems (Lemmens, Valkenburg and Peter, 2009), which in turn leads to game addicts to neglect their sleep, nutrition, hobbies, and social lives to create more time for gaming (Ciris, Baskonus, Kartal, and Tasdemir, 2022; Wang, Sheng, and Wang, 2019; Young, 2009). According to mental health professionals, addiction to games is when damage occurs in the individuals' functioning at different levels such as school, family, work, and psychological functions (Gentile, 2009; Mohammad, Jan, and Alsaedi, 2023; Zamani, Chashmi, and Hedayati, 2009).

Presenteeism

The concept of presenteeism has mostly been explained as either full participation or "absenteeism" (Johns, 2010:520). Presenteeism refers to the state of apparent physical existence, presence, and existence in the relevant institution (Dewa, Daid, and Ettner 2007; D'abate and Erik, 2007). The notion of presenteeism has been used in the literature for the psychological state of employees. Presenteeism is when employees go to work even if they are sick or injured (Cullen and McLaughlin, 2006; Demirgil and Mucevher, 2017), which is considered as an overwhelming situation for the employees (Cooper, 1998; Lowe, 2004). The emergence of this expression or this problem, is mostly used in the business world and job environment. Presenteeism is defined as the psychological absenteeism (Cooper, 1998) of the employees due to the work stress they experience despite being at work and continuing to work while they are ill (Aronsson, Gustafsson and Dallner, 2000; Schulze and Steyn, 2007). It has been stated that the causes of presenteeism should be investigated not only in the context of health at work or worker health, but also in other fields (Patel, Budhwar and Varma, 2012:216).

As a matter of fact, Matsushita et al. (2011) mentioned that presentism can be seen in the school environment. The indicators of presenteeism among students are as follows: not being present in lessons even though they are attending the lesson, seeming as if they are listening while they are in lessons when in fact their minds are elsewhere, engaging in other activities during the lessons, which causes low performance. One way to characterize presenteeism is a student's decreased performance as a result of health issues (Sarıçam and Çetintaş, 2015:1504). Students' presenteeism may be an indicator of other health problems and may lead to absenteeism and academic failure in the future. Paying attention to the lesson, participating in class discussions, attending class, attending class on time, and taking notes during class are important components for the concept of presence (Sarıçam and Özbey, 2019). Individuals who are not psychologically present in

the lesson will not feel a sense of belonging at school.

School engagement

One of the important indicators of students feeling a sense of belonging at school and adopting the requirements of the school is school loyalty (Akın et al., 2013). The common point among the definitions of the concept of "school engagement" in the literature is the "commitment" and "engagement" of the student in the school environment (Fredricks, Blumenfeld, and Paris, 2004), which is considered as an integral part (Furlong and Christenson, 2008). It is a structure that includes engagement to school, positive behavior, and psychological connections to the school environment (Önen, 2014:221), being attached to the school and feeling a sense of belonging at school (Finn, 1993; Osterman, 2000), believing that school is valued and respected (Goodenow, 1993; Savi, 2011), identifying with school (Finn, 1989), having positive and negative emotional reaction towards school issues (Skinner and Belmont, 1993) and having a sense of love and loyalty (Wilson, 2004). Arastaman (2009), based on definitions, said that the student's engagement with the school includes their participant behavior as well as feeling good about school.

Osterman (1998) treated school engegament and school loyalty as an interchangeable quality and found that students with school engagement received more support from their friends, teachers, and the qualities of school life, which in turn increased the students' engagement (Cetin, 2018). School engagement can be an important determinant of adolescent mental health. Caraway, Tucker, Reinke, and Hall (2003) argued that adolescents' non-school days (days spent out of school) status had very serious consequences including substance abuse, child pregnancies, involvement in criminal events, and dropping out from school. Besides, it was determined that students with low levels of school engagement had a higher risk of dropping out (Janosz, Archambault, Morizot, and Pagani, 2008). It has been claimed that failing at school and not feeling attached to school can lead to substance abuse in adolescents (Shek, 2006). According to McNeely and Falci (2004), adolescent risk behavior such as emotional problems, suicidal tendencies, substance abuse, violence, and adolescent pregnancies is due to the student's poor relationship with the school. On the other hand, school engegament has been found to have a protective effect on both the physical and emotional states of adolescents (Chapman, Buckley, Sheehan, Shochet, and Romaniuk, 2011).

Present study

According to the data included in the 2015-2019 Strategic Plan of the Turkish Ministry of National Education, 14.8% of primary school students, 35% of secondary school students, and 34.8% of high school students had been absent for more than 20 days. According to International Student Assessment Program (PISA) 2012 data, the rate of students who were late to class in the Organization for Economic Co-operation and Development (OECD) countries was 35%, while this rate was determined as 44% in Turkey (TEDMEM, 2016). These statistical findings are important indicators of school engagement in Turkey. According to the 2016 data of the Turkish Statistical Institute (TSI), the rate of desktop computers in households was 22.9%, the rate of the portable computers was 36.4%, the rate of tablets was 29.6% and the rate for mobile phones was 96.9%. According to the 2023 data of the Central Intelligence Agency (CIA), in Turkey 51.4 million mobile phones are used. It is projected that there will be 78.59 million smartphone users by 2028, marking a new peak (Statista, 2023). Considering that the majority of these are smartphones, it is clear that Turkey utilizes information technologies more than many countries. However, these indicators are also risk indicators for digital addiction. Although previous studies on presenteeism in the workplace and educational environments reported that the concept of presenteeism was due to health problems, it has been claimed that there may be different variables that cause student presenteeism (Çetintaş and Sarıçam, 2016; Sarıçam and Çetintaş, 2015). Based on this claim, the present study aimed to examine the possible relationships between computer game addiction, presenteeism, and school engagement among secondary school students. In the study the answers to the following research questions were sought:

- Is there a meaningful relationship between computer/tablet game addiction and school engagement in secondary school students?
- Is there a meaningful relationship between secondary school students' presenteeism in class and school engagement?
- Does computer/tablet game addiction meaningfully predict presenteeism in class and

school engagement among secondary school students?

The suppressor effect is a very old concept. It was not used much in research for a while due to doubts about the statistical technique used and its theoretical infrastructure (Conger, 1974; Lancaster, 1999; Rosenberg, 1973). However, in recent years, studies on the suppressor effect have increased (Moscoso and Salgado, 2021; Salgado, Blanco, and Moscoso, 2019; Schilbach et al, 2023). In this study, the relationship between gaming addiction and school engagement was examined in the context of presenteeism, which is the suppressor variable, and it was aimed to contribute to the discussions.

MATERIALS AND METHODS

Participants

A total of 300 pupils from secondary schools in Kütahya in Türkiye were chosen as participants through the use of a convenience sampling technique. 52.3% of the participants were female (N=157) and 47.7% were male (N=143). Exactly half of the participants were students in the 7th grade, while the other half were students in the 8th grade. The ages of the participants ranged between 12 and 16 and the mean age was 13.52 (SD=0.65). Approval was granted by the Uşak University Social and Human Sciences Scientific Research and Publication Ethics Board (approval number: 2023-180, date: 20.09.2023). 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. The study ensured the protection of children's rights and implemented the necessary measures to uphold them.

Data Collection Instruments

Computer Game Addiction Scale for Children (CGAS-C):

This tool was developed by Horzum, Ayas, and Çakır-Balta (2008) for the assessment of the level of video game addiction among children. CGAS-C includes four subscales and 21 items. A 5-point Likert scale ranging from 1 – Never, 3 – Sometimes, 5 – Always is used to score the instrument. The higher the score on the scale the higher the addiction level. The reliability coefficients for the scale obtained via Cronbach's alpha were α=.85 for the whole scale, α= .83 for the "cannot give up playing games" subscale, α=.60 for the "associating computer games with real-life" subscale, α=.45 for the "neglecting responsibilities because of computer games" subscale and α=.50 for the "preferring playing on the computer to other activities" subscale. In the present study, the internal consistency coefficient for CGAS-C was found as .84 for the whole scale.

Child and Adolescents Presenteeism Scale (CAPS):

This instrument was formulated by Matsushita et al. (2011) to gauge the presenteeism levels of undergraduates. The scale has two sub-dimensions, namely completing work and avoiding distraction. Sarıçam et al. (2013) adapted the scale to Turkish. It was later revised by Sarıçam and Çetintaş (2015) for children and adolescents. CAPS is a 5-point Likert-type scale ranging from 1 = never to 5 = always. It consists of 10 items (i.e. `I was able to finish hard homework/school tasks`, `I have enough energy to complete the assignments/homework/tasks`, `I need to take breaks from my homework`). The Cronbach's alpha internal consistency reliability coefficient was α = .76 for the whole scale among children and α = .83 for adolescents.

School Engagement Scale (SES):

The original scale was developed by Fredricks, Blumenfeld, Friedel, and Paris (2005). The scale is a 5-point Likert-type scale, with 1 representing never and 5 representing always. The scale allows for a minimum score of 19 and a maximum score of 95. Akın et al. (2013) translated SES into Turkish. According to the findings of the confirmatory factor analyses, 19 items produced three components as their original form, and the three-dimensional model was well-fitted (CMIN=289.67, df=142, RMSEA=.058, NFI=.94, NNFI=.96, CFI=.97, IFI=.97, RFI=.93, SRMR=.056). The loadings of the factors varied from.30 to.71. The overall scale's Cronbach's alpha internal consistency coefficient was found to be.87, that of the subscales measuring cognitive, emotional, and behavioral involvement was found to be .81, .82, and.62, respectively. The test-retest reliability coefficient was as *r*=.78 for the whole scale. The corrected item-total correlations ranged from .26 to .71. In this study, the Cronbach's alpha internal consistency coefficient was found to be α=.77 for the whole scale, α=.67 for the cognitive engagement subscale, α=.59 for the emotional engagement subscale and α=.64 for behavioral engagement subscale.

Data Analysis and Procedure

The data collected were transferred to the computer environment using SPSS 23 software package. Pearson product-moment correlation analysis was applied to determine the relationship between the variables and stepwise regression analysis was used to determine the suppressor role of presenteeism in the relationship between computer/tablet/smartphone game addiction and school engagement. Classical suppression occurs when the variable in the equation has zero or minimal correlation with the dependent variable, but simultaneously shows a large correlation with another predictor variable included in a regression equation (MacKinnon, Krul, and Lockwood, 2000; Tzelgov and Henik, 1991). On the other hand, McNemar (1945) pointed out the paradoxical quality associated with a suppressor stating that it was possible to increase prediction with a variable that has a negative correlation with the criterion, provided there is a high correlation with another variable that correlates with the criterion. This suppressor refers to the negative suppression effect. Similarly, reciprocal or cooperative suppression, which involves cases in which two predictors either (a) correlate oppositely with the criterion, but is positively related to one another or (b) are both correlated positively with the criterion but negatively with one another; in these cases, including both predictors in the regression equation increases both of their beta weights (Conger, 1974). The negative suppression effect was tested using the Venn diagram of Lancaster (1999) and Paulhus, Robins, Trzesniewski, and Tracy (2004) [see Figure 1]. The steps of the suppressor analysis for the present study are as follows: [see Figure 2]: (1) game addiction and presenteeism are covariate variables (path a), (2) presenteeism is a significant predictor for school engagement (path -b), (3) game addiction is a significant predictor for school engagement (path c) and (4) when game addiction and presenteeism are included in the equation together the coefficient value of game addiction for school engagement should become more significant or stronger (path c′). The coefficient value of presenteeism will go in a reverse direction (path +b′). Finally, to test the correlation and regression models, bootstrapping procedures were employed with a 10.000 random resampling (Davison and Hinkley, 1997; Efron and Tibshirani, 1993; Lee and Rodgers, 1998). The significance level was accepted as 0.05 ($p < 0.05$).

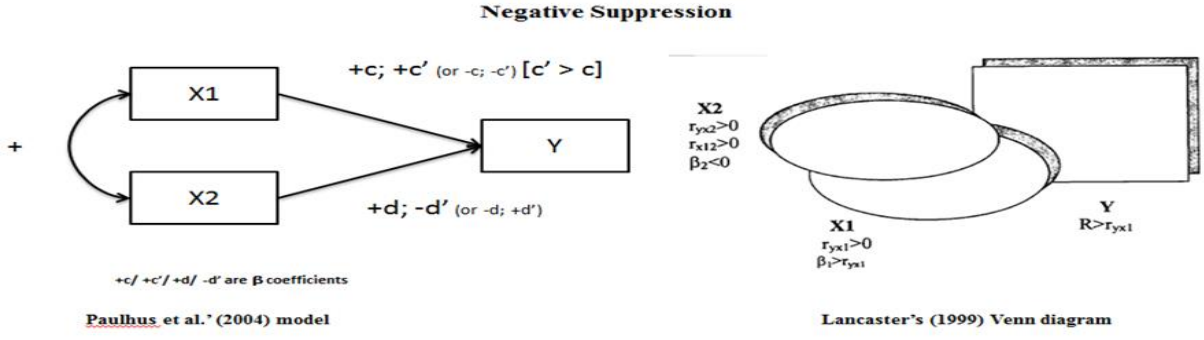

Figure 1. Negative suppression path

RESULTS

Findings of the Correlation Analysis

Pearson Moment Correlation Analysis was applied to examine whether there were any relationships among the variables or not, and the findings are given in Table 1.

Table 1 showed that game addiction had positive relationships with presenteeism and its subscales, namely completing work and avoiding distraction [r= .74; .64; .71, respectively, p<.01]. increased, while school engagement decreased. On the other hand, when presenteeism levels decreased school engagement levels increased.

Moreover, game addiction had negative relationships with school engagement and its subscales, namely behavioral engagement, emotional engagement and cognitive engagement [r= -.76; -.58; -.81; -.61, respectively, p<.01]. Furthermore, presenteeism had negative relationships with school engagement and its subscales, namely behavioral engagement, emotional engagement and cognitive engagement [r= .74; .64; .71, respectively, p<.01]. It was seen that as game addiction increased presenteeism also

Table 1. Descriptive Statistics and Correlation Values

Variables	1.GA	2.CW	3.AD	4.P	5.BE	6.EE	7.CE	8.SE
1. Game addiction (GA)	-	.64**	.71**	.74**	-.58**	-.81**	-.61**	-.76**
2.Completing work (CW)		-	.64**	.90**	-.26**	-.48**	-.31**	-.40**
3.Avoiding distraction (AD)			-	.91**	-.40**	-.55**	-.36**	-.50**
4.Presenteeism (P)				-	-.36**	-.57**	-.37**	-.49**
5.Behavioral engagement (BE)					-	.57**	.67**	.85**
6.Emotional engagement (EE)						-	.75**	.88**
7.Cognitive engagement (CE)							-	.91**
8.School engagement (SE)								-
Mean	68.23	9.71	14.01	23.72	10.24	14.69	14.61	39.54
SD	17.41	4.13	4.35	7.70	4.44	4.47	4.35	11.67

Note. **p < .01.

Bootstrapping Process

With the bootstrapping process, the aim was to compute the distributions of the significance of the Pearson correlation coefficients. Through this method, it is possible to simulate the population distribution of a statistic (mean, variance, correlation, standard errors, differences between means, time series and prediction lines, etc.) with confidence. As a consequence, 10.000 re-sampling was conducted with bootstrapping and bootstrap coefficients were created with 95% CI confidence intervals as well as the proportion of the samples above zero. The results are displayed in Table 2.

Table 2. Bootstrapping Results of the Pearson Correlation Coefficients

Variables			1.GA	2.CW	3.AD	4.P	5.BE	6.EE	7.CE	8.SE
1. GA	BCa 95% Confidence Interval	Lower	-	.56	.65	.68	-.66	-.85	-.68	-.81
		Upper	-	.70	.76	.79	-.49	-.77	-.52	-.70
2.CW	BCa 95% Confidence Interval	Lower		-	.58	.88	-.35	-.56	-.40	-.48
		Upper		-	.70	.92	-.16	-.39	-.20	-.31
3.AD	BCa 95% Confidence Interval	Lower			-	.90	-.49	-.62	-.46	-.58
		Upper			-	.93	-.30	-.46	-.26	-.41
4. P	BCa 95% Confidence Interval	Lower				-	-.45	-.64	-.46	-.57
		Upper				-	-.26	-.49	-.27	-.41
5. BE	BCa 95% Confidence Interval	Lower					-	.47	.59	.81
		Upper					-	.65	.74	.88
6. EE	BCa 95% Confidence Interval	Lower						-	.69	.85
		Upper						-	.80	.90
7. CE	BCa 95% Confidence Interval	Lower							-	.89
		Upper							-	.93
8. SE	BCa 95% Confidence Interval	Lower								-
		Upper								-
Mean	BCa 95% Confidence Interval	Lower	66.26	9.25	13.53	22.87	9.75	14.18	14.12	38.23
		Upper	70.16	10.17	14.49	24.56	10.76	15.22	15.12	40.93
SD	BCa 95% Confidence Interval	Lower	16.12	3.80	4.08	7.19	4.01	4.13	3.93	10.50
		Upper	18.62	4.46	4.61	8.18	4.84	4.80	4.75	12.80

Note. **p < .01. Note. Game addiction: GA, Completing work: CW, Avoiding distraction: AD, Presenteeism: P, Behavioral engagement: BE, Emotional engagement: EE, Cognitive engagement: CE, School engagement: SE

From Table 2 it can be inferred that the bootstrapping confidence intervals in the correlation coefficients did not include zero. Therefore, it can be said that all of the correlation

coefficients in the model were significant after the bootstrapping process.

Suppression Findings

Stepwise regression analysis was applied to determine the coefficients of prediction among the variables. The findings of the analysis are given in Figure 2.

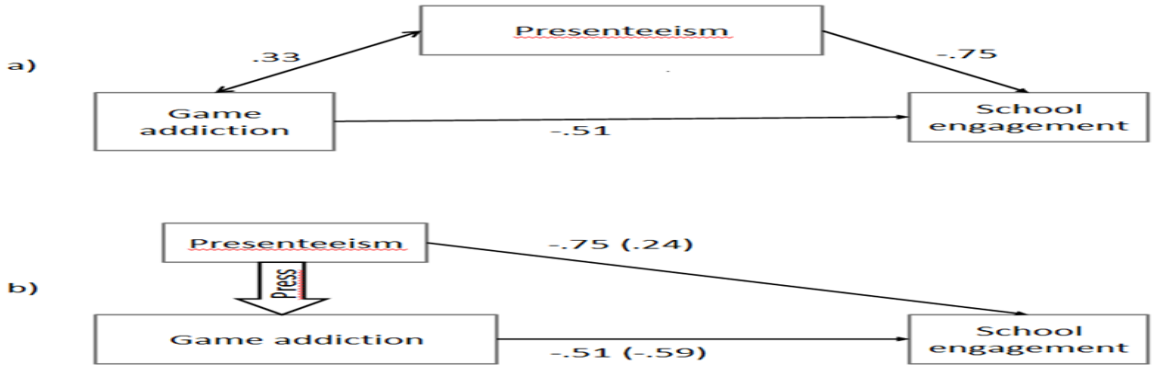

Figure 2. Findings of the Stepwise Regression Analysis

It can be seen from Figure 2 that in the first stage of regression (a), game addiction (β= -.51, p<.01) and presenteeism (β= -.75, p<.01) significantly predicted school engagement, separately. In the second stage of regression analysis (b), both game addiction (β= -.59, p<.01) and presenteeism (β= +.24, p<.01) significantly predicted school engagement. In the second stage of the regression analysis inclusion of the presenteeism variable into the regression model increased the school engagement-predicting capacity of game addiction from -.51 to -.59. Although a negative significant relationship was found between presenteeism and school engagement in the first stage (a) (Figure 1), presenteeism was found to be a positive significant predictor for school engagement in the second stage (b). Moreover, the regression analysis results that indicated the increase in the capability of game addiction in predicting school engagement further indicated that presenteeism (or game addiction) had a negative suppressive effect on the relationship between game addiction (or presenteeism) and school engagement.

Table 3. Bootstrapping Results of the Regression Model

Model stages					Estimate	BCa95% Confidence Interval	
						Lower Level	Upper Level
Direct effect							
GA	↔	P			.33	.30	.36
P	→	SE			-.75	-.90	-.60
GA	→	SE			-.51	-.57	-.44
Indirect effect							
GA	↔	P	→	SE	-.59/+.24	-.67/+.08	-.49/+.39

Note. Game addiction: GA, Presenteeism: P, School engagement: SE.

It can be inferred from Table 3 that the bootstrapping confidence intervals in the direct and indirect effects did not include zero. Therefore, it can be said that all stages in the model were significant after the bootstrapping process.

DISCUSSION

The purpose of this study was to investigate potential connections between secondary school students' computer game addiction, presenteeism, and school engagement. For this purpose, firstly, the relationship between computer/tablet game addiction and presenteeism was examined. As a result of the study, it was observed that there was a positive relationship between computer/tablet game addiction and presenteeism in secondary school students. In other words, it was shown that presenteeism grew along with game addiction. This result concluded that secondary school students' computer/tablet game addiction affects their school life. Studies in the literature found that computer

game addiction could decrease academic success (Horzum, Güngören and Kaymak-Demir, 2017; Wan, Wen, and Chiou, 2013), cause the deterioration of interpersonal relationships (Wan et al., 2013), cause delays in social skills (Gentile et al., 2011) and negatively affect family relations. The findings of the present study are in line with the findings of those conducted on computer game addiction.

In secondary school students, a positive relationship was found between computer/tablet game addiction and presenteeism and its subscales, namely completing work, and avoiding distraction. Studies conducted on computer game addiction among children and young adults have shown that computer game addiction can have various negative effects on development (Karacaoğlu, 2019). Computer games can affect students both psychologically and biologically (Chiu et al., 2004; Wan and Chiou, 2006). Even though computer games are used in the education of children, the use of entertainment purposes is predominant (Garris, Ahlers, and Driskell, 2002). In addition to using computers and the Internet to access information, using them for entertainment also increases the risk of addiction (Kıran, 2011:55).

In this study, it was observed that there was a negative relationship between computer/tablet game addiction and school engagement in secondary school students. A negative correlation was found between school engegament and its subscales (e.g. behavioral engegament, emotional engegament, and cognitive engegament), and computer/tablet game addiction in secondary school students. Addiction to online games has a bad impact on students' learning frequently. For example, students' online game addiction negatively affected their behavioral, emotional, and cognitive engagement (Sun, Sun, and Ye, 2023). According to Ye et al. (2023), students' behavioral, emotional, and cognitive engagement were negatively impacted by the problematic usage of short videos. Gentile et al. (2011) examined the relationship between digital game addiction, depression, and school success and found that while the depression, anxiety, social phobia and school success variances of the addicted players deteriorated the opposite was observed in normal players. Drummond and Sauer (2014) examined the data collected from more than 192,000 students from 22 countries participating in the 2009 PISA in terms of the relationship between adolescent science, mathematics and reading courses, and digital playtime. The findings of their study pointed out that the time spent playing digital games significantly affected the academic success of adolescents. Kovacevic, Minovic, Milovanovic, Pablos, and Starcevic (2013) also claimed that computer games affect the learning objectives and activities (Terry, Malik, Sinclair, Fines and Terry, 2014). The findings of the above-mentioned studies are in support of the findings of the present study.

A negative relationship was found between school engagement and its sub-scales (e.g. behavioral engegament, emotional engegament, and cognitive engegament), and presenteeism in secondary school students. Stated differently, students who have school engegament are present in the classroom both physically and mentally. Studies have shown that school engagement has various positive effects on students. According to a study by McNeely and Falci (2004), students with a high level of school engagement were less likely to drop out of school, be absent, or demonstrate behavioral problems. It has also been shown that students with high school engagement enjoy being in school (Curci, 2011). Also, it has been determined that students with a low level of school engagement have a higher risk of dropping out (Janosz et al., 2008). These findings are in line with the findings of the present study. School engagement and academic success (Finn and Rock, 1997) and school engagement levels (Sinclair, Christenson, Evelo and Hurley, 1998). Furthermore, in a study conducted by Chase Hilliard, Geldhof, Warren, and Lerner (2014) on high school students, it was concluded that school engagement positively predicted academic success and that it was an important predictor of academic success in terms of the behavioral, emotional and cognitive dimensions. On the other hand, in various studies in the literature have also been found that school engagement decreases the frequency of students dropping out of school (Janosz et al., 2008; Sinclair et al., 1998; Wang and Fredricks, 2014).
In one of the most important findings obtained in the present study was that the presenteeism and computer/tablet game addiction predicted the school engagement of the students separately. School engagement explained both computer/tablet game addiction and the presenteeism variable. Besides, the analysis result showing the increase in the ability of game addiction explaining school engagement also showed that the presenteeism in a

course had a negative explanatory effect on the relationship between game addiction and school engagement. According to the 2018 data of Turkey Statistical Institute (Turkstat) computer and Internet use in individuals was 59.6% and 72.9%, respectively, for those between the ages of 16 and 74. In 2019 Internet use was reported to be 75.3% among the individuals in this age group. Internet usage rates were 81.8% for males in the 16-74 age group and 68.9% for females. Home Internet access was found to reach 88% (TurkStat, 2018). This data shows that the Internet and computer use in Turkey, especially among young people, increased rapidly. Also, it was found that the time allocated by students to computer games gradually increased in Turkey (Onay, Hotomaroğlu, and Çağıltay, 2005; Tüzün, 2006). This has proved that students exhibit higher presenteeism, which is affected by the psychological absence in lessons (Hellgren et al., 2010).

The school life of adolescent children affects their overall development (Wigfield et al., 2006). Furthermore, students' lack of a sense of belonging to their classrooms and schools causes them to be physically and/or psychologically absent. This situation is problematic in terms of presenteeism. While the rate of students who express their feelings about school in Turkey is approximately 61%, this rate is, on average, 73% in OECD countries. According to the 2015 sense of school belonging index, Turkey was one of the countries with the lowest sense of school belonging with a score of -0.44. In a study by Finn (1989), students who did not actively participate in activities or identify with their school since the beginning of their education were found to be at risk of absenteeism, leaning towards crime, and dropping out. According to Turgut (2015:79), the students' presence in school depends on whether their various psychological needs are met at school. According to the 2018 Annual Activity Report of the Turkish Ministry of National Education, when compared to the previous year the rate of students who were absent for 20 days or more in 2018 increase from 39.8% to 44.0% in vocational and technical secondary schools and from 32.2% to %36,0 in Anatolian imam hatip high schools (ERG, 2019). These data show that the relevant goals set for 2018 were not achieved and the 2019 goals were difficult to achieve. The student's engagement in school is considered an integral part of academic success, as it involves students' social and emotional connections in the school environment (Furlong and Christenson, 2008). Students' engagement in school is related to the belief adults have towards school. If the student believes that the adults in question care about themselves as an individual and take their education seriously, they become highly dependent on the school (Blum and Libbey, 2004). It is known that gaming addiction causes many health problems such as sleep disorders, eating disorders, and decrease in social skills. (King and Delfabbro, 2020; Zincir et al., 2023). In addition, gaming addiction also damages brain activities (Hosseini et al., 2021). A persistent condition of hyperarousal in the brain can result from gaming addiction (Yu, Abdullah, and Mansor, 2024). Presenteeism is also the fact that although the individual is physically present in the environment, she or he cannot be in the environment mentally. In other words, in the case of presenteeism, brain activities do not function adequately like gaming addiction. Therefore, gaming addiction can cause presenteeism and vice versa. In this study, presenteeism increased school engagement by putting pressure on gaming addiction.

Conclusion

In this study, the role of computer game addiction, mental absence in class, and the predictive role of school engagement in secondary school students were examined. A positive relationship was determined between computer/tablet game addiction and presenteeism in the course. Also, presenteeism was found to have a negative relationship with school engagement and its subscales, namely behavioral participation, emotional participation, and cognitive participation and computer/tablet addiction. There was a negative relationship between game addiction and school attachment. Furthermore, it was determined that the mental absence of the students (presenteeism) and computer/tablet game addiction predicted school engagement separately. It can be stated that the present study had various limitations.

First of all, in the study, a quantitative research method was followed to determine the possible relationships between computer game addiction, presenteeism, and school engegament among secondary school students. The data of the study were limited to the participants who studied in the province of Kutahya in the 2016-2017 academic year and volunteered to participate. The limitations of the study are important in evaluating and generalizing the results. Informative seminars

can be organized for families regarding monitoring their children's usage of computers or the time spent on computers. By creating a more positive, more reliable, and more understanding school environment, students' school engagement can be increased. Efforts can be made to eliminate the factors that trigger presenteeism by causing stress and pressure on students. In conclusion, examining the relationships between variables with different study groups is considered important in terms of the generalization of the results.

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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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. The study of similar variables was partially presented in IVnd International Eurasian Educational Research Congress in Denizli, Türkiye. However, this study is different from the first one in terms of analysis, participants and content.

Ethical Aspects of The Study

Approval was granted by the Uşak University Social and Human Sciences Scientific Research and Publication Ethics Board (approval number: 2023-180, date: 20.09.2023). 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.

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RESEARCH ARTICLE

The Effect of Ramadan Fasting and Sport Detraining on Complete Blood Count, Testosterone Hormone and Biochemistry Variables Among Soccer Players

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Abstract
Aim: The study aimed to identify if Ramadan fasting and sport detraining affect complete blood count (C.B.C), testosterone and biochemistry variables among soccer players. **Method:** The researchers used a quasi-experimental method in the pre- and post-measurements of the study's variables, and 15 male athletes from the Faraon football club in the Tulkarm region of the State of Palestine conducted the study. Athletes (age, 19.86±1.64 years, Height (cm) 172.06±5.71, Weight (kg) 66.93±6.86, index: 24.62 ±1.4 kg/m^2) was determined as. The measurements were applied on the first day of Ramadan and on the last day of it. Paired sample t-test was used to assess the differences. **Results:** There are statistically significant differences between pre and post-tests means of Blood (CBC) parameters (WBC: t=2.553, p=0.023* ; HGB: t=2.265, p=0.040*; RDW: t=-3.606, p=0.003*; MPV: t=-3.445, p=0.004*) but there are no statistically significant differences between pre and post-test for the rest of Blood (CBC) parameters. There are statistically significant differences between pre and post-tests means of Testosterone Hormone (TH: t=3.024, p=0.009*). There are statistically significantdifferences between pre and post-tests means for biochemistry parameters (CPK: t=4.169, p=0.001*; HDL: t=4.017, p=0.001*; LDL: t=-4.805, p=0.000*; cholesterol: t=-3.891, p=0.002* and triglyceride: t=-2.362, p=0.033*) in favor to post-test mean. But there are no statistically significant differences between for the rest of the biochemistry parameters. **Conclusion:** This indicates that Ramadan fasting and sport detraining completely has a negative impact on the study variables among soccer players.

Keywords
Ramadan Fasting; Sport Detraining; Testosterone; Biochemistry

INTRODUCTION

Ramadan fasting (RF) is a religious tradition in Islam that requires healthy Muslims to abstain from eating, drinking, smoking, and sexual intercourse between sunrise and sunset (Fashi et al., 2021). Adult Muslims generally eat two main meals; The first meal is early in the morning, just before sunrise, and the second meal is after sunset, at the end of the fasting day (Chtourou et al., 2018). This eating pattern and the length of time between meals leads to some changes in sleep and lifestyle rhythms. Many previous studies have shown that Ramadan fasting is associated with significant changes in body weight (Leiper et al., 2008), basic hematological parameters, blood glucose levels, lipids (Leiper et al., 2008), resting metabolic rate (Aziz et al., 2018), respiratory function (Aziz et al., 2012) and physical activity level The significant reduction in training

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loadallows athletes to delay fatigue caused by high-intensity training (Chtourou et al. 2011). While some studies have shown that strength and intense aerobic and anaerobic performance are negatively affected by RF (Graja et al., 2020), others have failed to observe significant performance decrements following RF (Chaouachi et al., 2008).

For example, Souissi et al., (2007) showed that peak power recorded in the afternoon during the Wingate cycling test decreased after two weeks of fasting. Similarly, Aziz et al., (2012) reported a significant reduction in total work during six Wingate tests, each followed by 4-minute recovery periods. Stated that RF would not have negative effects on body composition, anaerobic power or capacity, and lactate metabolism in power athletes during and after high-intensity exercise.

Detraining is the temporary interruption of regular physical training directed at developing or maintaining the elements of physical fitness, which often occurs after the end of the sports season and before the start of the new season (Mujiki & Padilla, 2000). Detraining is defined as an inactivity period that appears following an intense training period, this is occurrence of losses in sportive performance and physiological adaptations when the training is reduced or completely ceased (Masden et al, 1992).Vagner et al. indicated the impacts of the detraining period can be classified under two topics as physiological and physical (Vagner et al, 1998).Importantly, detraining effects may influence how players prepare during pre-competition and potentially affect their performance levels in the first matches of the competition period (Kraemer et al, 2004). In our study, sport detraining came in the month of Ramadan and the players were fasting and completely stopped training. So the study aimed to identify if Ramadan fasting and sport detraining during transitional period affect some blood (C.B.C), hormones and biochemistry variables among soccer players.

MATERIALS AND METHODS

Participants

Fifteen male athletes (Age: 19.86±1.64 years, Weight: 66.93±6.86, Height: 172.06±5.71) voluntarily participated in this study. The researchersused quasi-experimental method and conducted the study on a purposive sample (S) of (15) players from Faraon soccer club and Table (1) illustrate the characteristics of the study sample. The study was approved and supervised by the departmental research committee, Palestine technical university kadoorie (Ref: 2024/20), dated 24 November 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.

Body composition

Subjects' body weight was measured to the nearest 100 g using a calibrated electronic scale, and their height was measured using a stadiometer. Body mass index (BMI) was calculated as weight (kg) divided by height (m) squared.

Table 1. Descriptive characteristics (mean ve standard deviation) of physically active men

Variables	M	SD	Skewness
Age (Year)	19.86	1.64	0.021
Height (Cm)	172.06	5.71	0.607
Weight (kg)	66.93	6.86	1.444
Body Mass Index ($kg \cdot m^2$)	22.58	1.62	-0.378

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 variables

The study consisted of the following variables:

The independent variables, which include Ramadan fasting and abstaining from training during the transitional period.

The dependent variables, which include the following:

Complete blood count tests which include (WBC, LYM, HGB, RBC, HCT, MCH, MCV, RDW, PLT, MPV).

Testosterone Hormone

Biochemistry tests, which include (S.G.P.T,CPK,HDL,LDL,Cholesterol,Triglyceride, Vitamin B12, Creatinine).

Study Procedures

Blood Samples

The researchers followed the following procedures in measuring the study variables:

The pre-measurement was performed on the first day of Ramadan (13/04/2021) at exactly eight o'clock morning in the laboratory by taking blood samples from the veins in the elbow according to the scientific principles followed by gently attaching the compressor around the upper arm and then cleaning the traction area by wiping it with a cotton swab moistened with ethylene alcohol 70 %, and then the blood was drawn using a sterile, dry syringe and used for one time, by holding the elbow with the left hand and placing the thumb on the vein and away from the place of the puncture, then holding the syringe with the right hand, inserting it into the vein, then withdrawing 5-10 ml of blood, and severing The compressive band, then put a piece of dry cotton, and put pressure on the place where the sample was drawn to prevent bleeding.

The blood samples were placed in a special refrigerator at a temperature between 2-8 °C.

The tests were carried out directly by using three devices (Medonic M-series for CBC test; TOSOH AIA-600II for hormones and vitamins testing; FUJIFILM DRI-CHEM NX500isa multi-purpose automatic dry-chemistry analyzer featuring remarkably short turnaround time, a touch screen interface and reliability).

The post-measurement was carried out on the last day of the month of Ramadan (12/05/2021) at exactly eight o'clock morning in the laboratory by following the steps of the pre-measurement.

Statistical analysis

The researchers used SPSS version 23 to analyze. General characteristics of the participants were presented as means and standard deviations. All data were assessed for normality by using the Shapiro–Wilk test. Paired sample t-test was used to assess the differences. Level of significance was accepted at $P<0.05$.

RESULTS

The changes in WBC,HGB,RDW and LYM, RBC, HCT, MCH, MCV and PLT are presented in Table 2.

There are statistically significant differences between pre and post-tests means of Blood (CBC) parameters (WBC: t=2.553, p=0.023* ; HGB: t=2.265, p=0.040*; RDW: t=-3.606, p=0.003*; MPV: t=-3.445, p=0.004*) but there are no statistically significant differences between pre and post-test for the rest of Blood (CBC) parameters (LYM: t=1.555, p=0.142; RBC: t=0.825, p=0.423; HCT: t=0.329, p=0.747; MCH: t=1.955, p=0.071, MCV: t=1.755, p=0.101 and PLT: t=1.417, p=0.178).

Table 2. The differences between pre and post tests means of (C.B.C)* variable

Variable	Parameters*	Pre-test		Post-test		T-value	P-value*
		M	SD	M	SD		
Complete Blood Count (C.B.C)*	WBC (10^9/1)	7.02	1.42	6.27	1.74	2.553	0.023*
	LYM (%)	40.25	8.20	38.28	8.92	1.555	0.142
	HGB (g/dl)	15.31	0.85	14.90	0.87	2.265	0.040*
	RBC (10^{12}/1)	5.42	0.22	5.38	0.30	0.825	0.423
	HCT (%)	46.32	2.01	46.15	2.52	0.329	0.747
	MCH (pg)	30.21	7.08	29.72	7.17	1.955	0.071
	MCV (f1)	85.39	2.31	85.10	2.24	1.755	0.101
	RDW (%)	15.03	0.50	15.44	0.36	-3.606	0.003*
	PLT (10^9/1)	220.53	32.83	209.53	26.33	1.417	0.178
	MPV (f1)	9.08	0.86	9.53	0.81	-3.445	0.004*

Note: M: Mean; SD: Standard deviation; * statistically significant at ($P \leq 0.05$); *Parameters: Explanation of the abbreviations for variables in Table (2).

There are statistically significant differences between pre and post-tests means of Testosterone Hormone (TH: t=3.024, p=0.009*) (Table 3).

Table 3. The differences between pre and post tests means ofhormone variable

Variable	Parameters*	Pre-test		Post-test		T-value	P-value*
		M	SD	M	SD		
Hormone	Testosterone (ng/dl)	868.66	274.29	668.13	178.94	3.024	0.009*

Note: M: Mean; SD: Standard deviation; * statistically significant at ($P \leq 0.05$).

There are statistically significantdifferences between pre and post-tests means for biochemistry parameters (CPK: t=4.169, p=0.001*; HDL: t=4.017, p=0.001*; LDL: t=-4.805, p=0.000*; cholesterol: t=-3.891, p=0.002* and triglyceride: t=-2.362, p=0.033*) in favor to post-test mean. But there are no statistically significant differences between pre and post-test for the rest of the biochemistry parameters (vitamin B12: t=-0.660, p=0.520 and Creatinine: t=-0.336, p=0.742) (Table 4).

Table 4. The differences between pre and post tests means ofbiochemistry variable

Variable	Parameters*	Pre-test		Post-test		T-value	P-value*
		M	SD	M	SD		
Biochemistry	CPK (U/L)	325.26	146.99	155.33	38.46	4.169	0.001*
	HDL (mg/dl)	49.46	17.72	41.86	11.78	4.017	0.001*
	LDL (mg/dl)	61.26	20.73	81.73	27.79	-4.805	0.000*
	Cholesterol (mg/dl)	122.06	30.11	147.86	36.22	-3.891	0.002*
	Triglyceride(mg/dl)	52.20	20.08	73.40	41.84	-2.362	0.033*
	Vitamin B12 (mg/dl)	231.86	102.93	235.60	84.90	-0.660	0.520
	Creatinine (mg/dl)	0.95	0.11	0.95	0.11	0.336	0.742

Note: M: Mean; SD: Standard deviation; * Statistically significant at ($P \leq 0.05$); *Parameters: Explanation of the abbreviations for variables in Table (2).

DISCUSSION

During the month of Ramadan, Muslims are obliged to fast during daylight hours and abstain from food and drinking after sunset, and this leads to an adjustment in the daily distribution of food, drink and sleep schedule, which in turn causes different changes in the metabolism process, in addition to stopping sport training completely, which prompted researchers to conduct this study, The results of table (2) showed that fasting Ramadan and sport detraininghad an effect on blood (CBC) variables, revealed an increase in the arithmetic averages as in the RDW and RDW variables, and decrease in the arithmetic means of blood (CBC) variables: WBC, LYM, HGB, RBC, HCT, MCH, MCV & PLT. This differed with the results of studies (**Trabelsi et al, 2011; Tayebi et al, 2010**), which showed no change in WBC, LYM, HCT, HGB, RBC, MCV, MCH, RDW, and PLT variables in the month of Ramadan. It also differed with the studies of (**Al Hourani et al, 2009; Azizi, 2002**) which the results showed no change in HCT, HGB & RBC. But the result of the study agreed with (**Ramadan et al, 1999; Al Hourani et al, 2009**) that PLT decreased in the month of Ramadan, This is due to a deficiency in micronutrients such as iron and vitamins. But the result of the study agreed with (**Ramadan et al., 1999; Hourani et al., 2009**) studies which revealed that PLT decreased in the month of Ramadan, and this may be due to a deficiency of micronutrients such as iron and vitamins. It was confirmed by (**Karakoc et al, 2005**) that RBC & HGB depend on the presence of iron. It also agreed with the study of (**Dewanti et al, 2006**) which showed a decrease in HCT & HGB, explaining this may be due to geographical, climatic, economic and nutritional differences. **Suzuki et al.,** (**2006**) indicated that well-trained athletes have high concentration of HGB and RBC than inactive people. Our study also agreed with the study of (**Farshidfar et al, 2006**) which showed a decrease in HGB when measured on the 28th day of Ramadan compared to its measurement a day before Ramadan. Also, our study results agreed with the results of (**Anindita & Amit, 2017**) study which showed a decrease in WBC, LYM, HGB, RBC at the end of Ramadan. It agreed with the study of (**Haq et al, 1997**) result in the decline of LYM at the end of Ramadan. The study of (**Bouhlel et al, 2006; Bigard et al, 1998**)

showed increase levels of HCT & HGB among fasters during Ramadan, which may be due to dehydration. On the contrary **Tayebi et al., (2010)** study revealed the reason of A reduction in HGB concentration and HCT might be due to the incomplete dehydration period which amplified by stop drinking and nutritional habits during the holy Ramadan.

The results of table (3) also showed that Ramadan fasting and sport detraining during transitional period had a statistically significant effect on the decrease in the level of testosterone hormone. This result differed with (**Koundourakis et al, 2014; Silva et al, 2014**) which revealed that sport detraining doesn't affect resting sex steroid levels. As **Mesbahzadah (2005)** reported in his study is the sex hormone in healthy adult males affected by fasting become reduced however, it is not reached to significant level. Testosterone is one of the anabolic hormones and it is the most important of them. Since it is a dominant factor of the influence on the increase of muscle mass, testosterone plays an important role when it comes to increasing muscle strength (**Rahimi et al, 2010; Zatsiorsky & Kraemer, 2009**). An increase in the concentration of testosterone is related to muscle strength and sports activity, it is known that its presence in the body is one of the most important conditions for muscle growth and strength training has the biggest influence on its secretion (**McCaulley et al., 2009; Linnamo et al., 2005**).From the foregoing, the researchers attributed the reason for the low testosterone hormone related to stopping sports training and low sexual habits during Ramadan month, which play an important role in its secretion, which reduces its functions. The functions of testosterone are: responsible for the expression of male secondary sexual characteristics, the effect on protein synthesis and muscle development, the effect on bone growth and retention of calcium and non-osseous minerals, the effect on the deposition of glycogen in the muscles, the effect on the formation of red blood cells & the effect on electrolytes and water balance (**Guyton & Hall, 2003; Nikolić, 2003; Wilmore & Costill, 2004**). Previous study of Iraki et al showed that abstinence from eating and drinking during Ramadan fast, which is accompanied by variations in the sleeping and waking pattern, and the psychological effects of fasting may bring about rhythmic changes in the secretion of most body`s hormones (**Iraki et al., 1997**).

The results of table (4) also showed that Ramadan fasting and sport detraining during transitional period had effect on biochemistry tests through decrease in CPK & HDL levels, and increase in LDL, Cholesterol, Triglyceride, Vitamin B12 levels, while Creatinine level wasn't changed, the researchers attribute this to eating a large amount of food meals that focus on fats, carbohydrates and sugars daily. It agreed with the result of (**Farshidfar et al., 2006**) study in the increase of Triglyceride & Cholesterol levels but differed in the decrease of HDL & LDL levels When measured on the 28th day of Ramadan. It also agreed with (**Khaled et al., 2006**) study which revealed a decrease in HDL level & an increase in LDL, Cholesterol,Triglyceride levels. **Chaouachi et al., (2008)** demonstrated that fasting during the month of Ramadan led to an increase in total cholesterol, HDL, LDL among judokas players.

CPK is the major enzyme that controls the ATP-PC system, an indicator that indirectly reflects metabolism in muscle cells and may be used as a marker that indicates the degree of body and muscle damage based on the increase in activation resulting from physical exercise (**Wallace, Mills & Browning, 1997**). The decrease in CPK in the study sample indicates the effect of stopping sports training completely because its concentration is high in the muscles when practicing sports activities (**Clarkson & Hubal, 2002**). There is a direct relationship between exercise, intensity, time, amount and CPK, Especially its increase is considered as a biochemical indicator of muscle damage (**Brancaccio et al., 2007**). CPK concentration increased significantly immediately after maximum exercise, this was confirmed by the study (**Kim et al., 2014**) that the concentration of CPK significantly increased after pilates exercise, indicating that the exercises affected the muscles and caused their damage. Also **Kim et al., (2006)** indicated that the concentration of CPK significantly increased after exercise when comparing the concentration before exercise with the concentration during the recovery period after intense running. **Yoon (1998)** also indicated that the concentration of CPK increased significantly after maximal exercise.

The results of our study showed that the level of Vitamin B12 increased slightly, but it is

considered low among the study sample, and the reasons for its deficiency need to be monitored by a nutritionist. Creatinine is an indicator of the health of athletes particularly in sporting competitions

where hydroelectrolytic balance is critical for success (**Banfi, 2010**) Our study findings revealed that Creatinine level had not affected by fasting and sport detraining, the researchers attributed this to stop soccer players playing completely, because the level of Creatinine is affected by muscle work and exercise, and this was confirmed by (**Kakadiya & Shah, 2010**) that creatinine is a waste product of creatine, which is an important energy storage substance in muscle metabolism. The researchers also attributed this to focus soccer players on food meals which are very rich in fats, carbohydrates, sugars, drink enough fluids and little proteins daily. **Trabelsi et al., (2011)** study indicated that increase levels of creatinine in the blood during Ramadan month is due to increased protein consumption and possibly dehydration due to lack of fluids. This finding of our study opposed the result of (**Farshidfar et al, 2006**) study which showed a decrease in creatinine level when measured on the 28th day of Ramadan.

Conclusion

According to the results of this study, which showed decrease in the means of post-measurements for most variables while showed increasing in the means of post- measurements of LDL, Cholesterol, triglyceride & vitamin B12 among soccer players. This indicates that Ramadan fasting and sport detraining completely during transitional period has a negative impact on the study variables among soccer players. This means that soccer players are Muslims who did not practice exercises during Ramadan and did not follow a balanced diet by eating sweets and many meals which rich in fat in a short period of time, in addition to their commitment with worship, social relations, staying up late at night and lack of sleep.

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Conflict of interest

Authors declared that there is no conflict of interest.

Ethics Committee

The study was approved and supervised by the departmental research committee, Palestine technical university kadoorie (Ref: 2024/20), dated 24 November 2024).

Author Contributions

Study conception and design: AQ, LH, HS ; Data Collection: AQ, MA; Analysis and Interpretation of results: AQ, GN, RK; Draft manuscript preparation: AQ, HS, GN; All authors reviewed the results and approved the final version of the manuscript.

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RESEARCH ARTICLE

The Effect of Rehabilitative Exercises in Improving (the range of motion, muscle strength, and the degree of pain) for Football Players After ACL Surgery

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Abstract
Objective: This study aims to prepare rehabilitative exercises for football players following anterior cruciate ligament surgery and to determine the impact of such exercises on the functional ability of the anterior cruciate ligament (muscle strength, range of motion, and level of pain) in advanced football players following surgery. Method: A sample of (6) injured, from Al-Kut club, (age = 27.33 ± 1.98 years, height = 174.7 ± 2.99 cm, mass 60.6 0.68 kg) participated in the study. The participants in the experimental group (n=6) completed pre-tests and post-tests. Results: The results of the experimental sample show that there was a significant improvement in the mean scores for Muscular strength on the post-test compared to the pre-test. The mean score for muscular strength increased from 18.50 to 33.33, $p<0.001$), the mean score for the range of motion increased (extension) from 163.50 to 177.33, (flexion) 68.83 to 21, $p<0.001$), and the mean score for pain decreased from 7.125 to 1.12, $p<0.001$). conclusion: following surgery, rehabilitation exercises improve the strength of the muscles that operate on the knee joint, increase the range of motion of the knee joint, and decrease pain degree.

Keywords
Rehabilitative Exercises, Football Players, ACL Surgery

INTRODUCTION

Modern football is characterized by the speed in play and skill in technical and tactical performance, and this is what requires the player to enjoy high physical fitness, which can be developed through sports training, sports training has a strategy that reflects the general goal far from it, which is to achieve access to the highest levels of sports for players, which generates tremendous pressure that leads to illness or injury in a member of the body.

It is recognized that football depends more on the lower extremities, and this is what makes the majority of possible injuries concentrated in this extremity. Among the most important and most common injuries of the lower extremity are knee joint injuries. This injury has received great attention from sports medicine specialists, and extensive research and studies have been conducted to provide the best possible means of treatment. One of the body's most vital and intricate joints is the knee, because its anatomical structure determines its function, as it is responsible for many different movements, which places a great burden on this joint and exposes it continuously to injury, as the knee injury represents about 70% of the injuries that affect athletes in sports stadiums (Awadi, 2004). The anterior cruciate ligament (ACL) injury is one of

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the most widespread knee joint injuries worldwide, with a total of about 250,000 cases per year (Leininger et al, 2019), so, the typical approach to anterior cruciate ligament rehabilitation has shifted from complete immobilization after surgery too early recovery of strength and range of motion and increased muscle activation because most of the patients undergoing anterior cruciate ligament surgery and subsequent restoration often suffer from atrophy of the large thigh muscles her survival is impaired for a long time after the operation, therefore, specialists are faced with the task of finding means and tools Alternative rehabilitation (Norte et al, 2018).

During competitions or training units, players are exposed to cutting the cruciate ligament, as a result of strong friction between the players or as a result of performing some movements imposed by the match situations, in addition to the great muscle effort and weakness of the ligaments in the knee joint, as well as the poor physical preparation of the player before the performance in a disproportionate manner, and so on. The effort, as well as a large number of cases of friction in which the weight of the body largely rests on this joint, leads to them stopping training for quite a while, leading to an extent that may prevent them from playing the game, and this is what prompted researchers and those interested in this field to use various means and modern techniques. To speed up the rehabilitation of the injured anterior cruciate ligament cut, the researchers attempted to prepare specific exercises to restore the functional ability of the muscles and ligaments working on this joint to its best levels and in the shortest possible period. The main research problem in this study is the prevalence of anterior cruciate ligament injuries and surgical operations to restore the ligament between football players, some of them completely moved away from playing and reinjured each other again, and most of the athletes were late in returning to the stadiums because they underwent long stages of treatment. Because some of them are influential players in their teams, whose absence affects the results and causes material, moral, and technical losses to their teams, the researchers sought to solve this problem by developing a set of rehabilitative exercises in a scientific way to rehabilitate this injury by strengthening the muscles surrounding the joint and increasing the range of motion and preserving the muscles from atrophy and reduce the degree of pain, As well as speeding up the rehabilitation process by restoring full functional capabilities to facilitate the return of the injured player to the field as soon as possible.

Hence, the importance of this study is that it resorted, t to preparing special rehabilitative exercises that work on the knee joint, aiming at rehabilitating the injured and returning them to practicing their normal lives and returning to the stadiums at maximum speed while restoring their functional efficiency to avoid complications and health problems that the athlete is exposed to as a result of undergoing surgery. The research aims to identify the effect of rehabilitative exercises in restoring the functional ability of the anterior cruciate ligament (range of motion, muscle strength, degree of pain) after surgery for advanced football players.

MATERIALS AND METHODS

Participants

The participants were composed of 6 volunteers who had undergone anterior cruciate ligament surgery, aged (23-30 years). All six patients attend regular physical therapy sessions for their rehabilitation. However, all of them had quadriceps and/or hamstring weakness and pain at least 2 weeks to 1 month after their last surgical procedure.

The lower extremities of all individuals were measured for comparison purposes. All patients underwent measurements of the affected lower extremity at least twice during the treatment period, pretest and posttest, and had been using rehabilitative exercise therapy as part of their rehabilitation routine for at least 12 weeks.

One participant with a hip fracture (6 males; see Table 1 for participant characteristics) volunteered to participate in the study and gave written informed consent for the experimental procedures. Participants had no known history of other disorders or diseases. In addition, none of the participants had engaged in any resistance training within the past 2 months. This study followed ethical standards and received approval from the Wasit University with reference number (No. 22/162 and dated 02/12/2023). 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.

Table 1. Group characteristics

Variables	Measuring unit	Mean	Std. Deviations	Median	Skewness
Length	Cm	165.0	3.67	166	0.817
Hight	Cm	74.67	1.63	74	0.38
Mass	Kg	60.60	5.412	67	0.886
Age	Year	27.33	1.92	29	0.312
Training age	**Year**	8.60	1.82	7	0.989

Data Collection Tools

Form for each player to record the sequence measurements

Goniometer to measure the range of motion of the knee joint

Measurements of joint range of motion (ROM) are part of a physical therapist's daily work. Activities of daily living and exercises can be complicated to perform when ROM is limited, and depending on the demands of daily living, the knee joint requires different ROM. In sports, a few degrees in ROM may make the difference between getting injured or not. The goals of physical therapists are to help patients to regain full ROM, mobility, strength, and function after sustaining an injury. To measure joints with the manual universal goniometer is considered time-consuming and difficult with respect to repeated measurements.

Initial position

The patient takes a prone position on the abdomen and installs the device on the outer side of the knee joint along the thigh bone. The knee joint is flexed to the maximum extent it can reach. The difference in reading the device is between zero degrees and the angle of maximum flexion of the knee joint (Pereira et al, 2017).

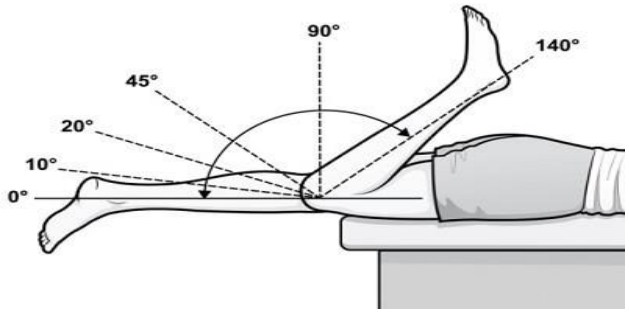

Figure 1. Measurement of knee joint range of motion

Hamstring muscle strength measurement with dynamometer

The Hamstring muscle strength of the individuals participating in the study was assessed using a hand dynamometer (Medical Commander Power Track 2, USA). The measurements were repeated three times for the right and left sides. The highest value was recorded as Newton (N) (Hasan, 2018)

Performance specifications

Person stands erect on base of the device in appropriate place on middle of the base, hands in front of the thighs, and the fingers of the hands are pointing down. The tester grips the tension column tightly so that the palm of one hand is directed forward and the other is directed to the body. When the tester is ready to pull, he bends his knees forward, forming an angle of 90°.

Figure 2**.** Measurement of the hamstring muscles strength

It must be noted that the back is not bent, as well as the straightening of the arms without any bending in the elbows. At the end of the test, the legs must be fully extended.

Quadriceps muscle strength measurement with dynamometer

The quadriceps muscle strength of the individuals participating in the study was assessed

using a hand dynamometer (Medical Commander Power Track 2, USA). The measurements were repeated three times for the right and left sides. The highest value was recorded as Newton (N) (Bandinelli et al, 1999).

Figure 3. Measurement of the Quadra muscles strength

Experimental Design

Participants were familiar with all testing and exercise protocols before starting the study. Rehabilitation exercises were done before and after. Therefore, the total duration of the experimental study was 12 weeks. During the rehabilitation exercises withdrawal period, the participants were asked to maintain their normal diet and physical activity levels.

Pre- measurements Measurements and pre-tests were performed on a group of members of the experimental research sample consisting of (6) injured, at the Specialized Center for Physiotherapy and Physical Rehabilitation in Al-Kut Sports Club on Sunday corresponding to 22/1/2023.

Rehabilitation exercises

The proposed rehabilitation exercises were prepared in three stages, where each stage lasted four weeks, and the total time required to implement the program in practice was three months. The rehabilitation stages contain different exercises to suit the stage that the injured player goes through. The training took place at the rate of (5) rehabilitation units per week, and the number of rehabilitation units for the injured over the course of twelve weeks was (60) rehabilitation units, and the time of the rehabilitation unit in the first stage was (45) minutes about the injury. This stage aims to activate muscle tissue, gradually move the joints near the site of the injury, and stimulate blood and lymphatic circulation at the site of the injury. The researchers used forced exercises and assisted exercises, and the number of exercises in one qualifying unit at this stage ranged between (8-10) exercises. One of the most important goals of the first stage was to stimulate blood circulation in the area of injury and prevent muscle atrophy and joint stiffness in the area of injury.

In the second stage, the time of the rehabilitation unit was (60) minutes, and the exercises of this stage begin when the healing is activated and the functions are gradually restored in the injured parts, where the patient has adapted to the physical effort and allowed him to move the injured part. It included static exercises for the muscles in the injured and healthy areas, and moving exercises for the injured muscles, starting with free exercises without resistance, followed by exercises against resistance, starting with the weight of the limb to resist the muscular work. Then we got to practice exercises in which the static and moving muscular work overlapped. (Hassan, 2019)

In the third stage, the time of the rehabilitation unit increased to (75) minutes, in which the researchers used simple strength and resistance exercises, in which the researchers took into account the use of gradation in their weights from easy to difficult, as well as kinetic exercises, taking into account the gradient load in the exercise. Resistance exercises aim to maintain the efficiency of the neuromuscular work of the muscles operating on the thigh by strengthening them as a result of the surgery period. Resistance exercises vary by either body weight resistance, gravity, rubber bands, or moderate external weight. These exercises must be performed slowly at the beginning. In addition, with full muscle control until the movement reaches its last range.

Post-measurements

Post-measurements and tests were carried out on a group of experimental research sample members on 25/4/2023 in the same order as the tribal measurements, under the same conditions, and for each patient separately.

Statistical Analysis

SPSS package program was used in the statistical analysis of our research. It was determined by the normality distribution and skewness coefficients of the data. Significance level was determined as P 0.05 and all data were presented as mean standard deviation (SD) unless stated otherwise. Independent samples t-test was

used to compare the scores obtained from the measurements according to categorical variables.

RESULTS

For patients participating in rehabilitation exercises at 12 weeks, no injury was recorded at any stage of the exercises, and no adverse events (both acute and chronic) were reported for anyone doing the exercise.

Table (2) Mean scores and standard deviations of the experimental group on the Pre-Test and Post-Test.

Variables		Measuring unit	Pre-test		Post-test	
			M	SD	M	**SD**
Muscular strength	Injured	Kg	18.50	1.048	33.33	**4.546**
	Uninjured	Kg	32.60	2.07	35.80	**0.83**
Range of motion (injured)	Extension	Degrees	163.50	3.27	177.33	**1.63**
	Flexion	Degrees	68.83	2.786	21	**4.656**
Degree of pain for the injured leg		**Degrees**	**7.125**	**0.478**	**1.12**	**0.629**

As Table (2) illustrates,

Strengthening of the damaged leg: The pre-test arithmetic mean was 18.50 with a standard deviation of 1.048, and the post-test arithmetic mean was 33.33 with a standard deviation of 4.546. The arithmetic mean for the muscular strength of a healthy leg was (32.60) with a standard deviation of (2.07) in the pre-test and (35.80) with a standard deviation of (0.83) in the post-test, respectively.

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The injured leg's range of motion was measured in pre- and post-tests. The arithmetic mean for the former was 68.83 with a standard deviation of 2.786, while the latter was 21% with a standard deviation of 4.656. Regarding the injured leg's range of motion (flexion), the pre-test arithmetic mean was 163.50 with a standard deviation of 3.27, and the post-test arithmetic mean was 177.33 with a standard deviation of 1.63. Arithmetic mean for the harmed leg: 7.125 with a standard deviation of 0.478 in the pre-test and 1.12 with a standard deviation of 0.629 in the post-test, respectively, representing the degree of discomfort.

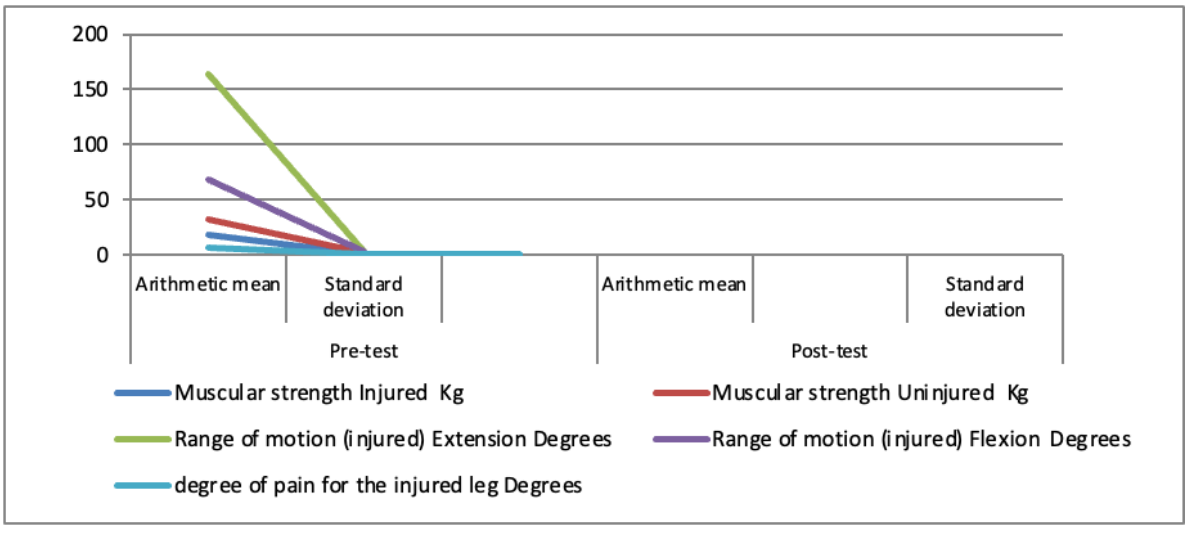

Figure 2. Statistical characterization of the variables examined before and after the Rehabilitation exercises with BFR program of the participant patients.

Table 3. Significant differences between the pre- and post-test in the variables under study for the study sample

Variables		Measuring unit	Difference between arithmetic mean	Difference between standard deviations	T value calculated	Level Sig	Type Sig
Muscular strength	Injured	Kg	14.833	5.036	6.241	0.002	**Sig**
	Uninjured	Kg	3.20	2.38	2.997	0.04	**Sig**
Range of motion (injured)	Extension	Degrees	47.83	5.98	19.591	0.000	**Sig**
	Flexion	Degrees	13.83	2.63	6.83	.0010	**Sig**
Degree of pain for the injured leg		**Degrees**	**6**	**1.08**	**7.407**	**0.005**	**Sig**

* Significant if the error level is ≤ or = (0.05) at the significance level (0.05).

It can be seen from Table (3)

The pre- and post-test findings showed a substantial difference in the injured leg's muscle strength, according to the study. With a standard deviation of 5.036, the arithmetic mean difference between the pre- and post-test values was 12.833. The post-test result outperformed the pre-test by a degree of freedom of (5), according to the computed (T) value of 6.241 and the confidence level of 0.002.

The results of a muscle strength test conducted on an uninjured leg showed an arithmetic mean difference of 3.20 and a standard deviation of 2.38. Significant differences were seen between the pre- and post-tests at the significance level of 0.05, with the post-test being favoured in front of the degree of freedom (5). With a confidence level of (0.04), the computed (T) value was (2.997).

Range of motion (extension) of the injured leg: A significant difference was observed between the pre- and post-test findings at the significance level (0.05) in front of the degree of freedom (5), favouring the post-test. With a confidence level of (0.000), the computed (T) value was (19.591). Between the pre- and post-test findings, there was an arithmetic mean difference of (47.83), with a standard deviation of the differences of (5.98). Regarding the injured leg's range of motion (flexion), the computed (T) value was 6.83, the confidence level was 0.001, and the arithmetic mean difference between the pre- and post-test values was 13.83, with a 2.63 standard deviation of the differences. This suggests that, at the level of significance (0.05) in front of the degree of freedom (5), there were noteworthy changes between the pre and posttest findings in favour of the posttest. Discomfort level in the injured leg: The difference in the arithmetic mean between the pre- and post-test findings was (6), with a standard deviation of the differences of 1.08. The computed (T) value was (7.407), the confidence level was (0.005). In front of the degree of freedom (5), these results demonstrate substantial differences between the pre- and post-tests at the significance level (0.05), favouring the post-test.

DISCUSSION

The outcomes of the muscular strength test's pre- and post-tests

Tables (2) and (3) make it evident that there are statistically significant differences in favour of the post-test between the pre and post-tests for the variable of muscle strength of the injured and healthy legs**.** The researcher attributes the appearance of these results to the rehabilitative exercises prepared by the researcher, as they included strength, lengthening and balance exercises. With rationing and organizing the exercises according to accurate scientific foundations and methods in determining the rehabilitative loads for the importance of this stage in the process of rehabilitating the injured joint after the restoration of the anterior cruciate ligament, where these exercises were developed on scientific bases that suit the ranges of motion, strength and the nature of the muscles working on the joint, this is consistent with what was stated by (Tarfa, 2004) “One of the most important foundations in preparing rehabilitative curricula is determining the ideal load for rehabilitative exercises, where the ideal load is defined as the specific amount of impact on the various organs and systems of the individual when practicing physical activity, as well as the effort or physical burden And the nervous system that affects the organs and systems of the body and the reaction to the physical performance performed.” Through this, the rehabilitative exercises worked on the development of muscle strength since the first

weeks after the operation, as the exercises contributed to avoiding a large part of the muscular atrophy of the muscles. This was confirmed by (Shephard, & Astrand, 1994). That people who stay in bed due to injury can avoid muscular atrophy by contracting their muscles for a period of seconds so that they are proportional to one-third of the maximum strength of the muscle, and it is not required here that the contraction be maximal, and this means that most injured athletes can exercise enough training to prevent muscular atrophy (Hasan, 2024).

The outcomes of the motor range test's pre- and post-tests (flexion, extension)

Tables (2) and (3) make it evident that the posttest significantly outperformed the pretest in terms of the motor range variable (extension, flexion) of the injured leg**.** The researchers attribute, through reviewing the results, that the improvement in the motor ranges in the stretching and flexion tests is due to the positive effect of the rehabilitative exercises, which included different types of methods for developing the range of motion, such as fixed and mobile flexibility exercises, and performing these exercises slowly and with a wide range of motion helped to obtain these results. The researchers refer This improvement of the motor range variable in flexing and extending the joint, which may approach 100% in the post measurement, indicates the efficacy of the rehabilitation exercises in its three stages, as the first and second stages included various stretching exercises that increase the degree of flexibility in the joints, and the third stage contained exercises of higher intensity and time Longer and more exercises than the first and second phases, which had a positive impact on increasing and developing the range of motion of the joint and in extending and flexing in a way that is almost like a healthy joint. And (Atheer Al-Jumaili, 2010) believes that the movement of the knee is determined by the pain and swelling that occurs in it, which leads to a loss of its efficiency, and this develops if the injured person does not receive appropriate treatment and rehabilitation for the injury, which in turn works to restore the mechanical movement in the knee.

This agrees with what was indicated by (Talha et al, 1997; Al-Khatib and Al-Nimr, 1997), and (Hasan, 2022), that flexibility exercises work to develop the muscle elongation component and increase the elastic property of the muscles and ligaments together, which leads to an increase in the range of motion of the joint. The researchers believe that the development occurred as a result of the effectiveness of the vocabulary of rehabilitative exercises, which was prepared according to the correct scientific foundations and based on the efficiency of the exercises used in strengthening the muscle groups surrounding the injured knee joint.

The outcomes of the degree of pain test's pre- and post-tests

Tables (2) and (3) show that there are significant differences between the pre-test and the post-test in the variable (degree of pain) of the injured leg, in favor of the post-test. The researchers attribute these differences in the research sample to the rehabilitative exercises prepared by the researchers, and this was confirmed by (Fox. B. 1997) that flexibility exercises complement the rehabilitative program as the player feels comfortable and relieves many of the pains he suffers from, and this comes through Increasing the speed and quantity of blood pumped into the circulatory system, which worked to get rid of the products of injury gradually, as well as the possibility of movement with the disappearance of pain and an increase in the strength of muscles and ligaments, and this is confirmed by Baker, (Baker, A.G., Webright, W.G., & Perrin, D.H. 1998). In rubber band exercises, it is characterized by the exchange of contraction and relaxation, and this results in an increase in blood flow flowing to the muscles, which leads to an increase in the disposal of work products during training and the outcome of sports injuries.

Conclusion

The available data strongly support the use of Rehabilitation exercises that have a positive effect on improving the muscle strength of the muscles working on the knee joint after surgery. Rehabilitation exercises that have a positive effect on increasing the range of motion of the knee joint after surgery. Rehabilitation exercises contributed to reducing the degree of pain eliminating it, and improving the muscular lengthening of the muscles and ligaments surrounding the knee joint.

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Disclosure Statement

The author have no conflicts of interest that are directly relevant to the content of this manuscript.

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Conflict of interest

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

Ethics Committee

This study followed ethical standards and received approval from the Wasit University with reference number (No. 22/162 and dated 02/12/2023).

Author Contributions

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

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RESEARCH ARTICLE

Physical Activities and sedentary time of Students Outdoor Education and Conventional Education in Primary Schools

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Abstract
This research set out to evaluate physical activity and sedentary time between outdoor education and conventional education settings. The research methodology employed a mixed method technique**.** The research methodology employed a mixed method technique. The research sample consisted of twenty-one students in fourth and fifth grades at an elementary school in Sudamanik 01, Cimarga District, Lebak Regency, Banten Province, Indonesia. The demographics of the participants in grades four and five were similar in terms of height (144.31 ± 2.01) centimeters and body weight (37.02 ± 1.26) kilograms. The level of physical activity and sedentary time were assessed through the utilization of an accelerometer. For twenty-one students, physical activity and sedentary time were compared in participating school during six days of outdoor education and five days of conventional education. The group in outdoor education exhibited a higher level of physical activity compared to conventional education, as evidenced by the results of statistical tests with a p - value < 0.001; conversely, outdoor education results in less sedentary time than traditional education ($p < 0.001$). The primary conclussions of research revealed that switching from conventional education to outdoor education environment reduced the sedentary time and increased light to moderate the level of physical activity during school hours. There are differences in leisure time physical activity on days at school with or without outdoor education. Henceforth, it can be concluded that outdoor education successfully prompted students to engage in physical activity.

Keywords
Physical Activities, Sedentary Time, Outdoor Education, Conventional Education

INTRODUCTION

Patton et al (2018) explaine that in recent years, lifestyle has shifted in various age groups, including children, especially in late childhood. Therefore, the World Health Organization and national public health guidelines in a number of countries recommend that children and adolescents aged 5 to 15 years engage in at least 60 minutes of moderate-to-vigorous physical activity (MVPA) per day or on average across days of the week (Parrish et al., 2020; WHO, 2020). It is also recommended to engage in vigorous PA at least three days per week to strengthen muscles and bones. PA in sports improves quality of life because of its psychological and social advantages. The positive correlation between student's performance in PA, improved behavior, and its relationship to academic achievements (**Pardos-mainer et al., 2021**).

The percentage in question tends to exhibit a decline as children progress through the developmental stage of adolescence (Merlo et al., 2020). During this period, the engagement in

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moderate-to-vigorous physical activity (MVPA), reducing by thirty-eight minutes/year from ages nine to fifteen, experiences a gradual reduction, it is important to study the positive impact of PA and sedentary behavior on cognitive function **(Cox et al., 2015**).

Based on the findings of a study conducted by (**Tammelin et al., 2015**), the average duration of leisure daily among elementary school students was six hours and twenty-four minutes. Student's daily of ST occurred during the school day, averaging thirty-nine minutes per hour. Excessive ST in students is poorly understood, but growing evidence from adult studies suggests that long ST is associated with negative outcomes such as waist circumference and fasting blood glucose **(Healy et al., 2011**). According to a researcher, it is advisable to give careful consideration to ST that extends beyond ten minutes, as research indicates that prolonged periods of inactivity are linked to heightened cardiovascular risk among adults **(Kim et al., 2015**).

In their study conducted by **(Fiskum & Jacobsen, 2012**), a group of twelve fifth-grade students were carefully observed over a period of four days in a CE setting, followed by three days of engaging OE instruction. The researchers conducted a systematic observation of students' PA across four distinct time periods throughout the day. The researchers classified a scale with three points: sedentary or standing, walking, or more active than brisk walking. Furthermore, boys exhibited more significant differences between the indoor and outdoor settings in terms of their levels of PA. This research measured a participant's level of PA through direct observations and an acceleration index of total PA. However, other studies have measured a participant's heart rate and found that exercise results in higher levels of PA (Dettweiler et al., 2015). Nonetheless, a number of researchers have advocated for a more sophisticated analysis of PA measurements during school-based Education Outdoor (Barnett et al., 2016; Dettweiler et al., 2023).

There has not been a significant amount of research conducted in elementary schools that investigates the relationship between physical activity and sedentary time. Based on the systematic literature, it was discovered that researchers from Indonesia have not studied a great deal about the relationship between physical activity and sedentary time in elementary schools. This is a researcher gap in this research.

The research examines at the impact of OE on the PA and ST of elementary school students. It compares the disparities in students' levels of PA and ST between OE and CE settings in the context of physical education. This research hypothesizes that students engage in Physics Activity with lighter, moderate, and vigorous intensity and ST during OE.

MATERIALS AND METHODS

Participant

This study followed ethical standards and received approval from the Institutional Review Board of Universitas Negeri Jakarta, Indonesia with reference number (Protocol code NO: 806/UN39.14/PT.01.05/XI/2023 and date of approval November 7, 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. 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.

Following receipt of an authorization letter from the Institutional Review Board (IRB) at Universitas Negeri Jakarta, the letter was forwarded to the school administration for voluntary completion by parents and students. Still, the completion rate was only 21 (parents and students). The demographics of the participants in grades four and five were similar in terms of height (144.31 ± 2.01) centimeters and body weight (37.02 ± 1.26) kilograms.

The sample in this study were students in grades 4 and 5 who attended Sudamanik 01 Elementary School, Cimarga District, Lebak Regency, Banten Province, Indonesia. Pragmatism has been widely acknowledged as one of the earliest philosophical frameworks to advocate for the integration of mixed methods research (Morgan, 2007). Participants were selected from

both fourth and fifth grades, as they were enrolled in concurrent physical education classes with the same teacher. In classes 4 and 5, there are a total of 53 students. Among them, 22 (41.5%) are male students and 31 (58.5%) are female students. Physical activity activities included students exploring the nearby forest, visiting the river bank, exploring the rice fields, and hiking up the hills. The mixed method research has been adopted to integrate qualitative and quantitative data, resulting in a more comprehensive understanding of student PA and the impact of OE.

Data collection tools

The levels of PA and ST among students were assessed using accelerometers, while the content and behavior of participants during the school day were evaluated through nonparticipant observations. For twenty-one students, physical activity and sedentary time were compared in participating school during six days of outdoor education and five days of conventional education. The students used accelerometers in the classroom during a 90-minute class period.

Statistical Analysis

Statistics analysis techniques used software statistics; specifically, the means and standard deviations for activity and step minutes during the school day, leisure time, and whole day. The ANOVA, analysis of variance, was applied to evaluate the differences between CE days and OE days. The most and least active students were measured by the number of steps, then an independent samples t-test was carried out. The analysis of participant was conducted as a one group due to the small sample size, but age and gender differences were examined.

RESULTS

The research examined the mean and standard deviation of PA and ST (minutes per hour) in the context of OE and convention education at school and during leisure time. During OE days, students engaged in ST and ST > 10 behavior and more light1, light2, moderate-intensity, and MVPA behavior than Conventional Education. Furthermore, the students demonstrated a greater inclination towards engaging in OE. Conversely, no differences in physic activity were reported between OE and conventional Education. The data indicated a significant increasing in the amount of time allocated to PA and sedentary behavior variables, specifically from 16% to 59%, when comparing CE to OE. The students in part two demonstrated a statistically significant difference ($p < 0.001$) in the number of steps taken during Conventional Education. The second group was more active in OE, but the less active group improved significantly more. There appear to be notable distinctions in the levels of PA and ST during leisure time between CE and OE. The students in part two exhibited a notable distinction ($p < 0.001$) in the quantity of steps taken during CE practices (Table 1 and Figure 1).

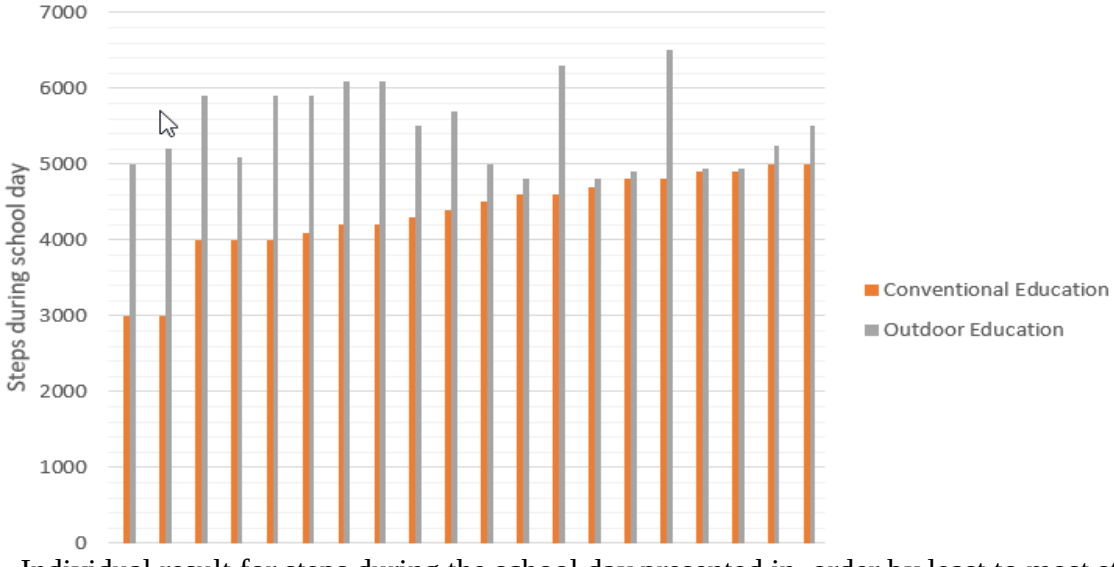

Figure 1. Individual result for steps during the school day presented in order by least to most steps taken during conventional days

Table 1. Data At school, leisure time, and Physical Activity (PA) throughout the day and (Sedentary Time) ST (Mean ± Standard Deviation) among elementary school students (n = 21) Conventional education and Outdoor education.

Physical Activity	Conventional education	Outdoor-education	Difference (percent)	P value
School day				
ST >10 minutes, minutes/hour	6.87 ± 5.18	3.44 ± 2.79	−56%	<0.001
ST, minutes/hours	34.26 ± 3.22	27.62 ± 4.27	−19%	<0.001
Light 1[x] physical activity, minutes/hour	16.08 ± 2.17	18.29 ± 3.03	16%	<0.001
Light 2[x] physical activity, minutes/hour	5.45 ± 1.65	8.06 ± 2.23	45%	<0.001
Moderate physical activity, minutes/hour	4.58 ± 0.67	6.73 ± 1.73	59%	<0.001
Vigorous physical activity, minutes/hour	4.24 ± 1.12	4.04 ± 1.73	−8%	0.268
MVPA[x], minutes/hour	7.87 ± 1.51	9.77 ± 1.34	37%	<0.001
Steps	4325 ± 657	5795 ± 546	25%	<0.001
Leisure time				
ST >10 minutes, minutes/hour	8,17 ± 4,56	9,05 ± 4.7	13%	0.168
ST, minutes/hours	43.89 ± 5.78	43.89 ± 4.89	1%	0.968
Light 1[x] physical activity, minutes/hour	16.87 ± 2.48	16.78 ± 2.27	−2%	0.666
Light 2[x] physical activity, minutes/hour	5.55 ± 1.78	5.68 ± 1.28	2%	0.588
Moderate physical activity, minutes/hour	4.00 ± 1.28	4.22 ± 1.21	3%	0.558
Vigorous physical activity, minutes/hour	2.39 ± 1.76	2.34 ± 1.73	−9%	0.282
MVPA[x], minutes/hour	5.39 ± 2.06	5.37 ± 2.6	1%	0.982
Steps	6567 ± 2345	6579 ± 1744	4%	0.550
Whole day				
ST >10 minutes, minutes/hour	7.69 ± 4.76	7.29 ± 4.45	−7%	0.459
ST, minutes/hours	43.1 ± 5.39	42.53 ± 4.85	−7%	<0.01
Light 1[x] physical activity, minutes/hour	21.49 ± 3.07	20.24 ± 3.07	3%	<0.06
Light 2[x] physical activity, minutes/hour	5.55 ± 2.35	6.50 ± 2.13	17%	<0.001
Moderate physical activity, minutes/hour	4.27 ± 1.96	4.98 ± 1.93	22%	<0.001
Vigorous physical activity, minutes/hour	3.11 ± 1.83	2.88 ± 1.66	−12%	0.078
MVPA[x], minutes/hour	6.37 ± 2.61	6.87 ± 2.47	8%	<0.06
Steps	11008 ± 2321	12232 ± 1911	11%	<0.01

Observation Process

Students primarily complete subject assignments at tables indoors. At the time of observation, Outdoor education teachers are responsible for facilitating, coordinating, and leading educational experiences that take place in natural environments such as lakes, rivers, rice fields, and hills. Outdoor education teachers intend to provide students with opportunities for experiential learning in natural settings, with the goal of assisting students in developing essential life skills and gaining a better understanding of the natural world. Outside education only requires students to sit for brief periods of time. Students participate in light activities during Outdoor Education by walking to the river bank, which is only a short distance from the school. The students' light activities are local traditional games that include elements of cooperation.

In outdoor education, students can go to the park behind the school during their breaks. This elementary school has a volleyball court where all students in first through sixth grades can play. During breaks, students play traditional games such as “bebentengan and gobags,” in which all students participate. When researchers observed students playing that game, bebentengan and gobags, because this game can be played by all levels of students. Students' levels of activity vary depending on the game and their individual roles, ranging from the lowest to the highest. The duration of the break time for students in first through sixth grade is consistent, occurring from 12:00 to 13:00 in the afternoon.

Physical education learning allows students to carry out high-intensity physical activities because starting at 07.30-11.20, including rest time. Students participate in physical education lessons, and the teacher has determined the lesson material. During OE, students carry out high activities according to the type of game. During outdoor and conventional education, numerous

students engage do light to high activity. Students need to look more enthusiastic when carrying out physical activities with increased intensity. Students are more enthusiastic about Outdoor Education because of the learning procedures and materials, after which students have break time. Because students are studying in an OE, participating students in OE are motivated to engage in PA. Majority students prefer outdoor education, because they have a higher PA and are more dynamic in their movement intensity.

DISCUSSION

The primary discovery indicated that the amount of Physical Activity (Minutes/Hour) was significantly greater in Outdoor Education compared to Conventional Education. There are many advantages to outdoor education for students, including enhanced learning and a deeper connection to the natural world (Kiviranta et al., 2023). In the course of this research, students participated in a variety of outdoor education activities. These activities included went to the hills, the river bank, the rice fields, and the forest that was located close to the school. The OE pedagogical framework influences students to participate in more PA; in addition, students derive happiness from time spent in outdoor and appreciate their teachers' efforts (Maynard et al., 2013; Waite et al., 2016) during the learning process.

However, the outcomes of learning outside the classroom have fallen short of expectations because students require more time to engage in strenuous physical activities while participating in OE. The results of previous researchers (Romar et al., 2016; Singerland et al., 2011), 10% high-intensity PA and an average of 41% MVPA, this is very clear differences between individual students. Aside from this, research (Mygind, 2007) comparing OE and CE in terms of PA did not reveal any significant differences. According to the findings of other traditional education studies, students took 45 to 90-minute outdoor breaks (Haapala et al., 2016). Participating in PA at school can be beneficial for students, as long as they also prioritize adequate rest and recovery (Blaes et al., 2013). However, students do not take advantage of the outdoors education, because some students are less physically active when using conventional education.

The primary finding is that OE is 20% and sed10 is 57%, resulting in a reduction of sedentary time. The effect on ST is indeed noteworthy, as the results demonstrate a significant decrease during the school hours. Furthermore, it is provided during break times in order to ensure students only sit for a short period of time while sitting on a stable ball (Braniff, 2011; Orlowski et al., 2013). Research has revealed that engaging in PA, even at lower intensities, can have a positive impact on overall health and well-being. This finding suggests that individuals should prioritize engaging in PA rather than remaining sedentary, as it can contribute to the promotion and maintenance of good health (Owen et al., 2010).

However, in outdoor and conventional education, students only move 45% while at school, and student behavior is sedentary. Previous findings are the same as our findings using CE (Haapala et al., 2016). Previous findings are the same as our findings using CE (Haapala et al., 2016). Similarly to the findings of our researcher, other researchers concur that OE will reduce ST. The sedentary lifestyle is of particular concern (Hegarty et al., 2016). CE emphasizes sedentary more than light PA (Haapala et al., 2016). CE should be revised. When using OE to teach, teachers must master the stages so that students are eager to participate in learning. Teachers must be capable at each stage of the process when utilizing OE to obtain students excited about learning.

Researchers have not optimally studied leisure time in elementary schools in Indonesia whether use outdoor or conventional education. However, numerous researches have been conducted in other countries because researchers are already aware of the low level of leisure time activity as a result of high activity at school (Møller et al., 2014). After a school day of OE, students may choose to particpate in indoor activities or perform other tasks (Yang & Kankaanpa, 2017). The findings of leisure time activities reveal that OE has a positive impact. The participants in this research were accustomed to spending their leisure time outside of their homes.

The present research represents the pioneering research in Indonesia that combines the PA and ST of elementary school students through the lens of OE and conventional education. The methodology employed for data collection involves the presence of researchers within the educational institution throughout the entirety of

the school day. However, it requires attention due to limitations, such as only one school and a small sample size.

Conclusions

This research provides evidence that participating in OE is associated with a reduction in ST through increased PA. In addition to this research, outdoor and CE provide reason for gaps in leisure time activities. In order to enhance the efficacy of learning through PA, it is imperative to employ OE as opposed to conventional education.

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Ethics Statement

The research was conducted in accordance with the declaration and approved by the Institutional Review Board of Universitas Negeri Jakarta, Indonesia (Protocol code NO: 806/UN39.14/PT.01.05/XI/2023 and date of approval November 7, 2023).

Conflict of interest

The authors declare no conflict of interest.

Author Contributions

Author Contributions: Study Design, HR and DW; Data Collection, DW and MR; Statistical Analysis, MR, DW, AH; Data Interpretation, HR, DW, MR and AH; Manuscript Preparation, HR, DW and MR; Literature Search, HR, DW and MR. All authors have read and agreed to the published version of the manuscript.

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RESEARCH ARTICLE

Fun Game Based Learning Model to Enhance Fundamental Movement Skills (FMS) Children with Mild Intellectual Disability

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Abstract
Children with mild intellectual disabilities struggle with learning, particularly in movement skills. Limited support facilities not tailored to their needs. FMS learning model centered on "Getting to Know Flowering Plants", enhancing movement skills and incorporating cognitive tasks. The research methodology employed in this study follows Borg and Gall's Research and Development approach. Procedure basically consists of two main objectives, namely: (1) developing products and; (2) testing the effectiveness of the product to achieve the goal. Small group trial subjects included 13 students (7 boys, 6 girls 9-10 years old) and 4 teachers, while large group trial subjects involved 26 students (12 boys, 14 girls 9-10 years old) and 4 teachers in the 3 SLB in Palembang city. The CVR analysis results for model indicate a value of 0.6, falling within the range of 1 to -1. This signifies that the content of the FMS getting to know flowering plants is deemed appropriate, relevant, and of high content validity. Upon calculating the correlation coefficient between rater test data for getting to know flowering plants instrument across movement skills, cognitive aspects, fun elements, and attention focus aspects, it is observed that there is a strong positive relationship between the scores assigned by rater 1 and the overall rater scores. Similarly, there is a substantial positive correlation between the scores given by rater 2 and the total rater score. Additionally, the relationship between rater score 3 and the total scores among raters also exhibits a significant positive relationship ($p > 0.05$).

Keywords
Fundemental Movement, Play, Intellectual, Dissablity

INTRODUCTION

Mentally retarded children are still considered as children who are a burden on the family and society, because their limited intelligence abilities are below average, they cannot live like normal children and this will obviously hinder all their daily life activities in socializing, communicating and most importantly is his inability to receive academic lessons like children his age (Kemis dan Rosnawati, 2013). The child in his life needs the help of others in order to be able to develop his or her potential to the maximum and they cannot struggle independently to defend their rights and fulfil their responsibilities and have some limitations (Nurrahima & Ariyanti, 2021), herefore the closest people such as parents, teachers and families have a very important role in finding the right steps to optimize the development and discover the potential that exists in the child (Maulidiyah, 2020), So more independent and not a burden for the family in their daily lives, in principle behind the weaknesses or shortcomings that they have

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(Lee & Burke, 2020), the child tunagrahita still has a number of abilities or modalities that can be developed to help him live a life like other individuals in general (Prasetyaningrum & Faradila, 2019).

Good mental health is defined as the capacity to overcome barriers and challenges without undue suffering, as well as the absence of mental illness and the ability to participate completely and effectively in one's own communities and activities (Saxena & Setoya, 2014). On the other hand, abnormal moods, emotions, ideas, and cognitions caused by mental illness interfere with normal functioning in the areas of familial, interpersonal, professional, and larger community social connections. This results in aberrant behaviors and functional impairments (Eisfeld, 2014). Deficits in cognition hinder communication and have a detrimental effect on social functioning, friendship formation and maintenance, self-esteem, and loneliness and other emotional issues. Children and adults with intellectual disabilities are overrepresented in mental health comorbidities (Buckley et al., 2020).

Approximately 2% of kids have an intellectual disability (Glasson et al., 2020). Prenatal environmental variables, such as the fact that some individuals have encountered risk factors like premature delivery or inadequate intrauterine growth (Leonard et al., 2008), drug addiction and usage, and viral, metabolic, and genetic illnesses, can also result in intellectual deficiencies. With radioactive X (Fryers, 2019). Intellectual disability has a separate hereditary origin for a minority of people (Vissers et al., 2016; Song et al., 2022). It is not unexpected that intellectual disability can result from a genetic mutation that impairs protein function in the central nervous system (Vissers et al., 2016).

The implementation and fulfillment of the rights of persons with disabilities is based on: respect for dignity, individual autonomy, non-discrimination, full participation, humanity, equality of opportunity, equality, accessibility, growing capacity, inclusiveness and special treatment.and more protection (Hasti et al., 2021). Teachers need to be ready to embrace the diversity of abilities and potential that people with intellectual disabilities possess. People with intellectual disabilities face significant challenges while trying to integrate into society. Both cognitive and functional limits in areas like daily life, social skills, and communication are what define them (Gierczyk & Hornby, 2021). Significant limits in intellectual functioning as well as adaptive behavior, as demonstrated by conceptual, social, and practical adaptive skills, are characteristics of intellectual disability. The disability began before to turning eighteen (Schalock et al., 2021;Tamm et al., 2022).

There have been various documented obstacles to involvement for kids with intellectual disabilities, which probably accounts for the decreased levels of physical activity (Yazdani et al., 2013), communicative abilities (Dhondt et al., 2020). The absence of programs that are easily accessible, disinterest, behavioral issues, motor difficulties, lack of time, lack of a physical activity space, and transportation issues have been noted as obstacles to involvement for kids with intellectual disabilities (Stanish et al., 2019).

When it comes to their physical and motor traits, children with intellectual disabilities differ from those without intellectual disabilities the least. Compared with normally developing children, children with intellectual disabilities have some motor problems (Hekim et al., 2016). Preparation for enhancing motoric and psychological skills through exercise is a fundamental process (Fikri et al., 2022). Children with intellectual disabilities had deficiencies and developmental delays in FMS (also known as gross motor skills, fundamental motor skills, or competencies) (Maïano et al., 2019).

In general, the delay in reaching significant developmental milestones increases with the severity of intellectual disability (Unver & Erdem, 2019). The most prevalent symptoms seen in these children are intellectual disability, with many of them being nonverbal and having delayed motor milestones (walking usually occurring between the ages of two and seven) (Jacher et al., 2019). Special attention is required for students with disabilities, particularly those who are mentally impaired (Buchner et al., 2021). When challenging skills are modified as necessary, students with ID can often participate successfully in physical education and sport alongside peers particularly true for children with ID who have associated health or physical impairments who need extensive or pervasive supports (Cavanaugh, 2017).

The definition of intellectual disability is focused on context and function. This perspective has limits when it comes to comprehending the

dynamic nature of intellectual functioning and how it varies with age throughout the developmental process, although being helpful in identifying individual strengths and limitations in current performance. An approach to intelligence that is so developmental fosters efficient teaching and programming (Tassé & Grover, 2021). Piaget's vast work, which argued that children go through four periods of cognitive development-sensorimotor, preoperational thought, concrete operations, and formal operations-must be consulted in order to determine developmental orientation (Wattad & Chen, 2023;Babakr et al., 2019).

Based on the results of observations (2017) conducted by researchers in the three special schools education serving children with ID at the elementary school level, it was obtained data that the FMS, the data obtained are as follows;

Children with ID experience disturbances and obstacles in carrying out movements, experience difficulties in adapting and social interaction, especially those related to moving movement.

FMS and physical fitness level of children with mild and moderate ID at primary school special eduacation Palembang City are still low.

Physical education learning materials provided by teachers are still less varied because the teacher's ability to develop models is still inadequate.

Implementation of physical education has not become an optimal means of addressing problems or movement barriers for children with ID in primary school special eduaction Palembang City.

There is no collaboration between physical education teachers, class teachers, and teachers of other subjects to collaborate in making learning material as outlined in the physical activities of children with ID.

Based on the results of the preliminary study, the researcher and team developed a Physical Education learning model specifically designed for children with mild ID individuals who have an IQ of 55-69 (Sajewicz-Radtke et al., 2022), capable of learning (can still be given verbal and non-verbal instruction even though it has to be 3-4 repetitions of instruction (Sari & Natalia, 2018), physically the same as a normal child, but still requires exercise for coordination of movements (Martinus & Kesumawati, 2020), especially those related to FMS, because FMS are an asset for everyone without exception children with ID as a provision for carrying out daily activities without significant obstacles (Kesumawati et al., 2021).

Previous research on games with grahita tuna kid like multimedia of educational game (Hardiyanti & Azizah, 2019), with videogame (Contreras et al., 2019) elearning model is named activities in the morning (Kesumawati et al., 2021), train concentration through fishing games (Sari & Natalia, 2018), using game learning analytics (Cano et al., 2018). In this study, the model development focuses on enhancing Fundamental Movement Skills (FMS) for children with mild ID. This is achieved through the modification of equipment, game rules, and movement activities, tailored to the specific characteristics and needs of these children. The approach involves incorporating play activities to create a specialized learning model for the development of FMS.

Children with ID exhibit cognitive behavior differences compared to their typically developing peers of the same age. The severity of the disability is inversely proportional to the cognitive level, meaning that a higher level of disability correlates with a lower cognitive level. Additionally, these children often face challenges such as a limited capacity to generalize information, a brief attention span, and difficulties understanding abstract concepts. Furthermore, students' performance or ability levels are closely linked to their challenges in controlling attention.

Building upon the background of the problem and the initial investigations conducted by the researchers, a fundamental movement learning model was formulated for children with mild ID. This model, centered around play activities, was aligned with the theme of the 2013 curriculum, specifically focusing on the theme of " Getting to Know Flowering Plants." The model comprises three distinct game stations, each featuring unique movement tasks, media, and equipment.

MATERIALS AND METHODS

Participant

Research and development procedures by Borg and Gall basically consist of two main purposes: (1) developing a product, or commonly referred to as a validation function, and (2) testing the effectiveness of a product to its objectives, or

as commonly known as an efficacy test function. Research and development procedures do not have to be followed, but each developer chooses or modifies measures that are tailored to the constraints and conditions faced by researchers in carrying out their research. This research and development consists of five major procedural steps (Randhawa, 1973):

(1) developing products and; (2) testing the effectiveness of the product to achieve the goal. Small group trial subjects included 13 students (7 boys, 6 girls 9-10 years old) and 4 teachers, while large group trial subjects involved 26 students (12 boys, 14 girls 9-10 years old) and 4 teachers in the 3 SLB in Palembang city.

The research and development phase employed a pre-experimental approach with a single one-shot case study design to assess the product trial. The participants included Physical Education (PE) teachers and first-grade students with mild intellectual disabilities at SLB Palembang. This study followed ethical standards and received approval from the National Paralympic Committe Indonesia Sumatera Selatan, Indonesia with reference number (No:180/NPC-SS/II/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 Data Collection Technique

Fun Game Based Learning Model

The motor skills learning model, designed around play activities, aligns with the 2013 curriculum theme. The theme of this game is "Getting to Know Flowering Plants." The model consists of three game stations, each with different movement tasks and using different media and tools. In Station 1, participants engage in rolling movements on a carpet. Upon reaching the finish line, they open and close zippers, buttons, and fasteners on prepared clothing items. In Station 2, participants run as fast as they can to move a ball along a carpet path. In Station 3, participants execute kicking movements to aim the ball towards a target.

The objectives of this game are to: (1) Improve rolling movements on a carpet, (2) Enhance running skills while following a designated path, (3) Improve ball-kicking skills, (4) Enhance cognitive abilities, enjoyment, and focus. By creating a fun and varied experience, the game aims to stimulate the physical and cognitive development of participants while fostering an interest in getting to know flowering plants.

The Fun Game Model Getting to Know Flowering Plants Post 1

Playing activities in post 1, using the following equipment: (1) 10 pieces of colorful Evamatt carpets with numbers 0 to 9, (2) A task board shaped like a shirt, modified with buttons, zippers, and snaps, (3) tape, (4) whistles.

The implementation of playing activities in post 1 by way of child sound of the whistle, the student immediately performs rolling movements on the Evamatt carpet while counting the rolls. (3) Once at the finish line, the child completes the task of opening and closing zippers, buttons, and fasteners. (4) Upon completion, the child promptly exits the play area.

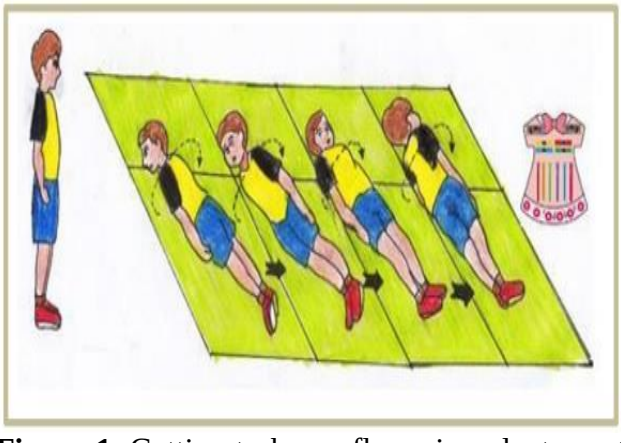

Figure 1. Getting to know flowering plants post 1 (Kesumawati et al., 2018)

Guidelines for Assessment Model Getting to Know Flowering Plants Post 1

Movement Skills Aspect

Score 4, if the student can perform the task without assistance from others.

Score 3, if the student can perform the task with minimal assistance from others.

Score 2, if the student can perform the task with full assistance from others.

Score 1, if the student requires special guidance to perform the task.

Cognitive Skills Aspect

Score 4, if the student can accurately count the number of sideways rolls they perform.

Score 3, if the student attempts to count the number of sideways rolls they perform, even if not entirely correct.

Score 2, if the student can count the number of sideways rolls they perform with minimal guidance from the teacher.

Score 1, if the student can count the number of sideways rolls they perform with full assistance.

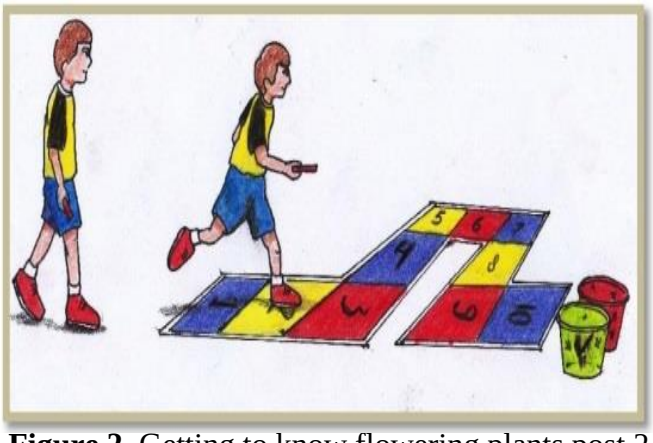

Figure 2. Getting to know flowering plants post 2 (Kesumawati et al., 2018)

Fun Aspect

Score 4, if the student displays a cheerful facial expression and sometimes accompanies it with joyful laughter.

Score 3, if the student shows a cheerful facial expression and occasionally smiles broadly while enjoying the activity.

Score 2, if the student does not express happiness (engages in movements arbitrarily and carelessly).

Score 1, if the student does not seem happy (frowns and appears reluctant while performing movements).

Focus Attention Aspect

Score 4, if the student is highly focused during the movement (from start to finish) and is not distracted by the surroundings.

Score 3, if the student's focus is occasionally disrupted, sometimes looking to the left and right.

Score 2, if the student is not focused and often stops during the movement task.

Score 1, if the student is extremely unfocused and unable to complete the movement task.

Table 1. Assessment rubric of model getting to know flowering plants post 1

No.	Student Name	Aspect				Total score
		Movement Skill	Cognitive Skill	Fun	Focus Attention	
1.						
2.						
e.g						

The Fun Game Model Getting to Know Flowering Plants Post 2

Playing activities in post 2, using the following equipment: (1) 10 colorful Evamatt carpets with numbers 0 to 9, (2) true or fals flashcard, (3) A basket in red and yellow colors, (4) Flower-themed flashcards, (5) coloring tape, (6) cone, and (7) whistle.

The implementation of playing activities in post 2 by way of: (1) The child stands ready behind the starting line, (2) Upon the teacher's whistle, the child moves, running along the Evamatt track, placing 5 flower-themed flashcards in the correct positions one by one, (3) After placing one flashcard in the right spot, the child walks back to the starting line, then runs again to move the second through fifth flashcards, (4) Once finished, the child leaves the playing field and proceeds to the next station.

Guidelines for Assessment Model Getting to Know Flowering Plants Post 2

Movement Skills Aspect

Score 4, if the student can perform the task without assistance from others.

Score 3, if the student can perform the task with minimal assistance from others.

Score 2, if the student can perform the task with full assistance from others.

Score 1, if the student requires special guidance to perform the task.

Cognitive Skills Aspect

Score 4, if the student can correctly place the flashcards in their designated positions

Score 3, if the student attempts to place the flashcards, even if not in the correct positions.

Score 2, if the student can place the flashcards in their designated positions with minimal guidance from the teacher.

Score 1, if the student can place the flashcards in their designated positions with full assistance from the teacher.

Fun Aspect

Score 4, if the student displays a cheerful facial expression and sometimes accompanies it with joyful laughter.

Score 3, if the student shows a cheerful facial expression and occasionally smiles broadly while enjoying the activity.

Score 2, if the student does not express happiness (engages in movements arbitrarily and carelessly).

Score 1, if the student does not seem happy (frowns and appears reluctant while performing movements).

Focus Attention Aspect

Score 4, if the student is highly focused during the movement (from start to finish) and is not distracted by the surroundings.

Score 3, if the student's focus is occasionally disrupted, sometimes looking to the left and right.

Score 2, if the student is not focused and often stops during the movement task.

Score 1, if the student is extremely unfocused and unable to complete the movement task.

Table 2. Assessment rubric of model getting to know flowering plants post 2

No.	Student Name	Aspect				Total score
		Movement Skill	Cognitive Skill	Fun	Focus Attention	
1.						
2.						
e.g						

The Fun Game Model Getting to Know Flowering Plants Post 3

Playing activities in post 3, using the following equipment: (1) 3 fabric balls with a diameter of 15 cm, (2) 15 colorful plastic cups, (3) coloring tape, and (4) whistle.

The implementation of playing activities in post 3 by way of: (1) The child stands ready behind the starting line. (2) Upon receiving instructions from the teacher (whistle sound), the child promptly kicks the ball towards the target. (3) Each child is given three chances to kick the ball. After each kick, the child counts the number of targets (plastic cups) that fall to the floor. (4) Once finished, the child exits the play area.

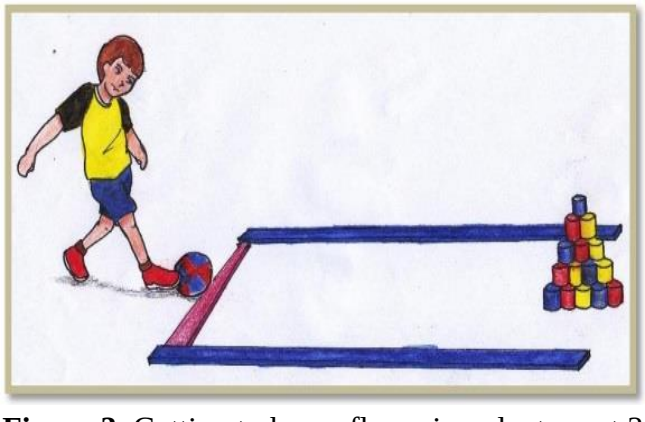

Figure 3. Getting to know flowering plants post 3 (Kesumawati et al., 2018)

Guidelines for Assessment Model Getting to Know Flowering Plants Post 3

Movement Skills Aspect

Score 4, if the student can perform the task without assistance from others.

Score 3, if the student can perform the task with minimal assistance from others.

Score 2, if the student can perform the task with full assistance from others.

Score 1, if the student requires special guidance to perform the task.

Cognitive Skills Aspect

Score 4, if the student can correctly count the number of plastic cups that fell to the floor.

Score 3, if the student attempts to count the number of plastic cups that fell to the floor, even if not entirely correct.

Score 2, if the student can count the number of plastic cups that fell to the floor with minimal guidance from the teacher.

Score 1, if the student can count the number of plastic cups that fell to the floor with full assistance from the teacher.

Table 3. Assessment rubric of model getting to know flowering plants post 3

No.	Student Name	Aspect				Total score
		Movement Skill	Cognitive Skill	Fun	Focus Attention	
1.						
2.						
3.						
4.						
e.g						

Fun Aspect

Focus Attention Aspect

Score 4, if the student displays a cheerful facial expression and sometimes accompanies it with joyful laughter.

Score 3, if the student shows a cheerful facial expression and occasionally smiles broadly while enjoying the activity.

Score 2, if the student does not express happiness (engages in movements arbitrarily and carelessly).

Score 1, if the student does not seem happy (frowns and appears reluctant while performing movements).

The researcher evaluated the "getting to know flowering plants" learning model activities with insights from four experts: an expert in adaptive PE materials, an educational psychologist, an expert in planning learning for children with special needs, and a special education PE teacher. During this phase, the activities are assessed and, if necessary, modified. The expert assessment utilizes a rating scale structured according to a predetermined grid that aligns with the research objectives. Experts and practitioners provide ratings from a scale of 1 to a scale of 4, For further clarification, please refer to the table 4.

Table 4. Instructional rating scale assessment for experts

No.	Scale	Assesment Description
1.	4	very suitable/very precise/very safe/very easy/very practical/highly optimizing.
2.	3	appropriate/precise/safe/easy/practical/can optimize.
3.	2	inappropriate/inappropriate/unsafe/not easy/impractical/unable to optimize.
4.	1	very inappropriate/very imprecise/very unsafe/very not easy/very impractical/ very unsafe.

After receiving assessments from the four experts, the next stage includes analyzing the acquired data to determine the validity of the "getting to know flowering plants" model using the Content Validity Ratio (CVR) table 5 below:

Table 5. Instrument of assessment expert validation

No.	Indicator Assessment	Rating Scale			
		1	2	3	4
1.	The suitability of the game model developed with competency standards and basic competencies and indicators				
2.	The suitability between indicators and subject matter and assessment				
3.	The accuracy of the contents of the FMS learning model developed for SLB students with intellectual disabilities.				
4.	The accuracy of the contents of the FMS learning model developed with the characteristics of the SLB students with intellectual disabilities.				
5.	The safety of the FMS learning model developed.				
6.	Ease of the developed FMS learning model.				
7.	Practicality of the developed FMS learning model.				
8.	The FMS learning model developed can increase the activeness of children with ID in SLB.				
9.	The FMS learning model developed can optimize the (cognitive) knowledge of children with ID in SLB.				
10.	The FMS learning model developed can optimize the FMS of children with ID in SLB				

Statistical Analysis

The validation of the getting to know flowering plants learning model was conducted by correlating the scores of the observed items with the total scores. A trial was performed to determine the magnitude and direction of the relationship. Values range from 0 to 1 or 0 to -1. The positive and negative signs indicate the direction of the relationship. The trial was conducted by means of an inter-rater test, using Thorndike's Anova-General Multifacet Model data analysis namely testing two variables of the type ordinal and scale with normal / parametric distribution using SPSS. The next step is the reliability test. There are two types of inter-rater reliability tests, if the number of raters is 2 people, the reliability test uses the inter-rater agreement correlation coefficient test, and if the number of raters is more than 2 people, the reliability test uses the correlation coefficient test between classes Intra class Correlation Coefficients (ICC).

In this study, three raters were employed, and the correlation coefficient test, specifically the Intraclass Correlation Coefficient (ICC), was utilized to assess the relationship between classes. The reliability of the instrument was examined through a test involving 13 students and 4 teachers participating in the small group trials, and 26 students and 4 teachers in the large group trials, all conducted in a 3rd primary school special education (SLB) in Palembang city. Both qualitative and quantitative data were utilized in this study. A questionnaire was employed as an instrument to gather teachers' opinions, while non-test techniques such as observation (rubric assessment) were used to collect data on learning outcomes. The data analysis involved the application of the t-test and the Wilcoxon test.

RESULTS

In this research, a rating scale instrument was utilized to appraise the feasibility of the initial Fundamental Movement Skills (FMS) development model during play activities with children experiencing mild intellectual disabilities (ID). The study utilized Adaptive Physical Activities and employed a rating scale for the expert validation of a developed model. Prior to conducting small group trials, the research focused on assessing the feasibility of the model. This evaluation engaged both experts (four specialists) and practitioners (teachers implementing the model). The purpose of the expert validation test was to determine the validity level of the learning model getting to know flowering plants, as evaluated by the four experts. The assessments made by the experts and the results of the data analysis using the Content Validity Ratio (CVI) and Content Validity Ratio (CVR) at table 6 were as follows:

Table 6. CVI and CVR test results for learning model "getting to know flowering plants"

No.	E1	E2	E3	E 4	ne	N	N/2	ne-(N/2)	CVR	Criteria
1	4	4	4	3	3	4	2	1	0.5	Valid
2	3	4	3	3	1	4	2	-1	-0.5	Valid
3	4	4	4	4	4	4	2	2	1	Valid
4	4	4	4	4	4	4	2	2	1	Valid
5	4	4	4	4	4	4	2	2	1	Valid
6	4	4	4	4	4	4	2	2	1	Valid
7	4	3	4	4	3	4	2	1	0.5	Valid
8	4	3	4	4	3	4	2	1	0.5	Valid
9	4	3	4	4	3	4	2	1	0.5	Valid
10	4	3	4	4	3	4	2	1	0.5	Valid
Total	39	36	39	38			Amount		6	
Mean	3.9	3.6	3.9	3.8			Average		0.6	Valid
Average			3.8							

CVR scores on each item ranged 1 to -1 Information: ne: Total Essential Subject Matter Expert (SME), N : Total of Subject Matte Expert V : Valid

The CVR analysis results for learning model "Getting to Know flowering Plants" (table 6) indicate a value of 0.6. This suggests that the content of the FMS learning model "Getting to Know flowering Plants" for children with mild ID are appropriate or relevant or good, and also have high content validity, so that it can be continued to be tested for empirical validation. Refer to table 7 for the outcomes of the validity test analysis of learning model "Getting to Know flowering Plants"instrument. By analyzing the correlation coefficients among the rater test data for learning model getting to know flowering plants instrument, considering movement skills, cognitive aspects, fun aspects, and attention focus aspects, it becomes apparent that there is a robust positive correlation between the assessments made by rater 1 and the overall rater scores.

Likewise, a noteworthy positive correlation is observed between the evaluations of rater 2 and the total rater score, along with a significant positive relationship between the assessments of rater 3 and the overall scores assigned by all raters.

The researcher conducted an evaluation of the learning model getting to know flowering plants reliability using the Intra-class Correlation Coefficient (ICC) test, which engaged three raters. The corresponding data is outlined in the following table (Table 8).

Based on the results of the ICC test 3 rater, it can be concluded that the reliability value of the four aspects is estimated using the Alpha coefficient, with data analysis using the Anova General Multifacet Model, showing the coefficient value and coefficient value between rater is high. After the results of the data analysis of the getting to know flowering plants instrument were declared valid and reliable, the researchers proceeded to the empiric test (field trials) on the products developed, namely by conducting small group trials and large group trials to determine the effectiveness of the product being developed.

Table 7. Instrument validity test results for learning model "getting to know flowering plants"

Aspect	Rater Score	Coefficient Correlasion	P	Status
Movement Skill	Rater 1 - score total rater	0,747	0,05	Valid
	Rater 2 - score total rater	0,798	0,05	Valid
	Rater 3 - score total rater	0,755	0,05	Valid
Cognitive Skil	Rater 1 - score total rater	0,754	0,05	Valid
	Rater 2 - score total rater	0,816	0,05	Valid
	Rater 3 - score total rater	0,770	0,05	Valid
Fun	Rater 1 - score total rater	0,516	0,05	Valid
	Rater 2 - score total rater	0,762	0,05	Valid
	Rater 3 - score total rater	0,520	0,05	Valid
Focus Attention	Rater 1 - score total rater	0,777	0,05	Valid
	Rater 2 - score total rater	0,683	0,05	Valid
	Rater 3 - score total rater	0,773	0,05	Valid

Table 8. Instrument Reliable Test Results for Learning Model Getting to Know Flowering Plants

Aspect	Coefficient	Coefficient Inter Rater	Status
Movement Skill	0,779	0,638	Reliabel
Cognitive Skill	0,762	0,615	Reliabel
Fun	0,784	0,644	Reliabel
Focus Attention	0,827	0,705	Reliabel

DISCUSSION

How information is presented to students with intellectual disabilities often makes the difference between success and failure. In general, learning enhanced if it is fun, ensures success, and keeps the student active. Because students with intellectual disabilities need more time and opportunities to learn new skills, good teachers plan an active class and provide many opportunities for students to practice targeted skills. They also carefully select teaching methods to match the students' level of cognitive development.

Development of children with mild intellectual disabilities emphasized the mutual relationships between many environmental components and how they affect children's development, it is true that a school classroom has an impact on kids' growth (**Smogorzewska et al., 2019**). Low FMS performance in children with ID is probably caused by poor cognitive capacities (Vuijk et al., 2010). Development used by trainers or PE teachers to create specific treatments to advance FMS (Kavanagh et al., 2023). Children with mild mental retardation are quite adept at running, jumping and rolling (Alesi et al., 2018). Motor ability for controlling items and moving around, especially kids with mild intellectual disabilities. Even while sprinting, leaping, and throwing, lower outcomes are attained, with significant individual variations. The development of motor skills in children with intellectual impairments (ID) is a priority to assist their inclusion in school, as only a small percentage of these children exhibit motor outcomes comparable to normal ones (Mocanu & Gavrila Udrea, 2021). Children with mild intellectual disabilities engage in physical activity, their FMS increases (Wang et al., 2022).

Saying the names of flowers that are found on colorful items is how my research attempts to train cognitive abilities. Nearly identical to (Russell, 2017): "people get together to converse and discuss a variety of topics while seated in a circle, including their favorite colors, animals". Children with modest intellectual disabilities showed notable gains in attentional performance measures, specifically visual attention (García-Redondo et al., 2019). Let's color play to be displayed on things like tiny balls, cones, circles, stripes, balloons, and scarves

(Regaieg et al., 2020). It's given kids the chance to engage their imaginations (Roberts-Yates & Silvera-Tawil, 2019). Learning children with mild ID must be carried out with simple instructions and accompanied by direct and concrete demonstrations to make it easier for children with ID to accept. Because Children with ID are Children affected by this condition experience a variety of challenges related to learning, communication, social skills, and independent functioning (Wolan-Nieroda et al., 2023). Verbal instructions with examples of the correct movements will be easier to imitate by children with ID, therefore the teacher places more emphasis on practicing the movements that the child must do.

FMS learning model for activities in the morning designed based on the needs of children with mild ID. After being validated by experts, analyzed and getting relevant results this model will be tested in the small and large scale trial stages on teachers and students in primary school special education in Palembang City. Significant gains in fine motor accuracy, fine motor integration, hand dexterity, bilateral coordination, balance, speed and agility, upper limb coordination, strength tests, and all dimension scores for quality of life were identified in the motor skill tests of the children with intellectual disabilities (Özkan & Kale, 2023).

Conclusion

(1) The CVR analysis results for model indicate a value of 0.6, falling within the range of 1 to -1. This signifies that the content of the FMS getting to know flowering plants is deemed appropriate, relevant, and of high content validity.

(2) Upon calculating the correlation coefficient between rater test data for getting to know flowering plants instrument across movement skills, cognitive aspects, fun elements, and attention focus aspects, it is observed that there is a strong positive relationship between the scores assigned by rater 1 and the overall rater scores. Similarly, there is a substantial positive correlation between the scores given by rater 2 and the total rater score. Additionally, the relationship between rater score 3 and the total scores among raters also exhibits a significant positive relationship ($p > 0.05$).

The outcome of this research is a learning model comprising activities designed to enhance fundamental movement skills, cognitive abilities, enjoyment, and attention focus in children with mild intellectual disabilities, aged 8-10, irrespective of gender. The model employs safe, affordable, educational, and entertaining media tailored for children. It is suggested for adoption not only by educators in special schools but also by parents with children who have special needs, particularly those with mild intellectual disabilities or facing challenges in movement-related learning.

Conflict of interest

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

Ethics Statement

Ethical clearance (No:180/NPC-SS/II/2023) for this research was obtained from the Research Ethics of National Paralympic Committe Indonesia Sumatera Selatan, Indonesia.

Author Contributions

Study Design, SAK, AF and HF; Data Collection, SAK, NS, HA and M; Statistical Analysis, HA, NS and BH; Data Interpretation, HA, NS and BH; Manuscript Preparation, AF, BH, and M; Literature Search, SAK and AF. All authors have read and agreed to the published version of the manuscript.

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RESEARCH ARTICLE

Determination of Situational Self-Criticism Levels of Athletes Engaged in Struggle Sports

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Abstract
The aim of this study is to determine the situational self-criticism levels of struggle athletes. The research was designed in cross-sectional survey model, one of the quantitative research methods. The population of the study consists of individuals who do combat sports in Yalova province. The sample consisted of a total of 202 athletes, 97 females and 105 males, who voluntarily accepted to participate in the study among the athletes constituting the universe. Athlete Situational Self-Criticism Scale consisting of 7 items was used as a data collection tool in the study. Statistical analyses in the study were performed using SPSS package programme. A significant difference was found between the participants according to nationality, age, sport age, education and branch variables p<0,05. As a result, it was determined that there was no difference between the situational self-criticism levels of the athletes in terms of gender and parental marital status variables. It was determined that there was a significant difference between the situational self-criticism levels of the athletes in terms of nationality, sports age, age, education and branch variables.

Keywords
Sports, Struggle, Self-criticism

INTRODUCTION

Self-criticism in sport competitions is a self-evaluation process in which individuals evaluate themselves, their personality traits, their physical condition or their performance in various situations by judging them negatively (Holle and Ingram, 2008; Powers et al., 2004). When the literature is examined, it is seen that self-criticism is also expressed as the individual's awareness of his/her faulty behaviours, making an objective evaluation and paying attention not to repeat these faulty behaviours (Uludağ, 2011; Turşak, 2017). In addition, self-criticism is explained as the individual behaving according to his/her own high standards and showing hostility to himself/herself when these high standards are not met (Shahar, 2015).

Individuals with high perfectionism tend to set high standards for perfection and good performance and overcriticise their behaviours (Flett and Hewitt, 2002; Frost et al, 1990). Therefore, high perfectionistic individuals with very high standards are more vulnerable to failure in targeted performance than low perfectionistic individuals because they are also overly self-critical (Anshel and Mansouri, 2005; Besser and et al., 2004).

Conceptually, self-criticism is based on unrealistic self-expectations as well as maladaptive thought patterns. Instead of promoting sport performance, it is seen to cause self-directed perfectionism, anxiety, and even sport burnout, which can negatively affect sport performance (Kowalski and Duckham, 2014).

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It can be said that the increase in the level of self-criticism brings negativities such as difficulties in progressing to the targeted goal, anxiety, and depressive state (Oliveira and et al., 2021; Powers and et al., 2009; Kowalski and Duckham, 2014). These negativities may cause negative effects on the performance of elite level athletes. Anxiety and depressive states seen in the athlete is a situation that coaches and athletes do not want to encounter, as it will cause a decrease in sports performance. In this context, the aim of the study was to determine the situational self-criticism levels of combat athletes.

MATERIALS AND METHODS

Research Model

Cross-sectional survey model, one of the quantitative research methods, was used. Cross-sectional survey design is a type of study that aims to describe a situation that has existed for a long time and exists today as it is (Karasar, 2004).

Research Group

The population of the study consists of individuals who do combat sports in Yalova province. The sample consisted of a total of 202 athletes, 97 females and 105 males, who voluntarily accepted to participate in the study among the athletes constituting the universe.

Table 1. Descriptive statistics results of the participants

Variable		**f**	**%**
Gender	Male	105	52
	Female	97	48
Age	Between the Ages of 15 and 17	120	59,4
	Between the Ages of 18 and 21	33	16,3
	22 years and over	49	24,3
Sports Branch	Taekwondo	22	48,5
	Boxing	21	10,4
	Wrestle	22	10,9
	Judo	24	11,9
	Karate	18	8,9
	Wushu	19	9,4
National Athlete	Yes	64	31,7
	No	138	68,3
Sports Age	1-3 Years	89	44,1
	4-6 Years	29	13,9
	7-9 Years	24	11,9
	10 years and over	61	30,2
Education	High School	136	67,3
	Undergraduate	56	27,7
	Postgraduate	10	5
Marital status of parents	Married	183	90,6
	Separated	19	9,4
Total		**202**	**100**

When Table 1 is analysed, 52% of the participants were male and 48% were female, 59-4% were 15-17 years old, 16.3% were 18-21 years old and 42.3% were 22 years old and above, 48,5% of them are taekwondo, 10,4% boxing, 10,9% wrestling, 11,9% judo, 8,9% karate, 9,4% wushu, 31,7% are national athletes, 68,3% of the participants were not national athletes, 44,1% had been doing sports for 1-3 years, 13,9% for 4-6 years, 11,9% for 7-9 years and 30,2% for 10 years

or more, 67,3% had high school education, 27,7% had undergraduate education, 5% had graduate education, 90,6% of the participants' parents were married and 9,4% were divorced.

Research Ethics

Ethics committee approval was received for this study from Süleyman Demirel University Faculty of Medicine Clinical Research Ethics Committee (E- 87432956-050.99-299639, Date:06.07.2022). 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.

Data Collection Tool

As a data collection tool, the Athlete Situational Self-Criticism Scale (SSAS) consisting of 7 items was used. The internal consistency coefficient of the scale was calculated as .782. Kaiser Meyer Olkin (KMO) coefficient was found to be .70 (Tingaz, 2021).

Structural validity analysis was also conducted for this study. The Kaiser-Meyer-Olkin value obtained was found to be ,702. This result shows that the scale is valid for the study sample group.

Analysis of the Data

When the normality analysis of the data was performed, it was found that the values were within the range of ±1.5 points. Since the result obtained is within the score range accepted as normal value, it can be said that the data show normal distribution (Tabachnick and Fidell, 2013). Independent Samples T-Test was used for pairwise comparison between groups and One-Way Anova test was used for multiple comparisons. Bonferroni test was applied to determine between which variables there was a difference between multiple comparison results. The results of the analyses were evaluated at 0.05 significance level.

Table 2. Normality test analysis results

ASSCS		Items	N	X̄	Ss	Skewness	Kurtosis
Single Factor	ASSCS Total Score	7	202	31,57	14,37	,130	-,757

When Table 2 is examined, it is seen that the skewness value is ,130 and the kurtosis value is -,757. If the data are within ±1.5 points, it can be said that the data are normally distributed (Tabachnik, Fidell, 2013). Since the study data are within the specified score values, it can be said that they are normally distributed.

RESULTS

Table 3. The results of the analyses according to the gender of the participants

	Gender	n	X̄	Ss	t	df	p
ASSCS Total Score	Male	105	33,30	13,12	1,785	200	,076
	Female	97	29,70	15,48			

p>0,05

When Table 3 is examined, it is seen that there is no significant difference between the athlete status self-criticism total score results according to the gender variable (p>0,05).

Table 4. The results of the analyses according to the national athlete variable of the participants

	National Ahlete	n	X̄	Ss	t	df	p
ASSCS Total Score	Yes	64	37,58	10,39	4,211	200	,000
	No	138	28,70	15,13			

p>0,05

When Table 4 is examined, it is seen that there is a significant difference between the total score results of athlete status self-criticism according to the national athletes variable (p<0,05). It was observed that national athletes made more self-criticism.

Table 5. The results of the analyses according to the marital status of the participants' parents

	Marital status of parents	n	X̄	Ss	t	df	p
ASSCS Total Score	Married	64	31,74	13,87	,533	200	,595
	Separated	138	28,89	18,94			

p>0,05

When Table 5 is examined, it is seen that there is a significant difference between the athlete state self-criticism total score results according to the parental relationship status variable (p<0,05).

Table 6. The results of the analyses according to the sport age of the participants

	Sport Age	n	X̄	Ss	F	p	Bonferroni
ASSCS Total Score	[a1]-3 Years	89	24,97	13,08	23,647	,000*	a<c a <d b <c a<d
	[b]4-6 Years	28	26,39	13,15			
	[c]7-9 Years	24	40,79	14,17			
	[d]10 Years and over	61	39,95	10,20			

p<0,05

When Table 6 is examined, it is seen that there is a significant difference between the athletes' state self-criticism total score results according to the sports age variable of the participants (p<0,05). According to the results obtained, it was determined that those with more years of sportsmanship had higher self-criticism than those with less years of sportsmanship.

Table 7. The results of the analyses according to the age variable of the participants

	Age	n	X̄	Ss	F	p	Bonferroni
ASSCS Total Score	[a]15-18 Years	120	27,07	14,76	17,454	,000*	a<b a<c
	[b]18-21 Years	33	40,09	10,43			
	[c]21 Years and Over	49	36,86	11,12			

p<0,05

When Table 7 is examined, it is seen that there is a significant difference between the athletes' state self-criticism total score results according to the age variable of the participants (p<0,05). According to the results obtained, it was determined that older athletes were more likely to make self-criticism.

Table 8. The results of the analyses according to the education variable of the participants

	Education	n	X̄	Ss	F	p	Bonferroni
ASSCS Total Score	[a]High School	136	28,04	14,91	14,255	,000*	a<b a<c
	[b]Undergraduate	56	38,54	10,07			
	[c]Postgraduate	10	40,50	9,06			

p<0,05

When Table 8 is examined, it is seen that there is a significant difference between the athletes' state self-criticism total score results according to the sports age variable of the participants (p<0,05). According to the results of the analysis, it was determined that the self-criticism levels of those with undergraduate and graduate education levels were higher.

Table 9. The results of the analyses according to the branch variable of the participants

	Branch	n	X̄	Ss	F	p	Bonferroni
ASSCS Total Score	[a]Taekwondo	98	28,69	14,78	3,549	,002*	a<d a<e a<f b<d b<e b<f
	[b]Boxing	21	26,38	16,81			
	[c]Wrestle	22	33,64	11,25			
	[d]Judo	24	37,79	9,91			
	[e]Karate	18	37,44	14,38			
	[f]Wushu	19	36,32	12,50			

p<0,05

When Table 9 is examined, it is seen that there is a significant difference between the athletes' state self-criticism total score results according to the sports branch variable of the participants (p<0,05). According to the results of the analyses, it was determined that Taekwondo and Boxing athletes were more self-critical than athletes in other branches.

DISCUSSION

Although the self-criticism level of male athletes (X=33,36) was higher compared to female athletes (X=29,70) according to the gender variable, when the ASSCS scale total score averages were examined, no statistically significant difference was found (p>0,05). In relation to this situation, it can be said that the self-critical situation of the individual is not a gender-related situation, it can be caused by the physical and psychological states that the individual is in. As a result of the study conducted by Adam et al., (2022) it was found that while the self-criticism levels of female athletes were low at the beginning of the season, their self-criticism levels were high at the end of the season. In the study conducted by Killham et al. (2018), no significant difference was found between self-criticism scores in terms of gender. In a study conducted by Bingöl and Alpkaya (2016), in which the self-esteem levels of high school students who do sports and those who do not do sports are compared, it was determined that when male and female students who do sports are evaluated among themselves according to gender, there is a statistically significant difference between those who do sports and those who do not do sports (p>0,05). It can be said that the fact that parents are married or separated does not have any effect on the self-criticism levels of athletes. There has not been a study in the literature about self-criticism and parents' relationship status.

When the ASSCS scale total score averages were examined, it was found that national athletes (X=37.58) had higher self-criticism levels compared to non-national athletes (X=28.70) according to the nationality variable, and statistically significant results were found. (p<0,05). According to Vural et al., (2019) in their studies conducted on the examination of self-esteem and decision-making styles of national athletes at the high school level in decision-making, it was found that the level of self-esteem of decision-making athletes participating in the study according to the sports branch variable differed significantly in terms of sports branch. In the study by Walton et al., (2020) contrary to expectation, the results suggest that even highly elite athletes may be open to using self-compassion.

When the total score averages of the ASSCS scale were examined, it was seen that the level of self-criticism increased as experience increased according to the sports age variable (1-3 years X=24.97, 4-6 years X=26.39, 7-9 years X=40.79, 10 years and above X=39.95), while statistically significant differences were found. (p<0,05). It can be said that this situation is related to the fact that as the experience increases, the person becomes more perfectionist and sharper in the self-evaluation process. In a study conducted by Frost et al., (1990) they found that individuals with high perfectionism also showed high levels of self-criticism (Frost and et al., 1990). In a study in which Şenel et al., examined the relationship between the self-compassion and self-criticism levels of volleyball players, they found that the self-criticism levels of athletes with a high year of

playing sports also increased (Şenel et al., 2023). According to Vural et al., (2019) in their conducted on the examination of self-esteem and decision-making styles of national athletes at the high school level in decision-making, they reached the conclusion that the athletes participating in the study differed significantly according to the age of sports in their comparisons according to the year of playing sports (Vural et al., 2019).

Looking at the total score averages of the ASSCS scale, it was found that the level of self-criticism also increased with increasing age according to the age variable (15-17 years X=27.07; 18-21 years X=40.09; 22 years and over X=36.86), while a statistically significant difference was found (p<0,05). It can be said that the level of self-criticism, especially between the ages of 18 and 21, is high because athletes evaluate themselves more sharply towards the end of their adolescence and evaluate their defeats and successes in competitions more consciously and goal-oriented. In parallel with the results of our study, Şenel and his colleagues found that the higher the age of athletes, the higher their self-criticism levels (Şenel et al., 2023).

When the ASSCS scale total score averages are examined, it is seen that the level of self-criticism increases as the education level increases according to the education variable (High school X=28.04; Undergraduate X=38.54; Graduate X=40.50), while a statistically significant difference was found (p<0,05). No study has been found in the literature regarding the level of state self-criticism and educational status. When the total score averages of the ASSCS scale were examined, statistically significant differences were found in the level of self-criticism according to the branch variable (taekwondo X=28.69; boxing X=26.38; wrestling X=33.64; judo X=37.79; karate X=37.44; wushu X=36.32) (p<0.05). This situation can be explained by the fact that the number of participants is not evenly distributed among branches. When the relevant literature was scanned, no studies related to situational self-criticism and sports branches were found.

Conclusion and Recommendations

As a result, it can be said that gender and parental relationship status variables did not affect the participants' status self-criticism levels. It can be said that national sportsmanship, sports age, age, education and branch variables affect the participants' status self-criticism levels.

studies

It is thought that the study we have done will contribute to new studies to be conducted in the related field. New research to be conducted may reveal different results with larger sample groups.

Conflict of Interest

There are no personal or financial conflicts of interest among the authors regarding the scope of the study.

Authors' Contribution

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

Research Ethic Information

Ethics committee approval was received for this study from Süleyman Demirel University Faculty of Medicine Clinical Research Ethics Committee (E- 87432956-050.99-299639, Date:06.07.2022).

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RESEARCH ARTICLE

The Relationships with Maximal Aerobic Speed, Maximal Oxygen Uptake and Isokinetic Strength in Hearing Impaired Men's Handball Players

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Abstract
Study aim: This study aimed to analyze the relationships between weekly training frequency, changes in training duration, and Maximal Aerobic Speed (MAS), Maximum Oxygen Uptake (VO_2max), and Isokinetic Strength over an 8-week period (pre-season 8 weeks). Material and methods: Eighteen hearing-impaired handball players (age: 26.78±2.26 years; height: 177.76±4.40 cm; body weight: 64.94±2.73 kg, training experience 13.1±2.6 years) were positioned in defense and offense based on their playing positions and were monitored for 8 weeks. Repeated Measures ANOVA test was performed for the pre-test and post-test comparisons of defense and offense players, frequency and distribution is observed, average standard deviation, maximum, and minimum values were taken. Results: The analysis results revealed a significant large positive difference in the agonist/antagonist ratio in the right extremity ($p < 0.01$). Conclusion: Throughout the study, fluctuating changes in the numbers and durations of training sessions were observed to significantly increase and correlate with changes in the players' fitness status. There is a statistically significant difference between pre-test and post- test values for maximal oxygen consumption (VO_2max), maximal aerobic speed (MAS), and maximal heart rate (HRmax) ($p< 0.01$). However, the variability in the large positive difference in the agonist/antagonist ratio in the right extremity suggests that it cannot be solely explained by the number and duration of training sessions in terms of fitness level.

Keywords
Training, Maximal Aerobic Speed, Maximal Oxygen Uptake, Isokinetic Strength

INTRODUCTION

In recent years, technology-based training methods have been implemented in elite-level teams to enhance the quality of training sessions. The objectives of these training methods are to determine the internal and external loads imposed on athletes during training and to assess the acute and long-term effects of the training sessions (Zemkova & Hamar, 2014; Chukhlantseva 2019). The assessment of training quality within athletic performance involves physiological measurements of internal factors such as maximum oxygen consumption and maximal heart rate, as well as external factors based on physical measurements including distances covered at varying speeds, corresponding pace, accelerations and decelerations, sudden changes in direction, jump height, and the summation of these variables at maximal intensity. These assessments are conducted through athletic performance tests (Timmins & Saunders, 2014; Bourdon et al., 2017).

The impact of training on players varies from athlete to athlete in team sports. These differences can be attributed to various factors such as age, gender, training history, adaptation period to training, metabolic response time to training, training intensity, and frequency, leading to variations in reactions among athletes (Altavilla

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et al., 2017). Considering all these various factors, it is acknowledged that training loads, both internal and external, do not necessarily produce similar or identical physical and physiological outcomes among team sports players (Petridis et al., 2021). This variability can be attributed to the specific nature of team sports, where training methods such as running, variable-intensity games, and high-intensity sprints, particularly in sports like handball, exhibit fluctuations in both internal and external loads (Park et al., 2021). In light of this variability, the application of the same training intensity and volume may result in different loads for athletes. This insight can provide coaches, conditioning coaches, and sports researchers with valuable information: some athletes may require additional training, while others may risk overtraining due to high levels of internal and external loading (Práxedes et al., 2018; D'Isanto et al., 2019).

Handball, a dynamic game requiring various physical abilities such as speed, agility, endurance, and strength, often exhibits differences in multiple variables. Consequently, it is observed that the preseason training period and subsequent periods minimize variations in the athletic performance and fitness levels of handball players (Müller & Brandes, 2015). The quality of training conducted on handball players during preseason preparation and subsequent training periods is crucial. During these periods, the aim is to minimize variations in the athletic performance and fitness levels of players. With the improvement in training quality, enhancements can be observed in parameters such as heart rate, maximum heart rate, muscle strength, muscle endurance, maximum aerobic speed, and maximum oxygen consumption levels (Saavedra et al., 2018; Ivrasson, 2014).

In the sport of handball, various physical abilities such as strength, muscular endurance, maximal oxygen consumption, and maximal aerobic capacity are required. Strength plays a crucial role in movements such as smashes, serves, and blocks, requiring both upper and lower body strength (Wagner et al., 2017). Players need a strong body to effectively hit the ball and compete with opponents. Muscular endurance, on the other hand, is essential for withstanding the continuous, fast, and intense movements throughout the game. It enables players to resist fatigue and maintain their performance for extended periods (Tyshchenko et al., 2017). Maximal oxygen consumption (aerobic capacity) is vital for long-term endurance in sports like handball. It involves increasing players' maximal oxygen consumption to sustain energy levels throughout lengthy matches (Gorostiaga et al., 2006). Given that handball is a fast-paced and dynamic team sport, maximal aerobic capacity (aerobic endurance) is crucial for players. Improving maximal aerobic capacity can enhance players' endurance and performance (Milanović et al., 2018).

Researching the characteristics of hearing-impaired handball players is of great importance due to the high aerobic and anaerobic capacities required in handball, being a high-intensity team sport (Drake et al., 2017). The investigation of maximal aerobic speed, maximum oxygen uptake, and isokinetic strength holds significant importance in the realm of sports science, particularly concerning hearing-impaired handball players, as these physiological and physical parameters play crucial roles in determining the athletic performance and overall fitness levels of individuals engaged in competitive sports activities (İbrahim et al., 2017). Upon review of the literature, aerobic capacity has been identified as a characteristic encompassing all metabolic processes contributing to athletes' overall work capacity (Jagim et al., 2016). Consequently, maximal oxygen consumption (VO2 max) is widely utilized as a criterion for aerobic capacity and is employed in the physiological monitoring of hearing-impaired athletes, as well as in determining indicators of their anaerobic capacities (Mujika et al., 2018). However, it is noted that studies conducted on hearing-impaired handball players at both field and laboratory levels are limited (Cameron et al., 2018).

In recent years, there has been a growing recognition of the importance of applying scientific principles to enhance the performance of athletes with disabilities (Dafoe, 2007). Noteworthy advancements have been achieved through training studies utilizing various methods and approaches (Gorostiaga et al., 2006). These investigations appear to be particularly geared towards enhancing the performance and success of disabled athletes, particularly those with hearing impairments (Kejonen et al., 2003). The enhancement of performance among hearing-impaired handball players, influenced by hearing loss, is crucial for optimizing physical, physiological, and biomechanical components

(Billat et al., 2000). The objective of this study seems to be centered around increasing the maximal work capacity of hearing-impaired handball players and pushing the boundaries of athletes' performance. It is postulated that targeting the physical and physiological parameters examined in the study is advantageous, provided that the body is subjected to a high level of adaptive challenge. The structural and physiological adaptations observed in hearing-impaired handball players suggest that training regimens tailored to these athletes should involve specific activities tailored to the scope, intensity, and frequency of the training applied. In summary, this study aims to investigate: a) The relationships between maximal aerobic speed, maximal oxygen consumption, and isokinetic strength in hearing-impaired handball players. The results obtained will provide insights into specific training methods tailored to these parameters. b) The aim of the study was to examine the relationships between physical fitness and strength variables (parameters maximum oxygen consumption (VO_2max), maximum aerobic speed (MAS), anterior and posterior peak torques at 60˚/s) over an 8-week period in hearing-impaired handball players following an 8-week training process section which is at the end of template.

MATERIALS AND METHODS

Ethical Approval

This study followed ethical standards and received approval from the Çankırı Karatekin University (Health Sciences Ethics Committee) in Turkey with reference number (08/05/2023; 7). 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.

Participants

During the 8-week training period, eighteen male handball players with hearing impairments (age: 26.78±2.26 years; height: 177.76±4.40 cm; body weight: 64.94±2.73 kg, training experience 13.1±2.6 years) were included in the study and observed.

Research design in the study

The hearing-impaired handball players participated in the deaf handball league affiliated with the Turkey Deaf Sports Federation during the 2023/2024 season. They played in the same team, and their playing positions within the team were distributed as follows: three were central playmakers, three were left playmakers, three were right playmakers, three were left wings, three were right wings, and three players were in the pivot position. The aim of the conducted study is to determine the cardiovascular fitness levels of hearing-impaired handball players through physical and physiological tests at the beginning and end of an 8-week training period, and to identify the relationships between these fitness variables over the 8-week process. The inclusion criteria for this research are as follows: not being a goalkeeper, participating in 75% of the training sessions during the eight-week period, not experiencing prolonged injuries, and not using alcohol or ergogenic supplements.

Hearing-impaired handball players participated in training programs prepared and designed by coaches and athletic performance coaches for eight weeks. Additionally, they did not engage in any other training programs. Before the study, players were informed about the design, structure, and content of the study, as well as the potential risks and benefits. Pre-study information was provided, and players declared their voluntary agreement to participate by signing informed consent forms that outlined the study conditions.

Experimental Approach to the Problem

This study, which commenced at the end of June and concluded at the beginning of September (over 8 weeks), was designed and implemented in the form of a pre-test-post-test experimental design (during the 8-week pre-season). The Timeline of the measurement in Table 1. For cardiovascular fitness assessments, players underwent pre-test evaluations within 1 day before the start of the 8-week period, and post-test evaluations were conducted within 48 hours after the conclusion of the 8-week training process. The fitness variations occurring in hearing-impaired handball players over the 8-week training period were also correlated in the study.

Pre- Workout Warm Up Protocol

The players underwent a 20-min warm up session led by a licensed strength and conditioning coach involving stretching, the classical warm-up

procedure applied in the study includes 5 minute-jogging with 40-50% of the maximum heart rate, followed by 5 frontal-lateral hopping, 5 mobilization, 5 upper extremity static stretching exercises and familiarization with the test, respectively. The movements were applied for 2 sets and 15 seconds. In addition, players did a standard warm-up focusing on lower limbs which consisted of self- paced low-intensity running, lower-limb dynamic stretching, and reactive strength exercises before the tests.

Table 1. Timeline of the measurement

Days	Measurements
Sunday	Resting Day
Monday	(10:00) Height and Body Weight Measurement (16 :00) Aerobic Assesment
Tuesday	(10:00) Isokinetic Leg Strength test
Wednesday	Resting Day
Thursday	Resting Day
Friday	Resting Day

Table 2. Detailed training program (Hantău, 2021)

Days of the Week	1st Week	2nd Week	3rd Week	4th Week	5th Week	6th Week	7th Week	8th Week
Sunday	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day
Monday	Resistance training	Resistance training	Sprınt Training	Plyometrıc Training	İnterval Training	Functional Training	Club Workouts	Club Workouts
Tuesday	Resistance training	Resistance training	Functional Training	Functional Training	İnterval Training	Functional Training	Club Workouts	Club Workouts
Wednesday	Resistance training	Resistance training	Functional Training	Functional Training	İnterval Training	Functional Training	Club Workouts	Club Workouts
Thursday	Resistance training	Resistance training	Functional Training	Functional Training	Club Workouts	Functional Training	Club Workouts	Club Workouts
Friday	Resistance training	Resistance training	Sprınt Training	Plyometrıc Training	Club Workouts	Functional Training	Club Workouts	Club Workouts
Saturday	Resting Day	Resting Day	Resting Day	Resting Day	Club Workouts	Club Workouts	Club Workouts	Club Workouts

Data collection tools

Anthropometric measurements

A stadiometer with a precision of ± 1mm (Holtain, UK) was used to measure the heights of the study group. Heights were measured with anatomical posture, barefoot, heels together, and the headboard touching the vertex point (Arslanoğlu et al., 2017). The body weights of the players (in kg) were measured using the Tanita BC 418 MA Professional Segmental body analysis system. The accuracy of the measurement tool was calibrated with a precision of 0.01 kg for weight. The measurements of the athletes were recorded in kilograms (kg) when they were barefoot, wearing only shorts and T-shirts.

Aerobic assessment

Aerobic capacity determination was conducted utilizing a stepwise incremental treadmill equipped with a direct calorimeter (Technogym, Skillrun Live 7000, Italy). The testing was carried out in a controlled laboratory environment maintained at a temperature range of 22-22°C and a relative humidity of 50-55%. A standardized warm-up protocol was employed, consisting of a 3-minute treadmill run at a speed of 8 km/h followed by 5 minutes of free stretching. The test protocol continued until exhaustion, with progressive increments of 0.5 km/h every 30 seconds at a constant incline of 2%. Exhaustio

was defined as the point at which participants voluntarily declared their inability to maintain the predetermined pace (Malone et al., 2015). The treadmill incline remained fixed at 2% throughout the duration of the test.

Respiratory parameters were measured using an automatic gas analysis system (Fitmate Pro, Cosmed, Italy) (Gabbett, 2020). The device was calibrated before each measurement session according to the manufacturer's recommendations and operated in "breath by breath" mode with a 5-second averaging option. Calculation of participants' VO_2max values utilized three criteria: a sustained increase in speed while a plateau was observed in VO_2, a Respiratory Exchange Ratio (RER) value exceeding 1.10, and an estimated heart rate exceeding 95% of the maximum predicted heart rate based on the formula 220 - age. VO_2max was calculated as the average of the highest three values where at least two of these criteria were met (Daros et al., 2012). Heart rate monitoring during the incremental test was conducted using a heart rate monitor (H10, Polar, Finland), recording participants' heart rates every second and synchronized with a local system. The maximum heart rate (HRmax) attained during the exercise was recorded for each participant.

Maximal aerobic speed was determined based on the highest speed achieved during the incremental treadmill test. Pre- and post-observation period tests were conducted in the same facility, at the same hour, on the same day of the week, maintaining a stable temperature of 22°C and relative humidity of 50-55% (Campos et al., 2017).

The isokinetic strength

The test was conducted using the Cybex Norm isokinetic dynamometer (CSMI, Stoughton, Massachusetts, USA) following a standardized warm-up on a cycloergometer (Monark LC4, Sweden) for five minutes. Prior to testing, the anterior and posterior lower limb torques were gravity-corrected, and dynamometer calibration was performed according to the manufacturer's guidelines. Lower limb assessments were conducted randomly after participants received verbal and visual instructions and feedback from the evaluator. Players underwent two non-recorded trial sessions to become familiar with the testing procedure. Once familiarized, players were evaluated through five repetitions of concentric knee extensions and flexions at 60˚/sec, with a 10-second recovery period allowed between repetitions. Isokinetic strength ratios were calculated based on measurements of maximal anterior and posterior peak torques (Śliwowski et al., 2017).

Peak torque deficits between lower limbs were assessed by comparing the best trials of left and right lower limb extension and flexion. The following measures were utilized during statistical analysis: Extension Peak Torque at 60˚/s (EPT); Flexion Peak Torque at 60˚/s (FPTL); Extension Deficit (DE); Flexion Deficit (DF); and Agonist/Antagonist Ratio (Rag/An). The testing environment maintained a controlled temperature of 22°C and relative humidity of 50-55% during both pre- and post-training evaluations (Söyler et al., 2023).

Data analysis

The statistical analysis of the data was conducted using the SPSS 22.0 software package. Repeated Measures ANOVA test was performed for the pre- test and post-test comparisons of defense and offense players.

Table 3. Training sessions and time of training week during the 8-week period.

	W1	W2	W3	W4	W5	W6	W7	W8
Training sessions	5	5	5	5	6	6	6	6
Total time (min)	350	350	375	375	450	450	480	480

W: Week

RESULTS

When looking at Table 4; There is a statistically significant difference between pre-test and post- test values for maximal oxygen consumption (VO_2max), maximal aerobic speed (MAS), and maximal heart rate (HRmax) ($p < 0.01$).

Table 4. Within-group differences of VO_2max, and MAS, between pre- and post-period of training in handball players with hearing impairment

Variable	Position	M (Sd) pre	M (SD) post	P	
				Group*Time	Int.group
VO_2max (ml.kg.min)	playmaker	42.92±1.57	46.53±2.05	0.013	0.935
	pivot	42.78±1.26	46.63±1.47		
MAS (m/min)	playmaker	3.87±0.06	3.75±0.07	**<0.001**	0.341
	pivot	3.88±0.06	3.74±0.05		
HRmax (bpm)	playmaker	198.91±0.76	192.81±2.20	**<0.001**	0.89
	pivot	198.59±1.09	192.35±1.83		

VO_2max: maximal oxygen consumption; MAS: maximal aerobic speed; HRmax: maximal heart rate

When looking at Table 5; There is a statistically significant difference between pre-test and post-test values for EPT: Extension Peak Torque at 60˚/s; FPT: flexion peak torque at 60˚/s; L): left; R): right; DE: deficit at extension; DF: deficit at flexion; Rag/An: ratio agonist/antagonist p < 0.01). In the Agonist/Antagonist ratio Rag/An), offensive players statistically have a higher value than defensive players p = 0.011).

Table 5. Within-group differences of ısokinetic strength between pre- and post-period of training in handball players with hearing impairment

Variable	Position	M(Sd) pre	M(SD) post	P	
				Group*Time	Int.group
EPT(L) (Nm)	playmaker	288.14±2.14	279.50±2.34	<0.001	0.831
	pivot	287.87±4.05	279.11±3.13		
EPT(R) 8Nm)	playmaker	270.88±3.23	281.09±2.33	<0.001	0.505
	pivot	269.40±3.91	278.36±5.34		
DE (Nm)	playmaker	10.53±0.35	11.14±0.35	<0.001	0.504
	pivot	10.38±0.33	11.22±0.22		
FPT(L) (Nm)	playmaker	174.97±1.95	186.50±3.47	<0.001	0.230
	pivot	175.94±2.38	185.06±4.0		
FPT(R) Nm)	playmaker	183.77±2.68	188.11±1.63	<0.001	0.255
	pivot	183.67±1.57	188.98±0.79		
DF (Nm)	playmaker	7.44±0.21	7.97±0.19	<0.001	0.807
	pivot	7.45±0.14	8.00±0.04		
RAg/An(L) (%)	playmaker	42.89±1.18	47.87±1.10	<0.001	0.057
	pivot	44.52±0.25	47.99±1.19		
RAg/An(R) (%)	playmaker	42.36±0.96	42.71±1.04	<0.001	0.011
	pivot	41.59±0.40	42.52±0.52		

EPT: Extension Peak Torque at 60˚/s; FPT: flexion peak torque at 60˚/s; L): left; R): right; DE: deficit at extension; DF: deficit at flexion; Rag/An: ratio agonist/antagonist

When looking at Table 6 mean values ±SD) of basic somatic variables determined in handball players with hearing impairment.

Table 6. Mean values ±sd of basic somatic variables determined in handball players with hearing impairment

Variable	n	M sd)	Min	Max
Age (year)	18	26.78±2.26	22.00	29.00
Body Height (cm)		177.76±4.40	171.56	188.41
Body Height (kg)		64.94±2.73	60.50	69.80
Training experience (years)		13.1±2.6	9.00	16.00

DISCUSSION

Handball is a contact sport that requires both high anaerobic and aerobic capacity and top-level performance. Similar to other contact sports, in handball, high aerobic capacity comes into play along with anaerobic capacity during the game, enhancing players' recovery speed Granados et al., (2008). Changes in the number and duration of weekly training sessions are crucial in enabling players to meet the intensity and duration of the game more effectively. It is stated that the weekly monitored training frequency and durations in team sports contribute positively to players, leading to improved muscular endurance, enhanced fitness values, and positive momentum based on their positions in the game (Williams et al., 2017).

In based on the conducted studies, it is emphasized that stabilizing and optimizing the pre-season training load of team sports players, as well as monitoring the training load throughout the entire competition period, is crucial for considering the players' positions regarding aerobic assessment Coutinho et al., (2015). The objectives of this study are as follows: a) To investigate the relationships between maximal aerobic speed, maximal oxygen consumption, and isokinetic strength in deaf handball players, aiming to provide insights into potential training programs that could be designed based on the obtained results. b) To explore the relationships between physical fitness and strength variables among deaf handball players over an 8-week standard club training period, focusing on maximum oxygen consumption VO2max), maximum aerobic speed MAS), and anterior and posterior peak torques at 60˚/s.

In their study focused on team sports, Beltz et al. (2016), designed a weekly training program in which the training load increased progressively, with a 10% increase in the first 2 weeks, 15% in the subsequent 3rd and 4th weeks, 20% in the 5th and 6th weeks, and a 25% increase in the last 7th and 8th weeks. This gradual increase ensured a consistent elevation in training load each week, allowing players to be aware of their individual training loads. Wolpern et al. (2015), in their study implementing a systematic increase in weekly training hours, noted parallel increases between training hours and training load, resulting in improvements in muscular endurance, cardiovascular fitness values, and alleviation of monotony for players. Our research aligns with similar structured literature, demonstrating comparable and parallel results regarding training hours and training load.

During the preseason initial four-week period, weekly training frequency and duration ranged between 350-400 minutes, while in the last six weeks, it increased to approximately 450-600 minutes per week.

Analysis of the physical and physiological variables in the study revealed variations in maximal oxygen capacity based on maximal contraction and maximum heart rates, depending on training variables, over the 8-week period among hearing-impaired men's handball players. Additionally, linear correlations were observed between changes in endurance parameters based on training durations and heart rate (Nopianto et al., 2021). During handball matches, players typically exhibit heart rates ranging between 165 and 198 beats per minute. In a one-hour match, on average, players' heart rates reach approximately 85% of the maximum heart rate, with heart rates exceeding 80% of the maximum for approximately 70-75% of the match duration (Hammami et al., 2022).

Pre- and post-test evaluations conducted over the 8-week period in both groups indicated closely aligned values of VO2 max levels, maximum aerobic speed MAS), and maximum heart rate HRmax) during endurance running. This alignment is believed to be due to handball's reliance on cardiorespiratory fitness, with sustainability stemming from the development and maintenance of such fitness. Results suggested high oxygen capacity and cardiac output in both groups, leading to increased oxygen supply to working muscles and demonstrating possession of maximum oxygen pulse associated with continuity. Additionally, both groups exhibited faster recovery post-exercise associated with maximum aerobic speed.

The results indicated that players from both groups possessed similar aerobic capacities, as evidenced by basic indicators of aerobic capacity. It is inferred that players from both groups reached the highest level of maximum oxygen consumption rate, likely due to extensive field coverage and running technique contributing to running economy. Furthermore, the manual nature

of handball play significantly influenced success. Considering field dimensions, the presence of short bursts followed by brief recoveries, and the importance of oxygen intake for recovery are crucial for regaining composure.

Bragazzi et al. (2020), states that aerobic capacity contributes to the ability of players to exert maximum effort during handball games, as well as to rapid recovery during low-intensity rest intervals, and is crucial in regeneration. The aerobic system can provide information for developing training and regeneration strategies to improve the performance of handball players and optimize their physical condition (Boraczynski & Umiaz, 2008). Such research is often used to create more effective training programs for athletes, reduce the risk of injuries, and enhance overall performance (Michalsik et al., 2013). Looking at the results obtained in terms of isokinetic strength; the similarity of the changes in fitness levels observed in both groups during the study has also led to similar results in terms of isokinetic strength. It can be said that the increase in weekly training durations is largely correlated with isokinetic peak torque during knee extension and the variation in the ratio of agonist/antagonist. Additionally, a significant superiority of the right lower extremity ratio agonist/antagonist) over the others is observed in terms of meaningful difference. Generally, in the handball training process, the division of the playing field into segments is believed to be beneficial for the increase in short and high-intensity movements sudden sprint, sudden deceleration, sudden changes of direction, etc.) and the development of handball-specific movements related to power. Moreover, similarities are observed between the increase in weekly training frequency and duration and the load-extension deficits. As a result, it is considered that the training process is a factor in complementing the deficits because in the case of deficits, the formation of a negative parameter between groups could have shown differences, and positive similarity is thought to stem from a closer resemblance to symmetry.

In a similar study, the relationship between medicine ball throwing and leg strength was investigated in a 6-week training program. The conclusion was that isokinetic strength and throwing speed increased equally (Andersen et al., 2018; Reader et al., 2015). In a different study conducted on elite young handball players, it was reported that different strength training programs showed significantly similar improvements in weekly training loads and durations over a 4-week period, with stationary and moving ball throwing speeds and leg isokinetics (Schwesig et al., 2016).

Aloui et al. (2021), examined the relationship between handball players' isokinetic shoulder strength and throwing speeds, determining that strength and throwing speed increased in parallel. In their analysis, Ignjatovic et al. (2012), investigated the correlation between isokinetic strength and various strength training regimens among handball players. They discovered that as the number of training sessions increased, handball players exhibited significantly greater improvements in performance tests. Furthermore, they noted that the ratio of agonist/antagonist muscles demonstrated a higher rate of development compared to other muscle groups. Similarly, Szymanski et al. (2007), conducted a 12-week study examining the effects of cross-training durations with different training programs involving moderate and heavy weights for both lower and upper extremities. They observed enhancements ranging from approximately 4% to 14% in the lower and upper extremities among player groups consisting of four distinct groups. Additionally, variations were noted in the ratio of agonist/antagonist muscle groups.

Conclusion

This study conducted on deaf handball players holds great importance in examining the relationship between different training frequencies-durations and significant fitness variables, given the limited and restricted literature in this area. From this perspective, the current study also has some limitations. The sample situation is one of the main limitations. Analyzing the relationship by collecting data only from one team and obtaining feedback from players may affect the inferences of the current study. Looking at systematically conducted previous studies, it is observed that the same limitations exist in those studies as well. Monitoring and analyzing multiple deaf handball players and teams pose certain challenges. Fitness values obtained based on weekly training frequencies and durations are highly similar and correlated with heart rate measurements and maximum aerobic speed values. On the other hand, for the variable of isokinetic strength, more information and a larger sample

size are required to explain the ratio of agonist/antagonist.

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Conflict of Interest

There is no personal or financial conflict of interest within the scope of the study.

Ethics Statement

This study followed ethical standards and received approval from the Çankırı Karatekin University (Health Sciences Ethics Committee) in Turkey with reference number (08/05/2023; 7).

Author Contributions

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

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RESEARCH ARTICLE

A Semiotic Analysis of A Sports Medical Drama Movie: Concussion

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Abstract
The increasing importance of concussion makes it necessary to read it from different perspectives within its reality. Therefore, this study aimed to comprehensively analyze the documentary film "Concussion" through Dr. Omalu's groundbreaking research lens. The study used semiotic analysis, a qualitative research method, to evaluate signifier-signified-sign and denotation-connotation in data analysis. In this context, The portraits of NFL, forensic pathologists, and team doctors were analyzed semiotically. The antecedents of athlete-rooted concussions and football participants' perceptions of American football were questioned. The study revealed that two phenomena become evident in the NLF's portrait: existential purpose and orientation toward threats. Another study result clarified that three main phenomena formed the portraits of the forensic pathologist and the team doctor: their behavior, mindset, and emotions. Research suggests that competition orientation is a leading factor for player-rooted concussion sequelae, characterized by the traits of war, hit, erase, fierceness, and endurance. Furthermore, American football was found to be depicted as a painful game that demands players' hardiness, winning will, awareness, strength, passion, forcefulness, and vigor. The connotation results maintained that American football is perceived as a battlefield, and a good footballer is interpreted as an assertive, resilient, aggressive, and challenging man overwhelming his opponents in any harsh way. In conclusion, the film invites viewers to consider how concussion affects football players and their families in the context of loss and trauma, how it inevitably exposes them to pain and death, and the struggle of a medical professional to prove a truth he has realized courageously.

Keywords
Athlete Health, Concussion, Mental Health, Soccer, Sport İnjury

INTRODUCTION

Sports-related concussion (SRC) is a severe type of sports injury that is receiving increasing attention worldwide. As per its current definition, SCR is a complex and pathophysiological process caused by biomechanical forces in the brain (Akıncı et al., 2021; Turner, 2019). SCR may momentarily disrupt the electrical activity of some brain cells, resulting in a brief cessation of proper brain functioning. This condition can lead to a range of clinical symptoms that may or may not include loss of consciousness (McCrea et al., 2013; McCrory et al., 2009). Considering the clinical effects of concussion, it became clear that the issue manifests itself as two comprehensive disorders with multiple dimensions. The first is early-phase posttraumatic disorder, which encompasses acute symptoms such as headache, dizziness, fatigue, sleep disruption, impaired cognition, and sensitivity to light and sound. The second is late-phase posttraumatic disorder, which includes somatic, emotional, and cognitive symptoms (Dwyer & Katz, 2018).

Yıldırım et al. (2020) state after sustaining a concussion, individuals typically experience a range of further physical symptoms, including nausea, sensitivity to light and sound, tinnitus, blurred or double vision, seizures, and sometimes even loss of consciousness. Cognitive symptoms

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such as slowed reaction time, difficulty concentrating, memory problems, weakness, and disorientation are also commonly seen. As emotional changes, athletes experience irritability, personality alterations, anxiety, depression, and eating disorders, may also occur. Moreover, sleep-related symptoms, such as insomnia, fatigue, or drowsiness, may be observed.

As Broshek et al. (2015) pointed out, elite athletes may indeed face significant cognitive and psychological effects from multiple concussions. Chronic Traumatic Encephalopathy (CTE) is a condition characterized by progressive neurodegeneration, which has been linked to repetitive concussions (Stein et al., 2014). Bennet Omalu, a forensic pathologist, discovered this disease in 2009 while performing an autopsy on retired NFL star Mike Webster (Mez et al., 2013).

The mechanism by which a concussion occurs is the most critical factor determining the injury's severity. The mechanism varies depending on the sport type and the athlete's position. Seiger et al. (2015), in their retrospective study, stated that concussions were most common in American football and football and that concussions resulting from motor vehicle accidents may be more serious injuries than typical concussions that occur during sports.

Studies in sports sociology present compelling evidence that psychosocial factors surrounding sports injuries, including concussions, are best understood in the context of sociocultural influences. This is due to the prevalent norms within sports culture that place greater emphasis on an athlete's performance over their well-being, often promoting and rewarding those who endure pain and injury as a means to gain respect (McGannon et al., 2013). However, Broshek et al. (2015).drew attention to the tendency to downplay the short- and long-term consequences of repeated head trauma.

While a concussion is often trivialized in the media and sporting circles as a “knock” to the head, the 2010 publication of the forensic pathology findings in a series of deceased professional American athletes aged 50 years or younger who died following suicide or after multiple suicide attempts, raised concerns regarding the possibility of long-term severe sequelae of repeated concussions (Khurana & Kaye, 2012).

In the scenes shown throughout the film, evaluating the events and facts surrounding the concussions experienced by football players playing in the American National Football League from the perspective of the work of Nigerian forensic physician Dr. Bennet Omalu and clarifying the psychosocial contents produced specifically for concussions in athletes constitute the other aims of the study. In line with these purposes, the research focuses on solving the following questions;

1. What is signified in portraying the organization featured in the film?

2. What is signified about the team doctor and the forensic pathologist as the main actors in the film plot?

3. What is intended to be shown about the athlete-rooted causes of concussion?

4. What does the movie produce the meaning of "American Football" through the individuals participating in sports?

The absence of semiotic analyses in existing research on sports-related concussions underscores the necessity for additional literature on narrative analysis. Regarding this necessity, documenting through a biographical sports drama film the signifier-signified-sign system, the system giving meaning to the signs in question, the codes generating the meaning, the intellectual structure, and the sociological implications that the codes reveal underpin this study's originality. The designed research will provide valuable insights to psychosocial experts in sports focusing on concussions, sports managers, scientists specializing in sports medicine and eclectic studies, and new researchers. This study is significant as it will help bridge a critical gap in the existing literature.

MATERIALS AND METHODS

This section provides crucial details regarding the utilized research model, the research unit, a brief overview of the film's content, and an in-depth analysis of the data gathered.

Research Design

This research used semiotic analysis method, one of the qualitative research designs. The study of signs is the subject of semiology, and the study of discourse and meanings is the subject of semantics. The systematic examination of verbal or non-verbal sign systems that constantly

reconstruct meanings is called semiotics (Mutlu, 2017). According to Rifat's (2022) interpretation, semiotics focuses on the form of the content and the elements that create meaning. Various indicators play a vital role in enhancing human communication. These include nonverbal cues like gestures and facial expressions, cultural practices like forms of worship, artistic creations like photographs and paintings, symbols like icons, and language itself. Semiotics focuses on three distinct areas: (a) the sign itself, (b) the codes or systems in which the signs are organized, and (c) the culture in which the signs exist (Fiske, 2010).

Ünal (2014) states that everything material or abstract that surrounds humanity is meant as a sign. As per the researcher, the objects, entities, or tools that are used and interacted with, the letters, words, and phrases used to express these, the terms used to describe various events, situations, and emotions, and the established systems, structures, and processes are telltale signs.

Ferdinand de Saussure argued that the most basic sign is language. His semiotic method emphasized that it consists of the holistic relationship between (a) the signifier and (b) the signified. Signifier is the word order that expresses the sign; the signified refers to the meaning created by this sign in the mind (Çakı et al., 2017; Güngör & Aydın, 2011; Mutlu, 2017). Fırat (2022) states that a sign represents something in any context or capacity. The signifier creates the meaning of the sign, and the interpretation of the signifier is shaped by one's mental understanding of the sign, as explained by Odyakmaz and Odyakmaz Acar (2008). Therefore, semiotics is a complex field encompassing multiple factors, as Akova (2020) noted.

Analyse Unit: A Brief Content of the Film

The severe injuries experienced by American Football players, such as critical head injuries, traumas, and brain injuries, have a tragic dimension that disables them for life. Director Peter Landesman, in his story based on a magazine article, emphasizes how the repetition of such damage affects the athletes and their lives.

Within the context of the game, Mike Webster is pointed out as the first player to suffer a concussion. Webster is a Hall of Fame Pittsburgh Steelers center. After his jubilee, he became homeless and led a self-destructive lifestyle. His persistent headaches, vision issues, and auditory hallucinations tested his fortitude, ultimately leading him down a path of self-destruction and substance abuse.

Before his passing, Webster is paid a visit by former football player Justin Strzelczyk. During this visit, Strzelczyk confides in Webster about his struggles with memory loss, erratic behavior towards his children, and nearly harming his wife. Despite the somber nature of this conversation, Webster responds with an unusual statement, suggesting that "all we have to do is to finish the game."

Bennet Omalu, a forensic pathologist in Pennsylvania, performed Webster's autopsy. Omalu closely examines microscope slides of his brain, wondering how a healthy man could be so damaged. On this examination, he finds evidence of austere neurotrauma. Omalu decided that Webster passed away as a result of the prolonged effects of repetitive beats to the head, a disorder he calls chronic traumatic encephalopathy (CTE).

Assisted by esteemed neurologists Julian Bailes, Steven DeKosky, and county coroner Cyril Wecht, Omalu shares his research in Neurosurgery, which the NFL swiftly disregards. Over time, Omalu uncovers that Strzelczyk, Terry Long, and Andre Waters, all deceased NFL players, displayed comparable symptoms to Webster.

After convincing newly appointed NFL commissioner Roger Goodell to allow him to present his findings before a player safety committee, Omalu was dismayed to find himself barred from attending the meeting. As a result, former NFL employee Bailes delivered the presentation on his behalf. Despite the gravity of the findings, the NFL dismissed them and denied any connection between head trauma and football. Former NFL Players Association executive Dave Duerson even went so far as to angrily confront Omalu, telling him to "go back to Africa."

Football is a widely beloved sport in Pittsburgh, providing jobs and college opportunities to players. Although, facing immense pressure, Omalu remained steadfast in his efforts to shed light on the dangers of football and refused to back down from his mission to uncover the truth. Wecht faces corruption charges due to political motives, while Omalu risks deportation and prison time for damaging the NFL's reputation. Prema, Omalu's wife, suffers an abortion after being chased in her car. The Omalus

are forced to leave their dream home outside Pittsburgh, relocating to Lodi, California, where he finds a job with the San Joaquin County coroner's office.

Prema, Omalu's wife, was exposed to an abortion after being chased in her car. The Omalu family is conceded to move their home outside Pittsburgh to settle in Lodi, California, where the doctor finds a job.

After three years, Omalu is justified when Duerson attempts to kill himself because he is unable to cope with worsening cognitive function. Duerson, in his suicide letter, clarified that Omalu was right and donated his brain for future research. Dr. Omalu has been extended an invitation to deliver a keynote speech on the subject of concussions and CTE at an NFLPA conference. During his address, he candidly reveals that there was a time he regretted ever knowing Mike Webster. Nevertheless, he recognizes that his connection with the late NFL player has instilled in him a duty to educate athletes about the perils of football. Dr. Omalu makes it clear that he bears no ill will towards the NFL and imparts on them to absolve themselves and seek inner harmony.

Throughout residual inspection from Congress, the NFL was compelled to give weight to the concussion issue. In 2011, NFL players indicted the league for not appropriately enlightening against the risks of CTE. Dr. Omalu was proposed for the job of Chief Medical Examiner for the District of Columbia. However, Omalu declined the offer to stay with his family in Lodi, becoming naturalized as a U.S. citizen in February 2015. A final fiction demonstrates reports of Junior Seau's suicide in 2012 and consecutive lawsuits brought against the NFL by thousands of former soccer players.

Descriptive Items of the Film as Research Unit

Table 1 provides the descriptive items of the movie ‘Concussion’.

Table 1. Descriptive items of the film

Descriptive Criterion	Details
Director	Peter Landesman
Story	Peter Landesman
Based on	"Game Brain" by Jeanne Marie Laskas
Producer	Ridley Scott, Giannina Facio, David Wolthoff, Larry Shuman, Elizabeth Cantillon
Cinematography	Salvatore Totino
Edited by	William Goldenberg
Music	James Newton Howard
Starring	Will Smith, Alec Baldwin, Gugu Mbatha-Raw, Arliss Howard, Paul Reiser, Luke Wilson, Adewale Akinnuoye-Agbaje, David Morse, Albert Brooks
Production	Columbia Pictures, LStar Capital, Village Roadshow Pictures, Scott Free Productions
Distributed by	Sony Pictures Releasing
Type	Sport Drama
Language	English
Released Date	2015
Running time	122 minutes
Country	United States

Data Analysis

According to Kaplan and Terek Ünal (2011), a text may analyzed at three levels: Discourse analysis, narrative analysis, and basic structure (logical-semantic structure) analysis. This study employed narrative analysis and discourse analysis methods. Narrative analysis investigates how the text content is organized; in other words, how people function in the plot and how these functions are articulated by creating a narrative. It also examines initial and final situations and the person and their actions that transform these two situations (Rifat, 2022). In analyzing the narrative of cinematic signs, the difference between "main

meaning and connotation" is essential, as Kaplan and Terek Ünal (2011) mentioned. In movies, actional relationship processes only sometimes go towards an end; occasionally, they are interrupted and continue by listing the same values without following a specific development. In other words, events progress in an episodic juxtaposition, as Sözen (2008) described. As Barthes (2023) states, what grounds the text is not a closed internal structure that can be foreseen but the point at which the text opens to other texts, codes, and signs. What makes a text is the intertextual relationships. Discourse analysis examines how a text is communicated linguistically, as well as its rhetorical dimension, which is concerned with the context in which the text is produced, including the time, space, and people involved (Kaplan & Terek Ünal, 2011).

This study carefully selected the sports medical drama movie "Concussion" as the research unit. The viewing experience was facilitated by the innovative online streaming platform Netflix, a renowned American technology and media services provider and production company headquartered in California. In order to fully comprehend the content of the film, a thorough and uninterrupted first viewing was conducted. This allowed for the creation of preliminary notes taken during the second and third viewings to address specific scenes in greater detail. In the next phase, the dialogues featured in the movie were transcribed and evaluated by a joint review of the recorded content and film footage. Following this iteration of the procedure, scenes that had been previously noted were carefully re-assessed and expanded. After careful consideration, the final decision was taken about which scenes illuminate the psychosocial processes experienced by American football athletes due to concussion, the managerial stance of the relevant league organization, the unique qualities of the team doctor and forensic pathologist playing pivotal roles in the plot, as well as another final decision was conducted about how the meaning of American Football is produced through individual sports players. Afterward, the analyzed expressions were meticulously subjected to a coding process. Finally, the determined codes were transferred to the study's thematic pattern as a signifier, signified, and signifier concept in the semiotic analysis and as the denotation-connotation construct in the narrative analysis.

Ethics Statement

This study was performed by adhering to the Helsinki Declaration. Ethical approval of the study was obtained from Istanbul Rumeli University Ethics Committee at the board meeting dated 17/01/2024 and numbered 2024/01-16.

RESULTS

This section provides research findings that align with this study's main and sub purposes.

The Sign-Signifier and Signed Trio

In accordance with the subject matter at hand, items have been unearthed and subsequently presented in tables. Each table outlines a detailed account of the items, providing a comprehensive overview of their respective attributes.

Semiotic analyses of the portrayal of NFL

The analyses showed to main topics about NFL, one is it's existential purpose, and the other it's orientation towards threats.

Table 2 indicates the semiotics NFL's existential purpose, while Table 3 highligts NFL's orientation towards threats.

Table 2. Semiotics of National Football League's Existential Purpose

Sign	Signifier	Signified
National Football League	NFL Managers	Power
National Football League	NFL Managers	Rule Maker
National Football League	NFL Managers	Confidentiality
National Football League	NFL Managers	Assertiveness
National Football League	NFL Managers	Harmony
National Football League	NFL Managers	Collaboration

The underlying essence and significance of the NFL's existence through the lens of semiotics can be portrayed through six phenomenon, respectively; power, rule maker, confidentiality, assertiveness, harmony, and collaboration.

Table 3. Semiotics of National Football League's Orientation Towards Threats

Sign	Signifier	Signified
National Football League	NFL Managers	Conservatism
National Football League	NFL Managers	Resistance to change
National Football League	NFL Managers	Loss of resistance
National Football League	NFL Managers	Acceptance
National Football League	NFL Managers	Harmony
National Football League	NFL Managers	Collaboration

Interpreting the NFL's orientation towards threats through semiotics brought light on six phenomena: conservatism, resistance to change, loss of resistance, acceptance, harmony, and collaboration.

Semiotic analyses of the team doctor's portrayal

The analyses showed three main topics about the team doctor: his behaviors, mindset, and emotions. Table 4 presents the semiotics trio of the team doctor's portrait.

Table 4. Semiotics of team doctor's portrait

Sign	Signifier	Signified
Team Doctor's behaviors	Team Doctor	Team cohesion
Team Doctor's behaviors	Team Doctor	Commitment
Team Doctor's behaviors	Team Doctor	Discreet
Team Doctor's behaviors	Team Doctor	Social support
Team Doctor's mindset	Team Doctor	Inquisitive
Team Doctor's mindset	Team Doctor	Self-reflective
Team Doctor's mindset	Team Doctor	Collaborative
Team Doctor's mindset	Team Doctor	Embracive
Team Doctor's emotions	Team Doctor	Helplessness
Team Doctor's emotions	Team Doctor	Astonishment
Team Doctor's emotions	Team Doctor	Sadness
Team Doctor's emotions	Team Doctor	Remorse

Upon analyzing the portrait of the team doctor, three significant aspects were identified as signs: his behavior, mentality, and emotional state, each pertained to four distinct subtopics. His behavior indicated a strong sense of team cohesion, commitment, discretion, and social support, while his mentality encompassed inquisitive, self-reflective, collaborative, and embracive tendencies. Furthermore, his emotions conveyed helplessness, astonishment, sadness, and remorse.

Semiotic analyses of the forensic pathologist's portrayal

The analyses mounted three main topics about the forensic pathologist: his behaviors, mindset, and emotions. Table 5 displays the semiotics trio of the forensic pathologist's portrait.

Table 5. Semiotics of forensic pathologist's portrait

Sign	Signifier	Signified
Forensic pathologist's behaviors	Forensic pathologist	Respectful even to dead people
Forensic pathologist's behaviors	Forensic pathologist	Commitment
Forensic pathologist's behaviors	Forensic pathologist	Discreet
Forensic pathologist's behaviors	Forensic pathologist	Inquisitive
Forensic pathologist's behaviors	Forensic pathologist	Fair
Forensic pathologist's mindset	Forensic pathologist	Interrogant
Forensic pathologist's mindset	Forensic pathologist	Self-reflective
Forensic pathologist's mindset	Forensic pathologist	Collaborative
Forensic pathologist's mindset	Forensic pathologist	Embracive
Forensic pathologist's mindset	Forensic pathologist	Uncommon
Forensic pathologist emotions	Forensic pathologist	Helpfull
Forensic pathologist emotions	Forensic pathologist	Impassioned
Forensic pathologist emotions	Forensic pathologist	Wise-hearted
Forensic pathologist emotions	Forensic pathologist	Calm
Forensic pathologist emotions	Forensic pathologist	Satisfied

By scrutinizing the portrait of the forensic pathologist, three significant aspects emerged as signs: his behavior, mentality, and emotional state, each concerned with five distinct subtopics. His behavior underlined a respectful orientation even to dead people, commitment, discretion, inquisitiveness, and fairness, while his mentality showed interrogative, self-reflective, collaborative, embracive, and uncommon tendencies. Furthermore, his emotions reflected helpfulness, patience, wise-heartedness, calmness, and satisfaction.

Semiotics of player-rooted sequelae antecedents

The analysis of the film flow has revealed some critical insights into the possible causes ofbrainconcussion initiated by player-rooted orientations. The conclusive findings of the analysis have been meticulously presented in Table 6.

Table 6. Semiotics of Contesting Orientation

Sign	Signifier	Signified
Contesting Orientation	NFL Soccer Players	War
Contesting Orientation	NFL Soccer Players	Hit
Contesting Orientation	NFL Soccer Players	Erase
Contesting Orientation	NFL Soccer Players	Fierceness
Contesting Orientation	NFL Soccer Players	Endurance

Table 6 indicates that the player-rooted antecedents of concussion sequelae can be succinctly summarized as "contesting orientation," which is characterized by the traits of war, hit, erase, fierceness, and endurance.

Analyses of narrative discourses

Denotaion-conotations of American Football

Throughout the film, utmost care was taken to reflect the literal and connotative meanings of the statements contributed by various individuals about American football. The findings are summarized and comprehensively presented in Table 7.

Table 7. Analyses of narrative discourses

Sayer/Signifier	Narrative Discourse	Denotation	Conotation
Former Player MW	Playing football can be very painful. To train twice a day under the sun and go head-to-head in that heat is not normal.	Football is a painful game due to difficult conditions.	Football is challenging for human health.
Former Player MW	All we have to do is finish the match; if we finish, we win.	Completing the match is winning.	Quitting the match is being a loser.
NFL Member	Do you want to weaken this country by softening football?	Hardness is strength.	Softness is weakness.
Coach A	This is an awareness game.	Football is awareness.	A footballer is an aware person.
Coach A	This is a game of passion.	Football is a passion.	A footballer is a passionate one.
Coach A	When I blow this whistle, find a teammate. No matter who it is fight!	Football is collision!	A footballer is a man who constantly collides!
Coach A	Be Tough!	Football players must be tough.	A footballer is a tough man.
Coach A	Be Aggressive!	Football players must be aggressive.	A footballer is an aggressive man.
Coach B	If you want to get rid of your opponent, you grab him by the throat and squeeze him. Squeeze him until he pees his pants.	In order to get rid of an opponent, it is necessary to strangle him so that he feels the big scare near his death.	Frightening an opponent is crucial to overwhelming them, so much so that they know they cannot stand a chance.
Commentator	You always have to be ready for big hits in American football!	Delivering hard hits is a fundamental aspect of the American football game.	American football is a battlefield.

According to narratives denotations in Table 7, American football is a painful game that demands players' hardiness, winning will, awareness, strength, passion, forcefulness, and vigor. The same table demonstrates the connotations as well. According to this connotation, American football is challenging for human health. To play a role in this game, a man should accept that softness is a weakness; American football is a battlefield, and a good footballer is an assertive, resilient, aggressive, and challenging man who also overwhelms his opponents in any harsh way.

DISCUSSION

Sport is inherently intertwined with socio-political context, embodying a sense of competition rooted in dominance and inter-group conflict dynamics. It is impossible to separate sports from these fundamental elements, which makes them a powerful arena for exploring and understanding complex societal issues (Guschwan, 2013).

Throughout history, sports have taken shape in the form of competitive activities and specialized training for sports-related professions. The purpose of these activities is to challenge individuals and enhance their physical capabilities. As such, the criteria for such challenges require a clear definition and symbolic representation within the context of sports (Saraf, 1977). This study aimed a semiotic analysis of a sports medical drama movie: Concussion.

The objective of this research was to conduct a semiotic analysis of the sports medical drama movie, Concussion. The study aimed to examine the signs, symbols, and meanings depicted in the movie, with a focus on how they contribute to the overall message and themes conveyed by the film. By analyzing the film from a semiotic perspective, this study sought to provide insights into the movie's cultural significance and its representation of sports-related injuries and their impact on athletes.

The comprehensive analysis conducted on the perception of American football among the participants of the sport revealed intriguing insights. The findings indicate that the players consider American football to be a challenging and demanding game that requires a combination of physical and mental traits. These traits include a strong will to win, heightened awareness, exceptional strength, robustness, and passion for the sport. The players must remain alert and resilient throughout the game, which can be physically exhausting due to the need for tremendous stamina and endurance. In a different

study, Michailidis et al. (2014) corroborates the results of this study, revealing how football, particularly as a grassroots sport, is a tool for social actors involved in creating teams, the game itself, and watching and experiencing sporting events to manage their passions. Overall, American football is a game that requires a combination of various attributes and skills to succeed and emerge victoriously.

Based on contextual implications, American football can lead to detrimental impacts on human health. To participate in this sport, an individual must have an unwavering belief that vulnerability is a significant setback. American football is similar to a battlefield, where a player's success relies heavily on determination, persistence, aggression, and perseverance. A player must be able to overpower their opponents through any means necessary, making this sport a physically and mentally demanding activity. In their study, Varlıgürer and Dönmez (2016) confirmed this research's results, stating that football functions as an area where the male-dominated discourse is dominated and recreated, with all layers of football being involved both as a spectator and a player. The researcher also underlines that sports are based on physical strength, endurance, aggression, competition, and race, making it associated with masculinity in almost every society.

This study has delved deeper into the underlying essence and significance of the National Football League's (NFL) existence, and has identified six key phenomena that depict the essence of NFL through semiotics. These phenomena include power, rule-making, confidentiality, assertiveness, harmony, and collaboration. The results suggests that the NFL's existence is not just limited to its popularity as a sport, but it also represents a manifestation of these six phenomena. The conducted analyses further suggests that these phenomena play a crucial role in shaping the NFL's culture and values, which are reflected in the league's policies, practices, and interactions with its stakeholders. The power, one of this six phenomena, refers to the ability of NFL to dominate the sports industry and shape the cultural zeitgeist. Rule-making signifies NFL's ability to set the standards and guidelines for how the sport is played and managed. Confidentiality refers to the league's ability to keep certain information and decision-making processes private, which contributes to its overall mystique. Assertiveness speaks to NFL's confidence and assertive approach to decision-making. Harmony denotes the league's ability to balance the interests of various stakeholders, including players, owners, and fans. Finally, collaboration highlights the league's ability to work with various partners and stakeholders to achieve shared goals and objectives.

Highlighting the gravity of the CTE crisis is the fact that it poses a threat to a deeply ingrained American cultural institution and an immensely lucrative industry. With over a hundred million fans spanning across the United States and a steadily expanding global following, the NFL's response to concussions is crucially important. Therefore, comprehending the reactions of diverse segments of the public to this issue is paramount for the NFL to adopt the most effective approach (Associated Press, 2014; Wilbur & Myers, 2016).

The study also questioned the National Football League's (NFL) approach to the threat of chronic traumatic encephalopathy (CTE) This neurodegenerative disease has been linked to repeated head injuries. The semiotical analyses brought six different phenomena related to this topic to light. These phenomena were conservatism, which refers to the tendency to maintain traditional beliefs and values; resistance to change, which denotes an unwillingness to accept new ideas or approaches; loss of resistance, which implies a gradual erosion of previous opposition to change; acceptance, which signifies a willingness to embrace new ideas or approaches; harmony, which refers to the peaceful coexistence of different viewpoints; and collaboration, which denotes a joint effort towards achieving a common goal. Through these analyses, the study aimed to shed light on the NFL's stance on this critical issue and provide insights into how different organizations can deal with similar challenges constructively and effectively.

Upon thoroughly examining the team doctor's portrait, the results discerned several noteworthy elements that offer valuable insights into his character and personality. These elements can be divided into three broad categories: conduct, mindset, and emotional condition, subdivided into four distinct subcategories. Firstly, in terms of conduct, the doctor's portrait suggests that he possesses a robust sense of team unity, dedication, discretion, and interpersonal support. This means he is committed to fostering a strong

sense of teamwork and camaraderie among the team members and is willing to go above and beyond to ensure the team succeeds. He is also very discreet and respectful of his colleagues' privacy and is always there to offer emotional support and guidance whenever needed. Secondly, the doctor's portrait reveals a curious, introspective, cooperative, and inclusive mindset. This means that he is always eager to learn and explore new ideas and perspectives and is willing to collaborate with others to achieve common goals. He is also very introspective, constantly reflecting on his thoughts and actions to improve himself. Finally, he is very inclusive and open-minded and is always willing to listen to others and consider their opinions and viewpoints. Finally, the doctor's emotional condition can be described as a mix of powerlessness, amazement, sorrow, and regret. This suggests that he is deeply affected by life's emotional ups and downs and is not afraid to show his vulnerability and humanity. He is often amazed by the beauty and complexity of the world around him but is also deeply saddened by the pain and suffering he sees. At the same time, he is not afraid to take risks and make mistakes and is willing to learn from his failures to grow and improve.

As another result, this study depicted that the forensic pathologist's portrait reflects three significant aspects that create a holistic picture of the individual: behavior, mentality, and emotional state. Each component signified five subtopics, providing a more detailed understanding of the forensic pathologist's personality.

The forensic pathologist's behavior is characterized by a respectful orientation, even towards deceased individuals. His two basic statements that reveal this orientation stand out in the film. The first is framed with the words, "I am a doctor. The dead are my patients. I utmost respect them." The other is woven with words, "If I know how they live, I know how they die." Another indication of Omalu's respect for the people he performed autopsies on was the conversations he had with each dead person before the autopsy. In one of these conversations, he tells Webster, "Mike, they are saying bad things about you. There is something wrong. However, I cannot solve this alone. I need your help to tell the world what happened." His respect is accompanied by a solid commitment to the profession, discretion in handling sensitive information, inquisitiveness in the pursuit of knowledge, and fairness in executing duties.

The mentality of a forensic pathologist is marked by several distinct tendencies essential for the successful execution of their responsibilities. These include an interrogative nature that is always seeking to uncover the truth, a self-reflective approach that enables the pathologist to learn and grow, a collaborative mindset that fosters teamwork and effective communication, an embracive attitude towards diversity and difference, and an uncommon perspective that allows for creative and innovative problem-solving. In one of his statements that shed light on these aspects of him, Omalu said: "Nowhere, neither in a book nor in a medical meeting. There has never been a case where a healthy man went crazy like this without any visible abnormality in his brain." In another response, he reveals his will with his words.: "People do not go crazy for no reason; I will continue investigating!"

Finally, the emotional state of a forensic pathologist is characterized by several desirable qualities that contribute to their effectiveness and well-being. These include helpfulness, a willingness to assist others, patience in dealing with challenging situations, wise-heartedness that allows for compassion and empathy, calmness in the face of stress and pressure, and satisfaction in their work.

Taken together, the findings of this study provide a comprehensive and detailed understanding of the forensic pathologist's portrait, highlighting the many qualities that make them such an essential and valued member of the medical profession.

This study has some limitations. First of all, this study is limited to the editing of the film analyzed. Another limitation of the research is that it focuses on the basic textures that become evident in fiction. Accordingly, NFL executives, the forensic doctor, and the former team doctor stand out as actors subjected to semantic analysis in the fiction. Other vital facts focused on in the research are the meaning of American football for its participants and, in addition, the scope of research on the CTE risks arising from the actions of football players.

Several limitations to this study warrant consideration. Firstly, it is confined to editing the specific film under analysis. Additionally, the research is oriented toward uncovering

fundamental themes that emerge in works of fiction. As a result, NFL executives, forensic doctors, and former team doctors are the primary subjects of semantic analysis within the work of fiction. The study also examines the significance of American football for its participants. It delves into the extent of research on the risks of CTE resulting from the actions of football players.

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In this study, the contribution rate of the sole author was 100%.

Ethics Statements

This study was performed by adhering to the Helsinki Declaration. Ethical approval of the study was obtained from Istanbul Rumeli University Ethics Committee at the board meeting dated 17.01.2024 and numbered 2024/01-16.

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RESEARCH ARTICLE

The correlation of endurance and speed on the performance of Long-Distance Runners 2022 in East Java Province

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Abstract
The study aims to investigate the correlation between anaerobic speed and endurance in the performance of a marathon 5 km. Twenty-one athletes (15 males(aged 16.7 ± 1.6 years old) and six females (aged 17.8 ± 1.2 years old). The study relied on A cross-sectional design with a survey test used for a 300 m sprint test, a balke test (Vo2 Max), and the time performed at 5 km. The results of the study analysis data showed that significant relationship between endurance and performance as the result of speed in the 5 km running (p=0.002, r = -0.735) in males. The male anaerobic power and performance had a strong correlation (p=0.000, r=0.944). Female long-distance runners showed a significant relation between VO2 max and performance (p= 0.016, r = -0.894). On the other hand, the anaerobic test had a significant correlation with performance (p =0.048, r =0.814). The study concluded that the endurance (Vo2 max) and speed (anaerobic 300 m) contributed to the running time of long-distance runners 5 K.

Keywords
Endurance, Speed, Performance, Long-Distance

INTRODUCTION

Long-distance running is one of the most popular sports today, as evidenced by amateur participation in hundreds of marathons around the world (Ahmadyar, et al., 2015). Long-distance running is a sport that requires higher aerobic endurance compared to short-distance running. (Nikolaidis, et al., 2020). Long-distance running is characterized by a relatively long running duration, varying from 15 minutes to several hours, and different intensities depending on the sport and the athlete's abilities. (Boccia et al., 2017). Typically, 30-60° is the maximum oxygen consumption capacity (VO2max). This value may vary depending on the runner's endurance, distance covered, and environment. Although middle-distance running events are characterized by a high relative contribution from the aerobic energy system (Spencer et al., 2001) and performance in these events are highly correlated with the speed at which maximal oxygen uptake is achieved (VO2max), the high speeds at which depend on the Power stand runner, distance taken, And the environment. elite races are completed and demand high levels of biomechanical power output and a well-developed anaerobic capacity (Di Prampero et al., 1993).

Efforts to improve performance in sports must go through a training process with a scientific approach based on related knowledge such as coaching, physiology, biomechanics, pedagogy, sociology, psychology, and health sciences (Callary et al., 2023). The dominant scientific

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approach with natural sciences such as biology, physiology, and biomechanics has had a significant impact on the development of sports achievements (Hardman, A., & Jones, C, 2011). The sports scientific approach certainly makes a significant contribution to the development of science and technology (IPTEK) in the process of data collection, management, and decision-making processes (Luczak. T, 2021).

The aerobic demands of submaximal running have ̇2 been widely investigated, with VO2max receiving the most attention because it establishes the upper limit of an individual's ability to produce energy through oxidative pathways (Joyner, 1993). It is well accepted that the major metabolic pathway used in distance running events is oxidative and that a high VO2 max is a prerequisite for success in national and international competition. In a recent review paper (Joyner, 1993), distance running was hypothesized to be limited to physiologic variables: VO2 max, lactate threshold, and running economy (RE). In elite athletes, Saltin and Astrand Saltın and Astrand (1967) found that VO2 max is the dominant factor in achieving better performance in endurance events.

Little attention has been directed toward the anaerobic power component of distance running. Among runners whose VO2max and RE are similar, the contribution that anaerobic energy production makes to the order of finish in a close race may be significant. Consequently, anaerobic factors may contribute more to success in distance running than previously recognized (Tharp et al., 1997) found significant relationships between velocity at VO2max, (r = 520.752), 50-m sprint time (r = 50.62), and peak knee extension torque at 4008·sec21 (r = 520.554) to 10-km run time.

Athletes involved in long-distance running often seek to significantly reduce body mass, especially upper body fat mass, to improve physical condition and speed and body efficiency to improve race performance (Knechtleet al., 2011). A carefully planned reduction in body mass index can contribute to increasing speed, improving dynamics, and increasing oxygen consumption of working muscles (Hoffman, 2008). As concluded by a study (Manore, et al., 2012), training in athletes should be based on increasing muscle endurance without excessively developing muscle mass. Greater VO2 max, endurance, and performance in athletes are better for predicting performance in marathon runners (Alvero-Cruz, et al., 2022). It should be noted that individual training for long distances often focuses only on running moderate distances and strengthening the lower limbs, neglecting general training and building skeletal muscle mass. Tests related to VO2 max with training variables (training load and speed) and anthropometric variables affecting long-distance race times (Alvero-Cruz et al., 2020). Five-week interval training reduced body weight, body mass index, fat, basal heart rate, and increased VO2 max (Lubis et al., 2022).

Maximum aerobic power, low body mass, and daily training of long duration and distance contribute to good performance times in long-distance running (Methenitiset al., 2022). Body composition can influence female athletes' elite running times (Mitsuzonoal., 1994). In long-distance running, especially in the case of continuous low-intensity efforts, it is mainly the aerobic capacity that is activated that correlates with performance and body mass index (Sengeiset al., 2021). Aerobic capacity depends on the amount of blood circulation, maximum heart rate, and lung capacity (Stögglet al., 2021). An athlete's performance is influenced by the time of maximum oxygen intake in the body, known as VO2 max. (Scheer et al., 2021). High-intensity training and running down mountains affect increasing VO2 max (Lemireet al., 2023). Physical performance is influenced by well-planned training (taking into account its duration and intensity), genetic and psychological factors (motivation), and the external environment (temperature, altitude, air humidity) (Belinchon et al., 2023). From a physiological point of view, physical activity is influenced by the activity of the cardiovascular and social systems. Strength training for leg muscles and abdominal muscles in adolescents is related to cardiorespiratory endurance (Moseset al., 2023). The two variables can also predict marathon performance, body fat percentage, and recovery heart rate (Kenneallyet al., 2021).lean the body forward running produces consistent acceleration performance (Nagahara et al., 2019)

MATERIALS AND METHODS

Study Design and Participants

The cross-sectional design with a survey test was used in the study. Twenty-six of the population in this study were all male and female athletes in long-distance running in the 5000m, who participated in the East Java Province Sports Games (PORPOV) in 2022. Based on the inclusion criteria, the athletes who signed informed consent and volunteered to be participants in the study were 21 athletes (15 male, and six female), and finished the long-distance running 5000 m championship. All participants completed a medical history and an informed consent form before testing. The Institute of Research and Community Service Center approved the study (Project no. 26/LPPM/STOK BINA GUNA/I/2022). All the data test procedures were conducted following the Declaration of Helsinki.
warm-upwas conducted before the test, including a jog, stretches, and some short sprints.The 300-m sprint was performed after all other tests had been completed because of the high level of fatigue reached during this test. Subjects were paired with a person of the same gender and a similar 5-km performance time to help elicit optimal performance. The 5-km race and the 300-m sprint data represented a competitive effort that allowed a more valid examination of the relationships between variables (Foster et al., 1993). From a standing start, the subjects were asked to run one 300-m race at maximum effort. Digital stopwatches (Accusplit, San Jose, CA) were used to record the total elapsed time for each runner.

Data Collection

Research Instrument

This study measured endurance by the Balke test. The Balke test was to get data on VO2 max by running for 15 minutes.

The speed variable data was tested by 300-meterrunning, and data obtained from the results was tested by the Athletic coach from each city in East Java, which was carried out four months before the 7th East Jave Province Games (POPROV) on June 29th – July 2nd,2022.

The performance of long-distance running was measured by the achieved time in running 5000 meters.

Maximal Oxygen Consumption (MaXVO2) Measurement

Before testing, subjects warmed up by jogging at an easy, comfortable pace for 5–10 minutes and then performed various stretches to reduce the risk of injury.

To estimate maximal oxygen power, an indirect method, the 12-minute run-walk test (Cooper), was performed. The results were determined by multiplying the number of laps run by the distance of each lap (400m) and adding the completed lap distance (in meters). MaXVO2 values were determined by Balke's formula (Balke, 1961).

MaxVO2 ml/kg-min. = 33.3+(X-150)x 0.178 ml/kg-min.

X= distance run in 1 minute

300 Meter Run Test

This test aimed to complete 300 meters in the quickest possible time. Ensure that a good

Data analysis

The data analysis technique used in this study was Pearson product-moment correlation coefficient analysis. All data were reported as descriptive statistics and correlation between physical condition and 5000m performance. The relationship between cardiovascular endurance (VO2Max), 300-meter running speed, and 5000m running performance was analyzed using the Pearson product-moment correlation coefficient with a significance level of p = 0.05. Statistical analysis using SPSS Statistics 26 software was used.

RESULTS

Based on the result showed that from the total of 26 participants long distance running in the East Java Province Games, only 88.8% fulfilled the inclusion criteria. The characteristics of data participants are shown in Table 1.

Table 1. Descriptive data of participants

Parameters	Female (N=6) M±SD	Male (N=15) M±SD
Weight (kg)	50.89 ± 4.73	54.64 ± 4.72
Height (cm)	163.17± 4.22	165.2 ± 3.89
Age (year)	17.83 ± 1.17	16.66 ± 1.58
Anaerobic	1.65 ± 0.04	1.63 ± 0.04
Vo2max	54.64 ± 4.72	50.88 ± 4.73
5k performance	19.99± 1.16	19.11 ± 1.53
BMI (kg/m^2)	19.11 ± 1.53	19.99 ± 1.16
BMI= Body Mass Index		

The normality test on male athletes showed (p = 200, p> 0.05), which means the distribution data is normal. While, for the female athlete's distribution data (p = 200, p> 0.05). The hypothesis is shown in Table 2.

Table 2. Hypothesis test for male athlete's long-distance running

		VO2 Max (ml/kg/min)	Speed (s)	Performance(s)
VO2 Max (ml/kg/min)	Pearson Correlation	1	-.721 **	-.735 **
	Sig. (2-tailed)		002	002
	N	15	15	15
Speed (s)	Pearson Correlation	-.721 **	1	.944 **
	Sig. (2-tailed)	002		.000
	N	15	15	15
Performance(s)	Pearson Correlation	-.735 **	.944 **	1
	Sig. (2-tailed)	002	.000	
	N	15	15	15

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

The normality test data of performance, VO2 max, and Speed for female athletes showed (p = 0.200, p > 0.05), so the distribution data was normal. Based on the distribution data, the data analysis for the hypothesis used parametric there is the person for product-moment because of more than 2 variables. The hypothesis test is shown in Table 3.

Table 3. Hypothesis test for female athletes of long-distance running

		VO2 Max (ml/kg/min)	Speed (s)	Performance(s)
VO2 Max (ml/kg/min)	Pearson Correlation	1	-.951 **	-.894 *
	Sig. (2-tailed)		.004	.016
	N	6	6	6
Speed (s)	Pearson Correlation	-.951 **	1	.814 *
	Sig. (2-tailed)	.004		048
	N	6	6	6
Performance(s)	Pearson Correlation	-.894 *	.814 *	1
	Sig. (2-tailed)	.016	048	
	N	6	6	6

**. Correlation is significant at the 0.01 level (2-tailed) ; *. Correlation is significant at the 0.05 level (2-tailed).

Table 3 presented that the female athletes the correlation between VO2 max and performance is – 0.894, its mean strongest correlation. The degree of relation between speed and performance is 0.814 is a strong correlation.

DISCUSSION

Metabolic effectiveness refers to the utilization of available energy to provide optimal performance, while cardiopulmonary efficiency refers to the smallest work output for processes related to oxygen transport and utilization (Peyre.

T. and Coertjens, 2018). Therefore, RE is an important physiological determinant of endurance performance (Kipp et al., 2019). Increased RE allows athletes to run at faster speeds for the same oxygen uptake (VO 2) and thus achieve superior performance (Hoogkamer et al., 2016).

According to McLaughlin et al. (2010), VO 2MAX explained 81% of the total variance, and RE accounted for an additional 11% of 16 km endurance running performance. These results complement what has been found in the literature as a predictor of maximal endurance running performance. These results are from previous research, which showed VO2Max and RE, as two main predictors of running endurance performance (Bassett and Howley, 2000).

The data showed the strongest negative correlation between VO2max, and speed, when the value of VO2 Max is more significant, and the speed is the shortest time for both male and female athletes in long-distance running. During training, the physical condition has improved even though not significant, because the physical condition is an effect of intensity, training session, body composition, and anthropometrics (Kagawa et al., 2023). This finding differs from a study that involved Body Mass Index and mass as good indicators compared to height (Sedeaud et al., 2023). The other study found that long-distance running training is practical in adapting endurance, body composition, and flexibility (Nikolaidis et al., 2021). Aerobic interval training for five weeks, two times a week, per session was a maximum of 77 minutes improved the physical condition of athletes (Lubis, et al., 2023).

Table 2 has two main findings, 15 male athletes of long-distance running 5000m revealed that the indicator of endurance (VO2 max) had a negative significant correlation with performance (finished time) (p = 0.002, r = -0.74). It means that when the VO2 max is higher the finished time gets shorter. The speed variable has a positive significant correlation to performance (p = 0.00, r = 0.94). It means that the correlation was inline, when the speed is quick, the finished time also fast. This finding has supported the study that VO2 max affected the time finished in the performance of trail runs (Ehrström, et al ., 2018). High maximal aerobic power (VO2 max) and running economy had a positive relationship in trained long-distance athletes (Shaw, et al., 2015).

In this study, the female athletes revealed the same result correlation as male athletes in long-distance running between VO2 max and speed on performance ((VO2 max, p = 0.016, r = -0.89), (speed p = 0.048, r = 0.94)). The previous study found that Speed and interval training increased the VO2 max of middle and long-distance running athletes (Wajib, M., & Sukma, 2022). The neuromuscular and muscle power characteristics were essential determinants of five km running performance. Run time and VO2 max correlated with maximal anaerobic power (p = 0.01, r = 50.68, p = 0.05, r = 50.54, respectively Paavolainen et al. (1991).

A cause-and-effect relationship between endurance performance and anaerobic training was demonstrated by Hickson et al. (1980). They determined that heavy resistance training increased endurance performance. The training program was designed to strengthen the quadriceps, with resistance placed at 80% of 1 repetition maximum. After the 10-week program, no change in VO2 max was found, but endurance time to exhaustion significantly increased by 8% when subjects exercised at 100% of their pretraining VO2 max.
In the present study, the results of the 5 anaerobic power tests were significantly intercorrelated (p<0.05). For example, the 50-m sprint was found to be significantly related to the plyometric leap test (r = 520.656), dynamic vertical jump (CMJ) power (r = 520.622), static vertical jump (SJ) power (r = 520.621), SJ height (r = 520.603), 300-m sprint time (r = 50.599), and CMJ height (r = 520.596). It is interesting to note that power was so well related to endurance performance, especially since so many of the subjects were training for a marathon. Marathon training typically reduces the size and power of fast-twitch fibers. The correlations of 50- and 300-m sprint times with 10-km run time indicate that as sprint time increased, so did 10-km runtime (r = 50.44,p<0.05 and r = 50.79,p< 0.05, respectively). Thus, individuals with faster 10-km run times tended to generate a greater degree of power on the anaerobic field tests and were able to sprint faster than their counterparts. Increased rate of force development and reduced time on the ground may be characteristic of the faster performers.

In the present study, both the 10-km race and the 300-m sprint were performed within a competitive environment. Consequently, the relationships between the 300-m sprint time with

the 10-km race performance can perhaps be viewed as a more valid measure than data from laboratory assessment. All of the relationships assessed in the present study were made with the 10-km run time that was performed in the competition. Thus, we avoided in part this limitation. In conclusion, the results of the present study showed a significant relationship between the plyometric leap distance, the results of both vertical jump tests, and both sprint times with 10-km run time (all $p < 0.05$). Multiple regression indicated that the plyometric leap distance and the 300-m sprint time were the best predictors of run performance, explaining 78% of the variance in 10-km run time (SEE, 2.92 minutes). Through the use of simple field tests of anaerobic power, one can predict success in 10-km run performance with a reasonable degree of accuracy in runners that are heterogeneous in ability (Sinnett et al., 2001).

Conclusions

The study concludes that endurance (VO2Max) has a negative relationship with performance and speed (an aerobic test 300-meter run) has a positive relationship with performance in both male and female athletes long-distance runners 5 km of the East Java Province Games in 2022.

The study recommends that coaches of long-distance running focus on increasing VO2 max and aerobic power to improve the performance of athletes.

Conflict of Interest:

There is no personal or financial conflict of interest within the scope of the study.

Information on Ethics Committee Permission

The study was approved and supervised by the departmental research committee, The Institute of Research and Community Service Center approved the study (Project no. 26/LPPM/STOK BINA GUNA/I/2022), dated 15 August 2022).

Researchers' Contribution Statement

Study conception and design: MW, SR, MEW and SS; Data Collection: MW, SR, MEW and SS; Analysis and Interpretation of results: MW, SR, MEW and SS; Draft manuscript preparation: MW, SR, MEW and SS; All authors reviewed the results and approved the final version of the manuscript.

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RESEARCH ARTICLE

Investigation of the Effect of Short-Term Karate Training on Walking Ability in Visually Impaired Children

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Abstract
This study aimed to investigate the effect of 6-week karate training on walking skills, a locomotor skill, in visually impaired individuals aged 10-14 years. A total of 20 visually impaired individuals participated in the study. To evaluate the walking skills of the visually impaired individuals, a 10-meter walking test was performed on a walking line that could be felt on the soles of the feet, and the participants' 10-meter walking time, step length, and step number values were recorded. SigmaPlot 11.0 program was used for data analysis. In the pre-and post-test comparisons, the Paired t-test was used for normally distributed data, and the Wilcoxon test was used for non-normally distributed data. In the comparison of two independent groups, a t-test was used for normally distributed data, and the Mann Whitney-U Test was used for non-normally distributed data. According to the findings, there was no statistically significant difference between the 10-meter walking pre-test results of the karate and control groups with and without glasses. When the post-test values were analyzed, a statistically significant difference ($p<0.05$) was found in all parameters of the karate group except the stride length parameter. In intra-group comparisons, while there was no significance in the pre-post test values of the control group, a statistically significant ($p<0.05$) difference was found in all parameters of the karate group. As a result, short-term karate training has a positive effect on the walking skills of visually impaired individuals aged 10-14 years.

Keywords
Visually impaired, Karate, Physical Fitness

INTRODUCTION

In visually impaired individuals, development lags, and the ability to move independently progresses differently than normal individuals (Sarimski, 1990). This is because not being able to see a reference point sufficiently limits the body's position awareness and the ability to maintain balance and adapt to new positions (Casselbrant et al., 2007). In addition to developmental delays in visually impaired individuals, different gait patterns emerge due to obstacle perception and balance problems. In individuals who can see at very narrow angles, different postures and gait patterns can be seen such as tilting the head to the side, turning, tilting forward to focus the angle of vision on the direction of movement during movement, extending the hands forward to prevent loss of balance during walking, to avoid accidents and to move safely, walking with slow but firm steps, limitation in joint movements while walking (Altunay & Akı, 2016; Arslantekin, 2014; Cengizel et al, 2022; Suveren-Erdogan, 2018; Suveren-Erdogan et al., 2018; Tuncer,T & Altunay,B, 1999).

Since physical awareness, correct body position, mobility, balance, and coordination skills can be supported and improved with sports, the importance of sports training in visually impaired people comes to the fore (Suveren-Erdogan, 2018; Suveren-Erdogan & Suveren, 2018). Sports

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activities are highly functional in minimizing developmental delay and the problem of independent movement in social life, to develop motor skills such as regular muscle activation, endurance, strength, balance, and coordination to provide the necessary motivation with self-confidence development and socialization (Altunay & Akı, 2016; Havik et al., 2010; Kalia et al., 2010; Winnick & Porretta, 2016).

People with disabilities can participate more in sportive activities by increasing the number of sportive activities they can do. Sportive activities can be adapted and diversified for individuals with disabilities, and such activities can increase their living standards and make their lives easier (Gallahue, 1987).

Walking skill, a locomotor skill, can be realized provided that the coordination and balance of the body are fully ensured. Individuals who have lost their eyesight and those who have no eyesight experience loss of balance due to obstacle perception problems. These balance losses cause injuries, especially during walking, and thus negatively affect social life (Coughlan et al., 2012; Jazi et al., 2012; Montarzino et al., 2007; Ray et al., 2008). Gait, posture, body control, and body management are part of the independent movement (Pogrund et al., 2012; Yılmaz, 2011). Planning sportive exercises to include auditory and kinesthetic stimuli can be used as a method to minimize balance losses by increasing the activation of motor skills (Deliceoğlu et al., 2017; Murphy, 1989; Pogrund et al., 2012). Karate exercises meet this need because they include both breathing techniques and audio stimuli while applying techniques. At the same time, since the karate techniques used for kata do not require traveling too much distance, it is essential for the body to maintain its position more quickly and to activate different functions in the meantime.

The fluent realization of walking skills is one of the most critical factors affecting the lives of visually impaired individuals. The limitation of movement caused by the lack of vision often constitutes a significant obstacle for visually impaired individuals to participate in social life and to do their daily chores without assistance. Improving walking skills helps them to open up to the outside world more efficiently, to be more independent in their social life, and to improve their quality of daily life. In addition, increasing self-confidence allows visually impaired individuals to mix with the outside world in compulsory situations and for social activities. Karate activities can become a form of self-expression by allowing visually impaired individuals to act together in a social environment and develop walking and balance skills. Visually impaired individuals can even participate in competitions in para-karate by progressing in this field. Based on all this information, the study aimed to investigate whether the 6-week teaching of basic karate (kihon) techniques planned for visually impaired individuals can improve walking skills in visually impaired individuals.

MATERIALS AND METHODS

Research Model

This quasi-experimental study includes pre-test and post-test evaluations with karate and control groups.

Study Grups

A total of 20 visually impaired individuals participated in the study. 10 participants were included in the karate group (5 boys, 5 girls) and 10 in the control group (6 boys, 4 girls). The karate group was given karate training in addition to physical education classes one day a week for 6 weeks, while the control group only attended physical education classes and continued their daily lives. This study followed ethical standards and received approval from the Gazi University with reference number (Approval Number: 2023 - 1052). For this study, the necessary permissions were obtained from the Mitat Enç Secondary School for the Visually Impaired administration and the parents of the students from with informed consent for the participants. 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 Tools

The "10 m Walking Test Scale" was applied to the students who voluntarily participated in the study.In the 10 m Walking Test; 10-meter-long starting and ending lines were drawn, a thin rope was placed on the 10-meter walking line, and visually impaired individuals were made to feel the ground with their soles. To prevent differences in vision levels from affecting the study, the tests were performed without glasses and with goalball goggles. In this way, the effect of the subjects'

vision on their walking skills was also tried to be revealed. Each subject crossed the starting line on command and the time was started. The subjects recorded in seconds. In addition, the length and number of steps taken by the subjects during walking were also recorded. Step lengths were calculated in cm by dividing the number of steps by 10 m.

Ex: Number of steps taken by the subject 30

1000 cm (10 m) / 30 steps = 33.3 cm (step length)

These measurements were administered to individuals who voluntarily agreed to participate in the study under the supervision of experts in the field in a suitable ground and environment. In the application phase of this test for the visually impaired, an audible stimulus was given using a rattle and the subjects were asked to move towards the audible stimulus.

sesli uyarana doğru hareket etmeleri istenmiştir.

Inclusion Criteria for the Study

a) The participant has a visual impairment

b) The participant must be between the ages of 10 and 14.

c) Not having any other disability related to visual impairment.

Exclusion criteria

walked to the finish line at an average walking speed and the time was terminated when they crossed the finish line. The elapsed time was

a) No physical injury or surgery in the last 6 months.

b) Not to have participated in more than 2 workouts.

Limitations

At the beginning of the study, 12 people were included in the control group and 14 in the karate group. However, 2 people from the control group and 4 from the karate group were excluded from the study due to not participating in more than 2 studies and health problems.

Data Analysis

SigmaPlot 11.0 program was used for data analysis. In the pre-and post-test comparisons, the Paired t-test was used for normally distributed data, and the Wilcoxon test was used for non-normally distributed data. A t-test was used to compare normally distributed data in two independent groups, and the Mann Whitney-U Test was used to compare non-normally distributed data.

RESULTS

Table 1: Analysis of Pre and Post-Test values of karate and control groups for 10 m walking with and without glasses

		Control					Karate				
10 m Walk Test Parameters		Mean		SD			Mean		SD		
		Pre Test	Post Test	Pre Test	Post Test	p	Pre Test	Post Test	Pre Test	Post Test	p
Walking Time with Glasses	(sn)	19,150	19,160	5,707	5,714	0,092	17,547	15,503	2,377	2,249	**0,001**
Walking Time without Glasses	(sn)	19,460	19,448	5,814	5,788	0,412	18,055	15,606	2,124	2,214	**0,001**
Number of Steps with Glasses		29,750	29,750	1,708	1,258	1,000	28,600	26,500	4,248	3,923	**0,001**
Number of Steps without Glasses		30,000	30,750	1,633	1,500	0,215	29,100	25,200	4,841	4,131	**0,001**
Step Length with Glasses	(cm)	33,650	33,650	1,905	1,905	1,000	35,770	38,290	5,011	5,367	**0,001**
Stride Length without Glasses	(cm)	32,525	32,525	1,595	1,595	1,000	34,450	37,560	6,047	6,211	**0,001**

($p<0,05$)

When the pre-test results of the 10 m walking test with and without goggles for the Karate and Control Groups were analyzed, no statistical significance was found between the pre-test values. When the post-test values were analyzed, a statistical significance was found in all parameters of the Karate group except the step length parameter. In contrast, no statistical significance was found in any control group parameter.

Table 2: Intragroup comparison of 10 m walking Pre-Post Test values of control and karate groups

		Pre Test					Post Test				
10 m Walk Test Parameters		*With Glasses*		*Without Glasses*			*With Glasses*		*Without Glasses*		
		Mean	*SD*	*Mean*	*SD*	*p*	*Mean*	*SD*	*Mean*	*SD*	*p*
Karate Gr. Walking Time	(sn)	17,547	2,377	18,055	2,124	0,089	15,503	2,249	15,606	2,214	**0,001**
Karate Gr. Number of Steps		28,600	4,248	29,100	4,841	0,485	26,500	3,923	25,200	4,131	**0,002**
Karate Gr. Stride Length	(cm)	35,770	5,011	34,450	6,047	0,245	38,290	5,367	37,560	6,211	0,450
Control Gr. Walking Time	(sn)	19,150	5,707	19,460	5,814	0,268	19,160	5,714	19,448	5,788	0,125
Control Gr. Number of Steps		29,750	1,708	30,000	1,633	1,000	29,750	1,258	30,750	1,500	0,092
Control Gr. Stride Length	(cm)	33,650	1,905	32,525	1,595	0,080	33,650	1,905	32,525	1,595	0,080

(p<0,05)

When the pre-test and post-test results of the 10 m walking test with and without glasses in the control group were analyzed, no significant difference was found in any parameter. In contrast, statistical significance was found in all parameters between the pre-test and post-test values of the Karate group.

Table 3: Intergroup Comparison of 10 m Walking Pre-post Test Values of Karate and Control Groups

		Pre Test					Post Test				
10 m Walk Test Parameters		*Mean*		*SD*			*Mean*		*SD*		
		Control	*Karate*	*Control*	*Karate*	*p*	*Control*	*Karate*	*Control*	*Karate*	*p*
Walking Time with Glasses	(sn)	19,150	17,547	5,707	2,377	0,456	19,160	15,503	5,714	2,249	0,099
Walking Time without Glasses	(sn)	19,460	18,055	5,814	2,124	0,503	19,448	15,606	5,788	2,214	0,086
Number of Steps with Glasses		29,750	28,600	1,708	4,248	0,616	29,750	26,500	1,258	3,923	0,138
Number of Steps without Glasses		30,000	29,100	1,633	4,841	0,728	30,750	25,200	1,500	4,131	**0,025**
Step Length with Glasses	(cm)	33,650	35,770	1,905	5,011	0,436	33,650	38,290	1,905	5,367	0,088
Stride Length without Glasses	(cm)	32,525	34,450	1,595	6,047	0,551	32,525	37,560	1,595	6,211	0,144

with and without Glasses

(p<0,05)

When the pre-test results of 10 m walking with and without glasses for the karate and control groups were analyzed, no statistical significance was found between the two groups. When the post-test results of the karate and control groups were analyzed, there was a statistical significance between the two groups only in the number of steps variable. In contrast, no statistical significance was found in any other variable.

DISCUSSION

The study examined the effect of short-term karate training on walking skills in visually impaired children, and 10 m walking time, step number, and step length parameters of the participants in the karate and control groups with and without glasses were examined. In the pre-tests, there was no significant difference between the two groups in walking with or without glasses. Still, in the post-tests, it was found that there was a significant difference (p<0.001) in favor of walking with glasses in the walking time parameter examined with and without glasses and a significant difference (p<0.002) in favor of walking without glasses in the step count parameter.

Vision helps to make sense of sound and movement experiences, provide motivation, and make sense of the world. Vision provides 80% of the information we receive from the outside (Cengizel et al., 2002). Communication with the environment, proprioception, and body awareness are extremely important for movement. Children with visual impairment are at risk of developmental processes due to learning difficulties because they cannot observe how people perform specific movements and model how they move their bodies while growing up (Mori & Olive, 1978). Postural adaptation limitations seen during gait in children with visual impairment may be due to the lack of vision, an essential motivator for early movement. Compared to the development of the sighted child, the motor development of the visually impaired child is

largely dependent on external guidance (Özyürek, 1995). At the same time, visually impaired individuals have different problems arising from lack of movement. Many studies show that visually impaired children's cardiovascular endurance is lower than their sighted peers (Hopkins et al., 1987; Kobberling et al., 1989; Lieberman & McHugh, 2001; Short & Winnick, 1986). Kobberling, Leger, & Jankowski (1989) and Short and Winnick (1986) suggest that children with visual impairment have consistently lower physical fitness than their sighted peers (Kobberling et al., 1989; Short & Winnick, 1986). It is stated that visually impaired children show delays in acquiring movement skills such as rolling and walking, which enable them to change places. They have problems developing posture, gait, trunk, extremity strength, flexibility, motor planning, body rotation, and coordination (Celeste, M. A., 2002; Sundberg, 1982).

Some typical views have emerged in studies on the gait pattern of visually impaired individuals. In a study comparing the stride-time parameters of sighted, later blind, and congenitally blind individuals, it was shown that visually impaired individuals have a slower walking speed, a shorter stride length, and a longer stance duration. These adaptations reflect a strategy to maintain a more stable posture without vision (Hallemans et al., 2011).

Postural stabilization during gait helps to improve motor performance. Reasonable postural control is dependent on good balance skills. Healthy individuals have been observed to compensate for disturbances during locomotor movements through "anticipatory postural corrections," which are known to precede the onset of voluntary movement and use a lateral swing foot placement strategy (Caderby et al., 2014; Roden-Reynolds et al., 2015). In a study conducted by Altunay Arslantekin, Altuntaş et al. (2015), the functional balance of individuals with and without visual impairment (Porro et al., 2005) was compared, and it was determined that the functional balance score was lower in individuals with more visual impairment (Altunay & Akı, 2016; Arslantekin, 2014). Akyol et al. (2017) concluded that sports positively affect balance and walking distance. They stated that visually impaired individuals can become more independent in their daily activities if directed to sports (Akyol et al., 2017).

In some studies in the literature, it has been reported that visually impaired individuals have shorter stride lengths, longer stance phases, slower gait, and less trunk flexion than sighted individuals (Hallemans et al., 2010; Nakamura, 1997; Ranavolo et al., 2011). The study conducted by Porro et al. (2005) found that a significant proportion of visually impaired students could not keep their heads upright while walking and the spine was tilted forward. This may be due to decreased postural tone and negatively affecting shoulder girdle and trunk stability. The study's results support the study conducted by Porro et al. (2005) (Porro et al., 2005). The researchers also observed that the subjects who participated in the study were limited in walking along a straight line. Huri concluded that basic position combinations, weight transfers, and direction changes also influence the vestibular system in many studies. In contrast, basic standing positions are very useful and applicable exercises in the gait training of visually impaired individuals (Huri et al., 2015).

In his study, Suveren concluded that wall-supported exercises positively affected the balance and walking skills of visually impaired individuals. In another study conducted by Suveren and colleagues, it was observed that basic postures positively affected visually impaired individuals. It is among the findings of the study that visually impaired individuals who successfully perform basic postures and combinations have smoother and safer walking skills, as well as increased walking distances, reduced balance losses, and fewer deviations (Suveren-Erdogan, 2018; Suveren-Erdogan et al., 2018). Urhan (2018) applied a 1-mile run-walk-run test to visually impaired children at the end of rope jumping and strength exercises, improving walking times and other findings (Urhan, 2018) .

As a result, the fact that there was a significant difference between the pre and post-tests as a result of the karate (kihon) training applied for 6 weeks in the karate group and that there was no significant difference in the control group shows that the karate training is beneficial for visually impaired individuals. It is thought that there was no significant difference in all parameters in the intergroup comparison related to the functional movement capacity of the participants, obstacle perception problems, the short duration of the study, and the training content. When the literature was examined, it was

found that physical activity improves gait, balance, and physical fitness in visually impaired individuals.

It is thought that extending the training duration and enriching the training content with exercises that require space, such as kata, may be more effective on the walking skills of visually impaired individuals.

Conflict of Interest

No conflict of interest was declared by the authors. In addition, no financial support was received.

Ethics Statement

This study was approved by Gazi University and Human Research Ethics Committee (Approval Number: 2023 - 1052).

Author Contributions

Planned by the authors Study Design- CS; Data Collection- CS,YA,SA; Statistical Analysis – YA,CS; Data Interpretation- YA,SA; Manuscript Preparation- CS,SA; Literature Review- YA,SA. The authors have read and accepted the published version of the article.

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