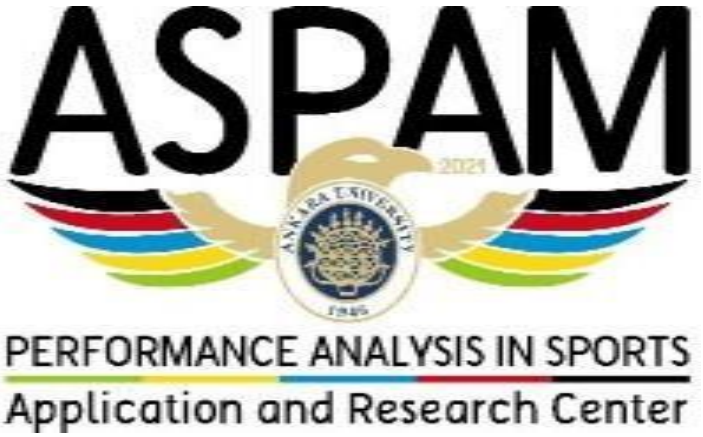
ANKARA UNIVERSITY SPORTS SCIENCES FACULTY

PERFORMANCE ANALYSIS IN SPORTS APPLICATION & RESEARCH CENTER



PERFORMANCE ANALYSIS IN SPORTS AND EXERCISE

Volume: 2

Issue: 2

December 2023

PERFORMANCE ANALYSIS IN SPORTS AND EXERCISE (PASE)

Preface

The Performance in Sport and Exercise aims to provide its readers with the highest quality and effective articles through a careful peer review and editorial work process. The articles to be published include both detailed scientific methods and guided results for sports professionals, providing the opportunity for immediate application in the field. In this sense, itwill contribute to the field of sports sciences by fulfilling the requirements and observing ethical principles.

The Performance in Sport and Exercise is the official journal of Ankara University Performance Analysis in Sports Application and Research Center (ASPAM). The ASPAM isa center established to combine theoretical knowledge and experience in all sports-related subjects and to contribute to the field of sports sciences.

The Performance in Sport and Exercise is published biannually (June and December) in English. The Journal publishes scientific papers in the scope of sport, exercise, physical activity, exercise and health, sports medicine, biomechanics, sport and exercise physiology, sport and exercise psychology, performance in sport, training, and technology in sport. As the editorial board, we sincerely wish the first issue of our journal to be beneficial to the sports science community.

Table of Contents

Performance Analysis in Sport and Exercise

Ankara University Performance Analysis in Sports Application and Research Center

Available online 31 December 2023

The Effect of 6-Week Basic Gymnastics Training on the Flexibility Parameters of Preschool Children

Müge Ünal [1*], Erdem Çakan [1]
[1] Institute of Health Sciences, Ankara University, Ankara, Turkey

Abstract

The aim of this study is to examine the effects of a six-week basic gymnastics training program on the parameter of flexibility in preschool children aged 6, as determined by conducted tests. The developmental changes in flexibility parameters, which are components of physical fitness in children due to early basic gymnastics training, were investigated. This research was conducted with a total of 21 participants. Measurements were determined as initial measurement - final measurement to understand the participants' status before the education. Measurements after six weeks of basic gymnastics training, conducted twice a week for one hour, were compared with the initial measurements. As a result of the examination, it was seen that gymnastics training contributed positively to the parameters of flexibility, balance, and strength.

Key Words: Flexibility, preschool, basic gymnastic training

INTRODUCTION

Gymnastics

Gymnastics is one of the special sports branches that want high levels of mixed movements, advanced performance where multiple motor skills are used at the same time. One of the subjects that makes gymnastics special is that it is a sport that constantly renews itself in terms of movements even though there are countless movements. It contributes to the development of various motor skills such as knowing how to use the body, maintaining balance in body positions, and improving strength and flexibility (27).

In itself, it is divided into artistic gymnastics, rhythmic gymnastics, trampoline gymnastics, aerobic gymnastics, general gymnastics, step, step-aerobics and pilates (27).

Gymnastics is a sport that dates to the ancient Greek civilization. At that time, a special physical education such as Gymnastics belonged only to the “noble class” children. It was later adopted in Roman civilization. Subsequently, after the Renaissance and Reform periods, it was put as a course in schools in various European countries. Gymnastics, which was not truly seen as an educational tool from around 1450 to 1800, began to gain popularity in the mid-19th century. In 1811, the first open-air gymnastics area was opened in the meadow called Hasenherde in Berlin, laying the foundation of German folk gymnastics. German Friedrich Ludwing Jahn is considered the person who shaped the artistic gymnastics used today (1).

Preschool Period and Developmental Characteristics in Children

It is known that the education implemented in the pre-school period has a great impact on determining the future lives of children. Environmental and hereditary interactions are determining factors for development (16).

Development and developmental characteristics are directly related to the environment and heredity, as well as the evaluation of developmental stages over time. Important time periods in terms of development are called "critical periods". If the organism has the necessary genetic potential during critical periods, it is possible to develop at the highest level in terms of some behaviors or some organs and their functions when it encounters sufficient stimuli. A child's development follows a certain path, but each child progresses along this path in a peculiar way. Although every normal child is ahead of others in some aspects and behind in others, the timely and inevitable sequence of developments in every period of childhood is a definitive sign of normality (16).

In a child who is six years old, the movements of the trunk, arms and legs are in harmony. In the gymnastics branch, these ages have an important place in terms of specialization (6).

Gymnastics Practices in Preschool Period

Gymnastics activities to be carried out in the preschool period should be chosen primarily in accordance with the development level of the child. It is appropriate to start at the game level and then move on to regular actions. Movements should be arranged from simple to difficult. Starting with a movement that children are accustomed to and enjoy increases their interest. Movements that require strength, challenging and a high degree of coordination movements should not be included in the program. Movements that require attention and have complex

rules should be avoided (17).

The Effect of Gymnastics Branch on Motor Development in Children

Motor development includes movement skills, especially under the influence of physical and biological changes, as well as interacting with all other areas of development (21). Gymnastics helps children to develop cognitive and social skills, relax emotionally, develop self-development, develop a sense of independence, entertain themselves (17). The most important benefits of gymnastics sport are its contribution to children's physical and motor development. Activities such as running, jumping and hopping during warm-ups, climbing on the gymnastics equipment during exercises, running on it, jumping, moving using one's own body, and getting off the equipment, all movements that constitute gymnastics, contribute to the child's cardiorespiratory system and muscle strength and endurance. During all these movements, different muscle groups in the body work and thus ensure their development. Gymnastics contributes to the development of the body's flexibility with bridges made using body parts, leaps made by opening the legs, stretching and stretching movements to cool the body at the end of the workout.

While gymnastics helps children develop skills from simple to more complex skills, it also supports their motor development (9).

Flexibility

The term flexibility in English-based literature has been adapted as (flexibility) in our sports literature. Flexibility, physical harmony is defined as a component of the ability to function within the framework of the normal opening of the joints. In other words, it can be said that it is the angle at which the joint moves freely within the normal width of movement (19).

Flexibility measurement can be easily performed with tools such as goniometer, flexiometer, tape measure, anthropometer, measuring sticks and caliper. Electrogoniometers, autogoniometers are also used. The most widely used flexibility test in mass measurements, health-related physical fitness test batteries and as a rough indicator of flexibility is the sit-access test (12).

METHODS

Research model

The study was designed with a single-group pretest-posttest design. Since the subjects were underage before starting the study, approval was obtained from the subjects' parents. The subjects participated in the measurement before the study in a random order. Measurements were taken at 17.00 before training in the Sınav College Gymnastics Hall; It was taken with v-sit test, reach-out test and split test. The study was applied for 6 weeks. The working order is mainly designed for flexibility, balance and strength. Working 2 days a week, 1 hour; 5 min warm-up, 20 min gymnastics-specific line work, 15 min gymnastics-specific work, 15 min specially prepared training for one of the flexibility-strength-balance parameters and the last 5 min cooling-down training program was applied. At the end of 6 weeks, the students were subjected to the v-sit test, reach-out test and split test for the second time, and the measurements were again taken in the Sınav College Gymnastics Hall.

Table 1. Weekly Exercise Schedule

Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
5-minute Warm Up Exercise	5-minute Warm Up Exercise	5-minute Warm Up Exercise	5-minute Warm Up Exercise	5-minute Warm Up Exercise	5-minute Warm Up Exercise
20-minute Gymnastics-Specific Line Exercise	20-minute Gymnastics-Specific Line Exercise	20-minute Gymnastics-Specific Line Exercise	20-minute Gymnastics-Specific Line Exercise	20-minute Gymnastics-Specific Line Exercise	20-minute Gymnastics-Specific Line Exercise
15-minute Gymnastics-Specific Exercise	15-minute Gymnastics-Specific Exercise	15-minute Gymnastics-Specific Exercise	15-minute Gymnastics-Specific Exercise	15-minute Gymnastics-Specific Exercise	15-minute Gymnastics-Specific Exercise
15-minute Flexibility Exercise	15-minute Flexibility Exercise	15-minute Flexibility Exercise	15-minute Flexibility Exercise	15-minute Flexibility Exercise	15-minute Flexibility Exercise
5-minute Cool Down	5-minute Cool Down	5-minute Cool Down	5-minute Cool Down	5-minute Cool Down	5-minute Cool Down

Research Group

A total of 21 volunteer pre-school children, 11 girls and 10 boys, who had just started gymnastics, participated in the research. Approval was obtained from the parents of the participants whose age was determined as 6 years old, height (114,00 ± 9,10 cm), body weight (20,11 ± 3,39 kg), body mass index (15,25 ± 1,26 kg/m2). The limitations of the study were that the children did not engage in any other sports in their daily routine before the measurements, that they fully participated in the organized program, and that they had experienced a serious injury and/or illness in the last month.

Data Collection Tools

Anthropometric measurements: Participants' body compositions were determined using the Avis 333 Plus analyzer (Korea) while individuals were in a standing position, wearing only gymnastics leotards. Heights were measured using the Holtain stadiometer with a 1 mm interval (Holtain, U.K.). To avoid affecting reliability, measurements were taken without shoes, and participants wore only leotards. Height, body weight, and body mass index parameters were recorded.

Sit-and-Reach Flexibility Test: This test is used to measure the flexibility of the lower extremities, lumbar region, and hamstring muscle groups. The participant was instructed to sit on the reach box with bare feet, fully supported on the ground. During the measurement, legs and arms were kept straight, palms facing down on the reach box, and participants were asked to slowly reach forward until they could stretch their bodies to the furthest point. They were then held at the stretched position for at least 2 seconds. The measurement was performed twice, and the highest value was recorded. The Baseline Sit and Reach flexibility measuring box (New York, USA) was used for flexibility.

V-Sit and Reach Test: No material was used for the V-sit and reach test. This test, which has high reliability coefficients, was employed to measure flexibility. The participant's heels were considered the zero point, marked on the ground. Participants were instructed to sit on the floor with legs stretched and feet toes up, heels in contact with the ground, and 30 cm between the two feet. The point where the heels touched the ground marked the zero point, and a straight line was drawn over two points from this point. Participants were then asked to stretch their upper bodies forward without bending their knees. The reached point was measured with a ruler

and recorded.

Splits Test: The splits flexibility test is performed to determine the flexibility of athletes' lower extremities. In sports where lower extremity flexibility is crucial, such as gymnastics and taekwondo, this test is easily applicable. Participants were asked to perform the splits position with the body upright, facing forward, knees in extension, and legs spread as far apart as possible. The distance between the pubic point of the participant and the floor was measured with a ruler, and the result was recorded in centimeters.

Data Analysis

To determine whether there is a significant difference in the data obtained from the measurements, paired-sample t-tests were conducted on pre- and post-test values. IBM SPSS Statistics 25 (IBM, Armonk, NY) was utilized for all statistical analyses. The significance level was set at 0.05.

FINDINGS

This section contains the statistical comparisons of the data obtained regarding the changes in flexibility parameters between the initial and final measurements after a 6-week gymnastics training.

Table 2. Tests Measurements Results

Tests	Pre-test	Post-test	t	p
Reach-Out	22.47 ± 2.83	23.30 ± 3.26	-1.87	.076
V- Sit	8.09 ± 3.03	8.92 ± 3.48	-5.22	.000
Split	14.23 ± 4.13	12.95 ± 4.44	5.92	.000

As a result of the conducted study, improvement was observed in the v-sit test and split test with a significance level of 0,000, indicating a significant difference. However, in the sit-and-reach test, where a p-value of 0,076 was obtained, no significant difference was found, suggesting insufficient improvement based on the measurements.

DISCUSSION

The aim of this research was to examine whether fundamental gymnastics training positively affects flexibility parameters in preschool children by comparing measurements of flexibility parameters before and after a 6-week gymnastics training program. Different muscle groups of the body work during movements, leading to variations in their developments. Body parts, for example, contribute to the development of body flexibility through stretching and lengthening movements performed to cool down the body after exercises such as jumps made from the legs (11). It is understood from the measurements in the v-sit and split tests that lower extremity exercises were more efficient. No improvement was observed in the sit-and-reach test due to the slower progress of upper extremity exercises. In another gymnastics study, the Sit-and-Reach Test showed improvement in the measurements, with an initial test of 8,62±4,52 and a final test of 11,85±4,77 (15). Similarly, the Split Test showed improvement with an initial test of 9,38±4,90 and a final test of 4,83±3,78 (15).

In a study by Kalyoncuoğlu and Şentürk (2016), an 8-week gymnastics program resulted in significant differences, with the Sit-and-Reach pre-test being 8,62±4,52 and the post-test being 11,85±4,77, the Split pre-test being 9,38±4,90 and the post-test being 4,83±3,78, the Bridge pre-test being 49,40±17,43 and the post-test being 43,72±15,65, the Flamingo Balance pre-test being 15,29±6,43 and the post-test being 21,25±9,22, and the Coordination pre-test being 16,20±2,68 and the post-test being 12,55±2,64.

In a study by Yavuz N. & Özyürek A. (2018), they implemented an exercise program for 14 weeks, twice a week, for a group of 4-6-year-old children. After the exercise program, the Sit-and-Reach test scores for the exercise group increased from an average of 21,40 cm to 23,05 cm.

Koyuncuoğlu and Şentürk (2015) found significant differences in the measurements of preschool children after a 10-week basic gymnastics training program. The pre-test and post-test measurements for the Sit-and-Reach test were 8,62±4,52 and 11,85±4,77, respectively, and for the Split test, they were 9,38±4,90 and 4,83±3,78, respectively.

Addressing the importance of gymnastics in child development, Tanasa et al. (2020) emphasize that most teachers agree on its significant role in promoting the healthy growth of children. The preschool period is recognized as a crucial time for making positive and lasting contributions to motor skills, guiding developmental stages that extend throughout life (17). Studies in motor

development highlight the influential role of environmental factors and activities on early brain development in children (2). Recent research underlines the pivotal impact of activities on children's development, reinforcing the importance of appropriate training programs during sensitive age periods (17). Gymnastics, known for its rich movement combinations, demands a high level of coordinative performance and flexibility from participants, making it particularly relevant in the preschool period for developing essential flexibility skills (9).

Building upon the positive impact identified by previous research, a study conducted by Irfannuddin et al. (2018) revealed that individuals engaged in regular gymnastics exercises demonstrated superior flexibility, agility, reaction speed, and coordination abilities compared to a control group. These findings resonate with the conclusions drawn by Bressel et al. (2007), who emphasized the beneficial effects of gymnastics on the development of coordination, flexibility, and balance in children. Atilgan et al. (2012) further supported this perspective, asserting that gymnastics training not only stimulates balance development but also facilitates nearly perfect stability, even under extreme conditions. The results of our study align with these insights, providing additional substantiation to the existing body of research. This consistent evidence underscores the significant role of gymnastics in enhancing coordination, flexibility, and balance parameters in preschool children.

Our study, along with similar studies, showed that the "Gymnastics Training Program" contributed to the development of flexibility parameters and led to significant changes in parameters such as balance and coordination. The implementation of the preschool "Gymnastics Training Program" is considered significant for flexibility, healthy motor development, and balance.

REFERENCES

1. Acet, M., & Yıldıran, İ. (1999). Development of Swedish gymnastic in Turkey and the World. Dumlupınar University Journal Of Social Sciences, vol.1, no.2, 291-300.
2. Altınkök, M. (2006). Investigating the effects of 16 weeks physical education programs on the physical fitness of preschool children aging 5–6. (Master's thesis, Marmara University, Istanbul).
3. Atılgan, A. O. E., Akın, M., Alpkaya, U., & Pınar, S. (2012). Investigating of relationship between balance parameters and balance lost of elite gymnastics on balance beam. Journal of Human Sciences, 9(2), 1260-1271.
4. Bağcı, E. (2003). The comparasion of some physical and conditional features between gymnastics sportswomen between 9-11 ages and the same ages rhytmic gymnastics sportswomen. (Master's thesis, Gazi University, Health Science Institutes, Ankara)
5. Bayhan, N., & Artan, İ. (2004). Çocuk gelişimi ve eğitimi. Morpa Kültür Yayınları, Istanbul
6. Baysaloğlu, O. (1994). Gymnastic education in middle schools (Master's thesis, Selçuk University, Health Science Institutes, Konya).
7. Bressel, E., Yonker, J. C., Kras, J., & Heath, E. M. (2007). Comparison of static and dynamic balance in female collegiate soccer, basketball, and gymnastics athletes. Journal of Athletic Training, 42(1), 42-46.
8. Doğan, A. A. (1995). Esneklik çalışmalarının bilimsel temelleri. Top-Kar Matbacılık, Trabzon.
9. Doğan, F., & Altay, F. (1996). Sportif ritmik cimnastik. Ankara: Ünal Ofset.
10. Fediani, Y., Santoso, B., Kadir, M. R., & Dewi, M. R. (2018). The recommended aerobic gymnastics has better effects on improving cognitive and motoric ability in children. Bioscientia Medicina: Journal of Biomedicine and Translational Research, 2(3), 25-34.
11. İnan, B. (1989). A research on the effects of physical education activities in preschool education institutions on the motor development of 6-year-old children. Gazi University, Ankara.
12. Kayapınar, F. (2002). Effects on movement education, hand-eye coordination and reaction time between 6-7 years old children (Doctoral dissertation, Marmara University, Istanbul).
13. Koyuncuoğlu, K., & Şentürk, U., (2016). The Effect of 8-Week Basic Gymnastics Training on Balance, Coordination and Flexibility in Preschool Children. 8. Uluslararası Eğitim Araştırmaları Kongresi (pp.63). Çanakkale, Turkey
14. Koyuncuoğlu, K., & Şentürk, U., (2015). The Effect of 10-Week Basic Gymnastics Training Program on Motor Development in Preschool (6 Years Old) Children. 5. Beden Eğitimi ve Spor Öğretiminde Yeni ve Yaratıcı Yaklaşımlar Sempozyumu (pp.15-20). Ankara, Turkey
15. Koyuncuoğlu, K., Şentürk, U., Abanoz, H., & Taşkiran, K., (2014). Influence Of Preschool (Ages 5 And 6) Gymnastic Exercises On Flexibility, Balance And Coordination (pp.30-35). Konya, Turkey
16. Kirici, H. M. (2008). The effect of movement education of eight weeks on the motor performance of 4-6 years old children in preschool (Master's thesis, Muğla University, Social Sciences Institutes, Muğla).
17. Mülazimoğlu Balli, Ö. (2006). The study of validity and reliability of Bruininks Oseretsky motor proficiency test and the effects of gymnastics education program on motor development of five-six years-old children (Master's thesis, Istanbul University, Social Sciences Institutes, Istanbul)
18. Özer, K. (1989). Artistik cimnastik antrenmanının temelleri. GSGM Spor Eğitim Dairesi Başkanlığı

Yayınları Yayın.

19. Polat, G. (2009). The effects of the 12-week-period basic badminton education trainings on 9- to 12-year-old kids? motoric features and the reaction time (Master's thesis, Çukurova University, Health Sciences Institutes, Adana).
20. Savucu, Y., Karataş, M., Eskiyecek, C. G., Yücel, A. S., & Karadağ, M. (2018). Effect of 12-Week Basic Gymnastic Training on Physical Fitness in 6- to 7-Year-Old Boys. Turkish Journal Of Educational Studies, 5(3), 53-65.
21. Sen, M. (2004). A Study on the Effect of Physical Education Studies on Motor Development of Size-Years Old Children Attending Kindergarten (Doctoral dissertation, Master's Thesis, Ankara University, Ankara).
22. Tanasa, R. A., Dumitru, I. M., & Budaca, M. V. (2020). The effects of gymnastics training on static balance among children aged 4 to 8. Bulletin of the Transilvania University of Braşov. Series IX: Sciences of Human Kinetics, 111-118.
23. Tavacıoğlu, L. (1989). The effects of strength, speed and flexibility parameters on performance in artistic gymnastics (Doctoral dissertation, Marmara University, Istanbul).
24. Türkeri, C. (2002). The Relationship between anthropometrics measuring and flexibility on sports aerobic gymnastics athletes (Master's thesis, Çukurova University, Health Sciences Institutes, Adana)
25. Yavuz, N., Özyürek, A. Effects of Physical Education and Sport Activities on Motor Skills of Preschool Children. Karaelmas Journal of Educational Sciences, 2018; 40-50
26. Yiğitbaş, H. A. (2020). Investigation effects of recreational ballet and gymnastics training on balance, flexibility, and joint mobility in children 6-8 years of age (Master's thesis, Hasan Kalyoncu University, Health Sciences Institutes, Gaziantep).
27. Yılmaz, A. (2019). Comparison of balance flexibility and anthropomotric characteristics of 9-12 years old competitor girls in different gymnastic branches (Master's thesis, Kırıkkale University, Health Sciences Institutes, Kırıkkale).

Performance Analysis in Sport and Exercise

Ankara University Performance Analysis in Sports Application and Research Center

Available online 31 December 2023

The Effects of Neuromuscular Fatigue on Functional Movement and Balance Performance in Youth Football Players

Sally Salam Abbas Ali[1*], Özkan Güler [2], Aysberg Şamil Önlü [1]
[1] Institute of Health Sciences, Ankara University, Ankara, Turkey
[2] Sport Science Faculty, Ankara University, Ankara, Turkey

Abstract

The aim of this study is to examine the effects of neuromuscular fatigue on functional movement analysis total score and balance ability. 28 professional football players participated in the study voluntarily. A 10-meter running and vertical jump test was used to assess neuromuscular fatigue in football players. Functional movement skills were made with the functional movement imaging method. Balance skill was measured with the modified Y balance test. Statistical analysis of the data obtained in the study was carried out with the t-test in paired samples. According to the t-test results in paired samples, the average functional movement total scores of the football players who participated in the study were 15.64 ± 2.34 while they were at rest, while the functional movement analysis total scores after fatigue were 13.78 ± 2.29. It was statistically determined that fatigue negatively affects functional movement and balance skills ($p<0.001$). Preventing or reducing fatigue in footballers affects functional movement and balance skills and increases the risk of injury. Therefore, delaying fatigue and accelerating recovery may be important to prevent injuries.

Key Words: Balance, functional movement, football, fatigue

INTRODUCTION

Football is a popular game with more than 240 million licensed athletes in the world. Many high-intensity movements are repeated hundreds or even thousands of times in one football match. These movements are usually repeated at high intensities from the beginning until the end of the football match. Fatigue during the match disrupts the patterns of these movements and increases the risk of injury. Many non-impact injuries in football matches are caused by deterioration of movement patterns while performing a technique as a result of fatigue. Improper technique leads football players to perform the work by consuming more energy and creating more load on the muscles, tendons and ligaments which if this load is not familiar, may

cause risk of injury.

Functional Movement Analysis is a movement scanning method used to monitor postural control, joint stability, and basic movement pattern quality in athletes (8,12). FMS is designed to evaluate a variety of skills that are necessary to participate in higher level functions. FMS requires the ability to move through three planes of movement (7). FMS is a movement scanning system that is based on seven different movement patterns and analyzes them according to predetermined scoring criteria (1). Functional movement analysis aims to evaluate postural control and obtain information about deficiencies or limitations that occur during the implementation of basic movement patterns. Functional movement analysis helps athletes evaluate various physical skills such as asymmetry between extremities, trunk stability, joint mobility, balance, neuromuscular control and coordination, strength and flexibility (9). It is stated that functional movement analysis is a movement screening test that can be used to determine and prevent injury risks not only in adult athletes but also in young and adolescent athletes. (9,15)

Screening tests that might identify modifiable intrinsic risk factors for musculoskeletal injury are appealing to applied practitioners working in sport and exercise medicine (13). In studies, the Functional Movement Analysis , which is a screening test, total score below 14 is considered as an injury risk (2,16). Functional Movement Analysis should be applied to athletes while they are at rest to acquaire a reliable results. As a result of the FMS applied in rest state, the test result may identify if there is no previous injury, lack of strength or imbalance in the movement patterns of the players (20).

Injuries in football matches occurs due to various reasons; insufficient warm-up at the beginning of the first and second half or due to fatigue accumulated at the end of the first and second half football, tackling or injuries caused by player to player contact, surface related injuries (10,14). Considering the FMS is better when using this test while at rest, the focus on this examination will be on injuries due to fatigue. As a result of high-intensity activities during a football match, energy reserves are depleted and fatigue occurs. In addition, neuromuscular fatigue (18) occurs because high-intensity repetitive activities require high motor activity. Neuromuscular fatigue is a condition that occurs in the neural networks between the central nervous system and muscles (6). As a result of neuromuscular fatigue, there are deteriorations in the excitation and contraction rates of the muscles. Therefore it may cause decrease of voluntary muscle contractions and the amount of force produced. The decrease in the amount of force produced, slowing down of muscle contractions causes movement patterns to deteriorate and the risk of

injury in football players increases (19).

Balance performance is important to maintain many athletic movements correctly.). Neuromuscular fatigue also negatively affects static and dynamic balance (3). Especially in football, static and dynamic balance must be maintained while displaying technical skills (passing, shooting, dribbling). Apart from this, in football competitions, football players need dynamic balance in many positions such as running, changing direction, acceleration and deceleration, jumping and falling. Loss of balance during these movements can cause falls and injuries. In a study conducted with female football players, it was stated that phyisological loads negatively affect balance performance and a period of at least 10 minutes is needed for regaining the ability of performing movements with balance as same as resting state. (11). In the same study, the effect of fatigue caused by the central nervous system on balance performance and the effect of peripheral fatigue on balance performance were compared. No statistical difference was detected between central nervous system fatigue and peripheral fatigue.

METHODS

A total of 20 football players playing in Kocaelispor U21 football team participated in this study. Functional movement analysis scores and balance skills of the football players were measured while they were at rest. Then, the neuromuscular fatigue protocol was applied and the FMS and Balance tests of the football players were repeated.

Functional Movement Analysis (FMS)

FMS test is a test that can be performed to evaluate functional movement. This test consists of seven movement patterns. The movements in this test are deep squatting, high stepping, single-line lunge, shoulder mobility, active straight leg lifting, trunk stability push-ups, rotation stability, respectively. The score of the FMS test is the total score obtained from the scores of the movements. Each move is scored between 0-3 points. Each individual participating in the evaluation can receive a score between 0-21. In calculating the total score, the lower score from the bilateral subtests is taken. Among the subtests, there is a "clearing test" for shoulder mobility, trunk stability push-ups and rotation stability tests.

Y- Balance Test

This test is a modified version of the Star Excursion Balance Test. This test involves reaching in the anterior, posteromedial (PM), and posterolateral (PL) directions. In the test, the angle

between the anterior-posteromedial and anterior-posterolateral directions is 135˚, and the angle between the posteromedial-posterolateral directions is 90˚. Participants lay down in three directions without changing their positions, with both hands on their waist and the sole of one foot maintaining contact with the ground. The test was performed as right foot anterior, left foot anterior, right foot PM, left foot PM, right foot PL, left foot PL. Both sided lower extremities were tested. Before the test, participants were made to practice reaching in all directions to help them learn the test. In the test, 3 reaches were made in each of the 3 directions (anterior, PM, PL) and the average of the 3 reaches for each direction was taken. Values are recorded in cm. Reach distances were normalized as a percentage by dividing the average value by the length of the lower extremity and multiplying by 100 (5,17).

Fatigue Protocol

A vertical jump test will be performed to evaluate neuromuscular fatigue. Jumping height will be measured using the Fushion Sport splash mat. The best jump height will be recorded and used to detect neuromuscular fatigue. After the jump height is determined, the athlete will be asked to sprint 6 times in a row in a 10-meter area and the vertical jump test will be repeated immediately afterwards. This protocol will continue until a score 30% lower than the athlete's best vertical jump height is achieved. If the Vertical Jump height is below 30%, it will be considered that sufficient neuromuscular fatigue has occurred (21).

FINDINGS

Table 1. Descriptive statistics

	Minimum	**Maximum**	**Mean**	**Standard Deviation**
Age	16	35	27	5.59
Heigth	165	188	176.03	6.25
Body Mass	65	80	71.07	4.01
BMI	20.98	25.45	22.97	1.02
Fat Ratio	6	14	9.32	2.46

According to the t-test results in the paired samples, the average functional movement total scores of the football players participating in the study measured while at rest were 15.64±2.34, while the total scores of the functional movement analysis performed after fatigue were determined to be 13.78 ± 2.29.

According to the results of paired sample t test statistical analysis, a statistically significant difference was detected between the functional movement total score measured before fatigue and the functional movement analysis total scores measured after fatigue (p=0.001).

Table 2. Comparison of FMS and Y Balance Test

	Pre-Test	Post-Test	Mean Difference	*p*
FMS	15.64 ± 2.34	13.78 ± 2,09	1.64 ± 1.54	0.001
Y Balance Test	95.11± 8.85	93.18 ± 7,06	2.11 ± 1.57	0.042

According to the t-test results in the paired samples, the average Y balance test total scores of the football players participating in the study, measured at rest, were 95.11±8.85, while the Y Balance Test total scores after fatigue were determined to be 93.18±7.06. According to the results of the paired sample t test statistical analysis before fatigue, a statistically significant difference was detected between the Y balance test total score measured at rest and the Y balance test total scores measured after fatigue (p=0.001).

DISCUSSION & CONCLUSION

Football is one of the sports where sports injuries occur most frequently in the world. The frequency of injuries in football varies depending on the morphological and anthropometric characteristics of the athletes. Especially young football players can be injured much more frequently than mature football players (4,18). In addition, most of the injuries seen in young football players involve lower extremity injuries.

It is thought that one of the main reasons for injuries in football players is fatigue. As a result of this study, it was determined that functional movement and balance tests performed after the fatigue test were worsened compared to the resting state. Impairment of functional movement and balance after fatigue is an important cause of disability. In a study conducted with female football players, it was stated that aerobic and anaerobic loads negatively affect balance performance and a period of at least 10 minutes is required for balance performance to return to resting level (11).

REFERENCES

1. Arslan, S., Engin, D. İ. N. Ç., & Yapalı, G. (13). 13 ve 17 Yaş Erkek Futbol Oyuncularının Fonksiyonel Hareket Taraması Skorlarının Karşılaştırılması. *Adnan Menderes Üniversitesi Sağlık Bilimleri Fakültesi Dergisi*, *1*(3), 112-116.
2. Agresta, C., Slobodinsky, M., & Tucker, C. (2014). Functional Movement ScreenTM–normative values in healthy distance runners. International journal of sports medicine, 1203-1207.
3. Behan, F. P., Willis, S., Pain, M. T., & Folland, J. P. (2018). Effects of football simulated fatigue on neuromuscular function and whole-body response to disturbances in balance. Scandinavian Journal of Medicine & Science in Sports, 28(12), 2547-2557.
4. Brink, M. S., Visscher, C., Arends, S., Zwerver, J., Post, W. J., & Lemmink, K. A. (2010). Monitoring stress and recovery: new insights for the prevention of injuries and illnesses in elite youth soccer players. *British journal of sports medicine*, *44*(11), 809-815.
5. Bulow, A., Anderson, J. E., Leiter, J. R., MacDonald, P. B., & Peeler, J. (2019). The modified star excursion balance and Y-balance test results differ when assessing physically active healthy adolescent females. *International journal of sports physical therapy*, *14*(2), 192.
6. Carroll, T. J., Taylor, J. L., & Gandevia, S. C. (2017). Recovery of central and peripheral neuromuscular fatigue after exercise. Journal of Applied Physiology, 122(5), 1068-1076.
7. Chorba, R. S., Chorba, D. J., Bouillon, L. E., Overmyer, C. A., & Landis, J. A. (2010). Use of a functional movement screening tool to determine injury risk in female collegiate athletes. North American journal of sports physical therapy: NAJSPT, 5(2), 47.
8. Cook, G., Burton, L., Hoogenboom, B. J., & Voight, M. (2014). Functional movement screening: The use of fundamental movements as an assessment of function-part 1. *International journal of sports physical therapy*, *9*(3), 396.
9. Cook, G., Burton, L., Hoogenboom, B. J., & Voight, M. (2014). Functional movement screening: The use of fundamental movements as an assessment of function-part 2. *International journal of sports physical therapy*, *9*(4), 549.
10. Ekstrand, J., & Nigg, B. M. (1989). Surface-related injuries in soccer. Sports medicine, 8, 56-62.
11. Güler, Ö., Aras, D., Akça, F., Bianco, A., Lavanco, G., Paoli, A., & Şahin, F. N. (2020). Effects of aerobic and anaerobic fatigue exercises on postural control and recovery time in female soccer players. *International Journal of Environmental Research and Public Health*, *17*(17), 6273.
12. Koehle, M. S., Saffer, B. Y., Sinnen, N. M., & MacInnis, M. J. (2016). Factor structure and internal validity of the functional movement screen in adults. *The Journal of Strength & Conditioning Research*, *30*(2), 540-546.
13. Moran, R. W., Schneiders, A. G., Mason, J., & Sullivan, S. J. (2017). Do Functional Movement Screen (FMS) composite scores predict subsequent injury? A systematic review with meta-analysis. British journal of sports medicine, 51(23), 1661-1669.
14. Nielsen, A. B., & Yde, J. (1989). Epidemiology and traumatology of injuries in soccer. The American Journal of Sports Medicine, 17(6), 803-807.
15. Paszkewicz, J. R., McCarty, C. W., & Van Lunen, B. L. (2013). Comparison of functional and static evaluation tools among adolescent athletes. *The Journal of Strength & Conditioning Research*, *27*(10), 2842-2850.
16. Perry, F. T., & Koehle, M. S. (2013). Normative data for the functional movement screen in middle-aged adults. The Journal of Strength & Conditioning Research, 27(2), 458-462.

17. Plisky, P. J., Gorman, P. P., Butler, R. J., Kiesel, K. B., Underwood, F. B., & Elkins, B. (2009). The reliability of an instrumented device for measuring components of the star excursion balance test. *North American journal of sports physical therapy: NAJSPT*, *4*(2), 92.
18. Price, R. J., Hawkins, R. D., Hulse, M. A., & Hodson, A. (2004). The Football Association medical research programme: an audit of injuries in academy youth football. British journal of sports medicine, 38(4), 466-471.
19. Robineau, J., Jouaux, T., Lacroix, M., & Babault, N. (2012). Neuromuscular fatigue induced by a 90-minute soccer game modeling. The Journal of Strength & Conditioning Research, 26(2), 555-562.
20. Small, K., McNaughton, L. R., Greig, M., Lohkamp, M., & Lovell, R. (2009). Soccer fatigue, sprinting and hamstring injury risk. International journal of sports medicine, 573-578.
21. Warren, M., Lininger, M., Chimera, N., & Smith, C. (2018). Utility of FMS to understand injury incidence in sports: current perspectives. Open Access Journal of Sports Medicine, Volume 9, 171–182.
22. Zhang, X., Xia, R., Dai, B., Sun, X., & Fu, W. (2018). Effects of exercise-induced fatigue on lower extremity joint mechanics, stiffness, and energy absorption during landings. *Journal of sports science & medicine*, *17*(4), 640

Performance Analysis in Sport and Exercise

Ankara University Performance Analysis in Sports Application and Research Center

Available online 31 December 2023

Shot Selection Trends in Euroleague Basketball from 2013 to 2023

Tugay Durmuş[1], Övünç Erdeveciler[1]

[1] Faculty of Sport Sciences, Ankara University, Ankara, Turkey

Abstract

This study provides an extensive assessment of the trends in offensive shot selection in Euroleague basketball during a ten-year period, spanning from the 2013-2014 to the 2022-2023 seasons. The following game-related statistics from 1899 games were examined in this study: two-point attempts (2PA), three-point attempts (3PA), and free-throw attempts (FTA). Mean statistics were employed, and the percentage of each shot selection was calculated to offer a understanding of evolving team strategies. The results show a constant and significant shift in the preferences for shot selection, with a noticeable decrease in two-point attempts and a concurrent increase in three-point attempts. Three-pointers made per game had a significant increase, going from 20.86 in the first season to 25.10 in the most recent. The observed trends suggest that Euroleague teams are progressively adapting to the success of three-point shooting in modern basketball. The implications extend beyond the court, influencing team efficiency, player development, and the overall landscape of global basketball. Future research may delve into defensive adaptations in response to increased three-point attempts and compare trends observed in the Euroleague with other prominent basketball leagues globally.

Keywords: Basketball, game trends, shot selection

INTRODUCTION

Sports analytics and data-driven forecasting constitute a rapidly expanding field with versatile applications across various perspectives. This dynamic field is characterized by rapid growth and offers a range of methodologies to explore (3). Research in sports performance analysis aims to identify key performance indicators and effective offensive strategies for coaches. By accumulating data from a substantial number of games, teams can discern patterns in both offensive and defensive aspects. This data-driven approach enables teams to prepare for upcoming games by anticipating the expected offensive and defensive strategies of their opponents (11). Additionally, it aids in monitoring both teams and individual players, contributing to optimum performance and even injury prevention.

Numerous approaches exist for monitoring and enhancing sports performance, with one prevalent method involving the use of game-related statistics to assess technical and tactical aspects. These statistics are invaluable for evaluating team efficiency over the course of a season. Certain research in basketball has employed game-related statistics as a means to quantify player performance. The outcomes resulting from such analyses enable the assessment and definition of performance results across various competition standards. Scoring in a basketball game is entirely achieved through shooting and successful shooting stands as the ultimate goal of offense in basketball (6). In the course of a basketball game, the selection of an appropriate offensive strategy holds paramount importance in determining a team's success. The success of elite basketball teams appears to hinge not solely on the quantity of scoring opportunities a team encounters, but rather on how effectively the team capitalizes on the existing scoring chances (7). Studies have proved that in basketball, the scoring both two- and three-point field goals significantly influences game outcomes and rankings (5). Another study disclosed that three-point performance and successful free throws played a decisive role in determining the outcomes of wins and losses in basketball games (1).

One of the most noticeable trends in basketball in recent times is the emphasis on three-point shooting. Once considered a specialist's domain, the three-point shot has now become a foundation of offensive schemes (4). This trend has not only altered the way teams approach offensive play but has also redefined player roles and skill sets. While the three-point field goal may not be the sole determinant of a basketball game's winner, it undeniably exerts a significant impact on the overall results of basketball games (8). Studies demonstrated that there was a significant increase in the number of three-point attempts (3PA) over time, accompanied by a decrease in the number of two-point attempts (2PA) in the National Basketball Association (NBA) over the course of 40 seasons (14). The global shift in basketball trends exceeds specific leagues or regions, signifying a universal transformation in the way the sport is played and appreciated worldwide. During the 2001-2002 season, teams in the Euroleague attempted an average of 18,5 three-point shots per game. In contrast, this number increased to 24,8 by the conclusion of the 2020 season, proving a notable evolution in the strategic approach to three-point shooting over the years (2). While the game trends in basketball widely suited in the last decade, there is still need for deeper analysis to understand the variety of changes occurred over the years. Therefore, the aim of this study is to conduct a comprehensive offensive shot selection analysis trough the game-related statistics within the Euroleague basketball competition across the last ten seasons.

METHODS

Study Design

This study analyzed the game-related statistics from ten (2013-2014 - 2022-2023) Euroleague regular seasons. Game-related statistics of 1899 games has been analyzed in this study. Parameters used to analyze shot selection in this study were: two-point attempts (2PA), three-point attempts (3PA) and free-throw attempts (FTA). All statistics obtained from publicly accessible official website of Euroleague website (*euroleaguebasketball.net/euroleague/stats*).

Statistical Analyses

Mean statistics of each parameter has evaluated in order to compare the game-related statistics collected between ten seasons. Each number of shot selection is divided by the total number of shots taken in a game to calculate the percentage of a specific shot. All analyses were made in SPSS software (IBM SPSS Statistics for Windows, Ver. 22.0. Armonk, NY: IBM Corp.).

FINDINGS

This study is aimed to analyze the shot selections of teams within the Euroleague basketball competition throughout the last ten seasons. Table 1 presents the average number of shots taken in seasons.

Table 1. Average number of field goals and free throw attempts for each season

SEASON	2PA	3PA	FTA
2013-2014	39.68	20.86	16.58
2014-2015	39.48	22.58	18.17
2015-2016	38.40	22.39	17.69
2016-2017	38.96	22.61	17.75
2017-2018	38.55	22.82	18.93
2018-2019	38.34	23.14	17.86
2019-2020	36.97	24.76	17.70
2020-2021	36.33	23.86	16.81
2021-2022	36.38	24.17	15.82
2022-2023	35.72	25.10	18.34

2PA: two-point attempts; 3PA: three-point attempts; FTA: free-throw attempts

As can be seen in Table 1, there is a general decreasing trend in 2PA over the seasons and it might indicate a shift in playing style or strategy. Overall shot distribution is changed

throughout the seasons, it may indicate a potential shift towards more emphasis on three-point shooting.

Table 2. Distributions of field goals and free throw attempts for each season

SEASON	% of 2PA	% of 3PA	% of FTA
2013-2014	51.00%	27.00%	22.00%
2014-2015	49.21%	28.14%	22.64%
2015-2016	48.93%	28.53%	22.54%
2016-2017	49.12%	28.51%	22.37%
2017-2018	48.00%	28.42%	23.58%
2018-2019	48.32%	29.17%	22.51%
2019-2020	46.54%	31.17%	22.29%
2020-2021	47.18%	30.98%	21.84%
2021-2022	47.64%	31.64%	20.72%
2022-2023	45.12%	31.71%	23.17%

2PA: two-point attempts; 3PA: three-point attempts; FTA: free-throw attempts

It is possible to notice the changing offensive focus of teams in Table 2. There is a consistent decrease in the percentage of 2PA over the years. Teams has been shifting towards a greater reliance on three-pointers, as reflected in the increasing percentage of 3PA.

Figure 1. Trends of field goals and free throw attempts over the years

DISCUSSION

The primary objective of this research was to conduct a comprehensive offensive shot selection analysis within the Euroleague basketball competition over the last ten seasons. By leveraging game-related statistics, the study aimed to discern patterns and trends in offensive strategies, with a particular focus on the evolution of three-point shooting. Results showed consistent and notable decrease in two-point attempts (2PA) across the seasons, accompanied by a simultaneous increase in three-point attempts (3PA). This trend suggests a fundamental alteration in the shot selection preferences of teams. Notably, the average number of three-point attempts per game has seen a substantial rise from 20.86 during the 2013-2014 season to 25.10 in the most recent 2022-2023 season. Similar results were found in earlier studies suggesting that the 3PA has increased over the years in Euroleague (2) and the NBA (10).

he percentage of two-point attempts has experienced a gradual decline, starting from 51.00% in the 2013-2014 season and reaching 45.12% in the 2022-2023 season. Concurrently, the percentage of three-point attempts exhibits a steady increase, rising from 27% to 31.71% over the same period. This consistent shift towards a higher reliance on three-pointers underlines a strategic evolution in offensive play. According to another study, offensive factors play a pivotal role in determining success in the Euroleague between 2003-2016 were the number of midrange shots made and attempted (2PT-made, 2PT-attempts), the quantity of free throws made (1PT-made), the number of successful long-distance shots and attempted shots (3PT-made, 3PT-attempts) (13). Research indicates that the playing style of the current pace-and-space era differs significantly from that of the mid-2000s, playing a major role in the decline of the mid-range jump shots and long two-point attempts (10). Studies also compared NBA to Euroleague to gain insight about the changing dynamics of basketball. Results showed that the quantitative differences have decreased over time, but offensively, NBA exhibits more possessions, and free throws per foul committed (12). Another study compared the structural differences between NBA and Euroleague and conclude that the fundamental offensive structures, including transition, early offense, and set plays, differ between the two styles of play. European basketball emphasizes set plays and control, especially through the pick-and-roll, while American basketball relies more on transition and early offense, emphasizing one-on-one situations (9).

The observed trends suggest that teams in the Euroleague have been progressively favoring a perimeter-oriented offensive strategy, possibly influenced by the success of three-point

shooting in contemporary basketball. This shift poses implications for team dynamics, player roles, and overall game outcomes. The strategic emphasis on three-point shooting warrants further exploration into its impact on team efficiency, player performance, and the evolving nature of basketball as a global sport.

CONCLUSION

The data consistently demonstrates a significant and overarching trend – a notable shift towards three-point shooting. Both the average number of three-point attempts and the percentage distribution of three-point attempts exhibit a steady increase across the seasons. This emphasizes a strategic preference for perimeter shooting, reflecting a departure from traditional two-point-centric playing styles. The shift towards a three-point-centric strategy not only influences offensive play but also redefines player roles and skill sets. Coaches may need to adapt their strategies to accommodate this evolving landscape, and players may find themselves increasingly valued for their three-point shooting proficiency. This study provides insights for coaches, teams, and analysts, prompting further exploration into the impact of this strategic shift on team performance, player development. Further research can investigate the defensive side of the game by analyzing how teams adjust their defensive strategies in response to the rise in three-point attempts. Additionally, there is still need for analysis to compare the trends observed in the Euroleague with other prominent basketball leagues globally.

ACKNOWLEDGMENTS

Competing Interests: The authors have no relevant financial or non-financial interests to disclose.

Funding: The author received no financial support for the research, authorship, and/or publication of this article.

Author contributions: Research concept and study design: TD; literature review: TD; data collection: ÖE; data analysis and interpretation: ÖE; statistical analyses: ÖE; writing of the manuscript: TD.

REFERENCES

1. Csataljay G, O'Donoghue P, Hughes M, and Dancs H. Performance indicators that distinguish winning and losing teams in basketball. *International Journal of Performance Analysis in Sport* 9: 60-66, 2009.
2. Ertetik G, Durmuş T, Erdeveciler Ö, and Ersöz G. Basketbolun değişen oyun yapısı: NBA ve Euroleague örnekleri. *Avrasya Spor Bilimleri ve Eğitim Dergisi* 3: 81-95, 2021.
3. Gerrard W. Beyond Moneyball: Using Data Analytics to Improve Performance in Elite Team Sports. *Sport and Entertainment Review* 2, 2016.
4. Goldsberry K. *Sprawlball: A visual tour of the new era of the NBA.* Mariner Books, 2019.
5. Gomez MA, Gasperi L, and Lupo C. Performance analysis of game dynamics during the 4th game quarter of NBA close games. *International Journal of Performance Analysis in Sport* 16: 249-263, 2016.
6. Gryko K, Mikołajec K, Maszczyk A, Cao R, and Adamczyk JG. Structural analysis of shooting performance in elite basketball players during FIBA EuroBasket 2015. *International Journal of Performance Analysis in Sport* 18: 380-392, 2018.
7. Ibáñez SJ, Sampaio J, Feu S, Lorenzo A, Gómez MA, and Ortega E. Basketball game-related statistics that discriminate between teams' season-long success. *European journal of sport science* 8: 369-372, 2008.
8. Jaguszewski M. Increasing role of three-point field goals in National Basketball Association. 2020.
9. Jørgensen JH, Selmanovic A, and Thomann K. Difference of offensive structure between European and American top-level basketball. *Journal of physical education and sport* 21: 1988-1997, 2021.
10. Kilcoyne S. The decline of the mid-range jump shot in basketball: A study of the impact of data analytics on shooting habits in the NBA. 2020.
11. Lord F, Pyne DB, Welvaert M, and Mara JK. Methods of performance analysis in team invasion sports: A systematic review. *Journal of sports sciences* 38: 2338-2349, 2020.
12. Mandić R, Jakovljević S, Erčulj F, and Štrumbelj E. Trends in NBA and Euroleague basketball: Analysis and comparison of statistical data from 2000 to 2017. *PloS one* 14: e0223524, 2019.
13. Mikołajec K, Banyś D, Żurowska-Cegielska J, Zawartka M, and Gryko K. How to win the basketball EuroLeague? Game performance determining sports results during 2003–2016 matches. *Journal of human kinetics* 77: 287-296, 2021.
14. Zając T, Mikołajec K, Chmura P, Konefał M, Krzysztofik M, and Makar P. Long-Term Trends in Shooting Performance in the NBA: An Analysis of Two-and Three-Point Shooting across 40 Consecutive Seasons. *International Journal of Environmental Research and Public Health* 20: 1924, 2023.

Performance Analysis in Sport and Exercise

Ankara University Performance Analysis in Sports Application and Research Center

Available online 31 December 2023

Acute Effect of Breathing Exercises on HRV (Heart Rate Variability) in Kick Boxers

Benhur Ünlügüzel[1], Hamza Kaya Beşler[1], Başak Tezel[1]
[1]Faculty of Sport Sciences, Pamukkale University, Pamukkale, Turkey

Abstract

The purpose of study is to measure the acute effect of 4x4 diaphragm breathing exercise on HRV of the kickboxers. For this purpose, two different measurements were carried out on 5 female and 5 male kickboxers, one without using a breathing technique and one using the 4x4 diaphragmatic breathing technique. The Inner Balance Heartmath biofeedback device was used to collect data. According to the research results, there is a statistically significant difference between the results of the pre-test and the post-test. 4x4 diaphragmatic breathing has a positive effect on the heart rate variable of kickboxers.

Keyword: Kickboxing, coherence, HRV, breath

INTRODUCTION

The history of breathing, which begins with the birth of humanity, is a physiological process that not only transports oxygen to the cells, but also connects humans to life (Önal, 2023). From the past to the present, researchers have claimed that breathing exercises have positive effects on the human body. Many studies have shown that diaphragmatic breathing relaxes the body and mind (Farhi, 1996; Hamasaki, 2020). Diaphragmatic breathing consists of intensive breathing when the abdominal cavity grows. This situation reduces the frequency of breathing. Stress and anxiety situations can be controlled with breathing exercises based on this fact. In this way, it is possible to ensure that body and mind are coherent. It is claimed that breathing exercises, when performed correctly and effectively, reduce the person's burnout and also have a positive effect on the person's cognitive performance (Ma et. all., 2017).

HRV (Heart Rate Variability) is the change in time between successive heartbeats (Shaffer & Ginsberg, 2017). History of HRV dates back to the early twentieth century, also describes the heart's ability to respond to stimulating factors in the environment. In this respect, HRV; is an important phenomenon that is also used in sport. It shows the coherence of the athlete's and can influence the performance (Triposkiadis et. all., 2009; Ateş et. all., 2021; Alvurdu, 2023).

Sport; It is a phenomenon that occurs when there is a high level of competition and stress (Şahinler & Ersoy, 2019). In order to be mentally strong during sport, mental preparation should be a high priority alongside physical exercise (Ekmekçi, 2020).
Different sports may require different physical and mental abilities. Kickboxing, especially in the category of martial arts, is a branch in which the physical and mental performance is crucial. Kickboxing; in contrast to Thai boxing and Western boxing, it is a combat sport in which kicks and punches are used for defence or attacking (kickboks.gov.tr, 2021; Boz et. all., 2023).

In kickboxing, athletes can compete in 3-4 fights per day in some competitions. In addition, the competitions generally consist of 3 rounds with 1 minute rest between rounds. Considering the physical and mental difficulties associated with kickboxing, it is important to control breathing and use correct and effective breathing techniques. For this reason, importance should rely on mental preparation techniques supported by breathing exercises to balance the autonomic nervous system and increase mental performance before, during and after the competition (Erbaş, 2022; Stepanyan & Lalayan, 2023).

Considering the physical and mental activity involved in the kickboxing and also due to the effects of HRV on the athletes, the purpose of study is to measure the acute effect of 4x4 diaphragm breathing exercise on HRV of the kickboxers.

METHODS

Research Design

A quantitative research design was preferred in this study. The experimental method with pretest-posttest control group, one of the types of quantitative research, was used.

Research Group

The research group consists of a total of 10 athletes, 5 women and 5 men, who are actively licensed kickboxers in Denizli.

Data Collection Tool

The Inner Balance Hearth Math device was used as a data collection tool in the study. This device connects to smart devices via Bluetooth and provides HRV measurements with instant real-time biofeedback via the application.

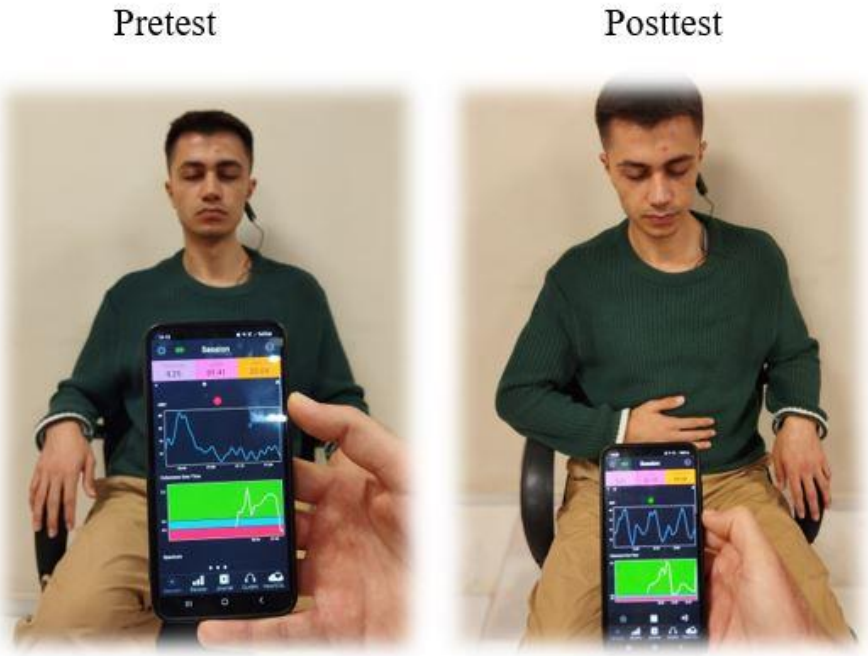


Figure 1. Example of Inner Balance Device, Application and Measurements

Experiment Process

During the experiment, the measurements were carried out in the psychophysiology laboratory of Pamukkale University, Faculty of Sports Sciences. The kickboxers were invited to the psychophysiology laboratory one by one after they had made an appointment. The measurements were based on the equality of all physical conditions. During the pre-test, 5-minute measurement were taken while the athlete was at rest, the light was switched off, the eyes were closed and no breathing techniques were used. Subsequently, 5-minute measurement were performed with 4x4 diaphragmatic breathing under the same conditions. measurements are carried out on the same chair, in the same sitting position and under the same condition.

Data Analysis

The SPSS 24 program was used to analyse the data. As the number of participants in the normality distribution was less than 50, the Shapiro-Wilk test was considered. Whether there

was a difference between the results of the pre-test and the post-test was analysed using the paired samples t-test.

FINDINGS

Table 1.1. Research Group Demographic Information

Nick Name	Gender	Age	Sports Age
Melisa	Women	18	1 Year
İrem	Women	18	1 Year
Veli	Man	18	5 Year
Ayça	Women	18	1 Year
Fatih	Man	18	1 Year
Sibel	Women	22	6 Year
Furkan	Man	20	4 Year
Emre	Man	20	8 Year
Nuri	Man	18	3 Year
Burcu	Women	20	1 Year
Mean		**19**	**3,9**

The research group consists of a total of 10 (N:10) kickboxers, 5 women and 5 men. Each athlete was given a nickname. While the average age of the athletes is 19 years, the average sports age is 3.9 years.

Table 1.2. Paired Sample T-Test Results of Kickboxers According to Heart Rate Variabilty

	N	Mean $\bar{x}$ Coherence	SD	t	p
(Pretest)	10	1,4200	,59029		
4x4 Diaphragm Breathing Exercise (Post-test)	10	2,8300	1,21751	-4,080	,003

While the pre-test coherence levels of the athletes were $\bar{x}$ = 1.4200, the post- test were $\bar{x}$ = 2.8300. According to the results of the study, there was a significant difference between the pre-test and post-test.

DISCUSSION

In this study, the pre-test results, the average coherence level of the athletes, have increased from $\bar{x} = 1.4200$ to $\bar{x} = 2.8300$ after the application of 4x4 diaphragmatic breathing. The results showed that there was a statistically significant difference between the two test results. In simpler terms, 4x4 diaphragmatic breathing has been found to have a positive effect on the autonomic nervous system of kickboxers. In kickboxing, athletes compete in more than one fight a day during a tournament and have a 1-minute break between rounds. Considering the physical and mental difficulties in kickboxing, it can be argued that breathing exercises will be beneficial for kickboxers in line with the results of the research. Some studies in the literature show that martial arts athletes use different techniques to maintain their motivation when their stress levels are high. In this process, competitive athletes, who are influenced by various internal and external factors, use different methods to motivate themselves (Boz et. all., 2023; Öztürk, 2023; Prabowo et. all., 2023; Karabulut et. all., 2013). Other studies carried out in this context show that various breathing techniques balance the autonomic nervous system (Beşler, 2023; Yılmaz, 2023; Ekmekçi & Miçooğulları, 2019; Yılmaz, 2019). Considering the results of the studies the literature on sports, they support the results of this research.

CONCLUSION

Result have shown that 4x4 diaphragmatic breathing exercise brought the kickboxers' autonomic nervous systems into balance, in other words, their coherence levels increased. Research in the literature supports these results. These results can be interpreted as an effective technique that can be used by kickboxers, considering the physical and mental difficulties of kickboxing.

REFERENCES

1. Alvurdu, S. (2023). Yorgunluk Monitörizasyonunda Kalp Atım Hızı Değişikliği Ölçümü ve Değerlendirilmesi: Geleneksel Bir Derleme. Journal Of ROL Sport Sciences, 4(1), 336-358.
2. Ateş O, Işık A, Topçuoğlu K. Spor Teknolojisi ve İnovasyon ile Kas Yaralanmaları Engellenebilir mi?. Dönmez G, Editör. Sporcularda Kas Yaralanmalarına Güncel Yaklaşım. 1. Baskı. Ankara: Türkiye Klinikleri; 2021. P.131- 5.
3. Beşler, H. K. (2023). The Acute Effect Of Zero Gravity Chair And Breathing Exercises On Soccer Players Hrv. Performance Analysis İn Sport And Exercise, 2(1), 1-10.
4. Boz, E., Şipal, O., Safi, Z., & Ünlü, Y. Boksörlerin Endişe ve Mücadele Düzeylerine İlişkin Görüşlerinin İncelenmesi: Karma Model Araştırması.
5. Ekmekci, R. Mental Training İn Sports (3b). Ankara: Detay Yayıncılık, 2022.
6. Ekmekçi, R., & Miçooğulları, B. O. (2019). Developing Mental Toughness With Mental Training And Meditation. In 20th Lisbon International Conference On Marketing, Economics & Interdisciplinary Studies (Pp. 23-25).
7. Erbaş, Ü. (2022). Mücadele Sporcularının Zihinsel Dayanıklılıklarının Bazı Değişkenler Açısından İncelenmesi, International Journal Of Eurasia Social Sciences (IJOESS), 13(48), 638-655.
8. Farhi, D. (1996). The breathing book: Good health and vitality through essential breath work. Holt Paperbacks.
9. Hamasaki, H. (2020). Effects of diaphragmatic breathing on health: a narrative review. Medicines, 7(10), 65.
10. Karabulut, O., Atasoy, M., Kaya, K., Ve Karabulut, A. (2013). 13-15 Yaş Arası Erkek Futbolcuların Durumluk ve Sürekli Kaygı Düzeylerinin Farklı Değişkenler Bakımından İncelenmesi. Ahi Evran Üniversitesi Kırşehir Eğitim Fakültesi Dergisi, 14(1), 243-254.
11. Ma, X., Yue, Z., Q., Gong, Z., Q., Zhang, H., Duan, N., Y., Shi, Y., T., Wei, G., X., Li, Y., F. (2017). The Effect Of Diaphragmatic Breathing On Attention, Negative Affect And Stress İn Healthy Adults. Frontiers İn Psychology.
12. Önal, G., F. (2023). Gündelik Hayatta Nefesin Önemi ve Mesleki Nefes Çalışmaları. Uluslararası Toplumsal Bilimler Dergisi, 7(2), 63-83.
13. Öztürk, E. (2023). Savunma Sporu ile Uğraşan Sporcularının Müsabaka Öncesi Stres Düzeylerinin İncelenmesi. Spor Eğitim Dergisi, 7(1), 40-44.
14. Prabowo, T. A., Tomoliyus, T., Ve Fauzi, F. (2023). Validity Of Sports Competition Anxiety Tests For Amateur Boxing Athletes. Halaman Olahraga Nusantara: Jurnal Ilmu Keolahragaan, 6(1), 31-38.
15. Shaffer, F., And Ginsberg, J. (2017). An Overview Of Heart Rate Variability Metrics And Norms. Front. Public Heal. 5:258. Doi: 10.3389/Fpubh.2017.00258
16. Stepanyan, L., & Lalayan, G. (2023). Heart Rate Variability Features And Their İmpact On Athletes' Sports Performance. Journal Of Physical Education And Sport, 23(8), 2156-2163.
17. Şahinler, Y., & Ersoy, A. (2019). Sporcuların Zihinsel Dayanıklılıklarının Farklı Değişkenlere Göre İncelenmesi. International Journal Of Social Sciences And Education Research, 5(2), 168-177. Https://Doi.Org/10.24289/İjsser.558658
18. Triposkiadis F, Karayannis G, Giamouzis G, Skoularigis J, Louridas G And Butler J: The Sympathetic Nervous System İn Heart Failure Physiology, Pathophysiology, And Clinical İmplications. J Am Coll Cardiol. 54:1747–1762. 2009.

19. Yılmaz, C. (2023). Sporda Görme ve Solunum Sistemi İlişkisi. Spor Bilimleri Üzerine Araştırmalar-II, 57.
20. Yılmaz, O. (2019). Zihinsel Antrenman Uygulaması Otojenik Antrenman. Spor ve Rekreasyon Araştırmaları Dergisi, 69-85.
21. Kickboxing.Gov.Tr. (2021, April 10). Turkish Kick Boxing Federation: Retrieved From Https://Kickboks.Gov.Tr/Kategori/5- Brans-Listesi.Html