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ORIGINAL RESEARCH

Comparison of foot measures on dynamic and static balance in children engaged in different sports disciplines

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Abstract

It is known that sports contribute to the development of children's anthropometric, biomechanical, postural and proprioceptive characteristics. By participating in a sport discipline in childhood, it is possible to gain sports-specific features. Comparing sports that require different motoric features and neuromuscular competencies raises the question of how these different requirements might also affect biomechanical and balance skills. The aim of this study is to compare the foot posture, foot function and dynamic-static balance in children who engaged sports in different sport disciplines. The study included totally 66 child athletes with the mean age of 13.19±2.11 from the box, basketball and swimming disciplines. 54.55% of the participating athletes were female and 45.45% were male. Demographic and sport-specific characteristics of the participants were questioned with an 11-question case form. The Foot Posture Index (FPI) and the Foot Function Index (FFI) were administered. Static balance assessment was performed with the Flamingo Balance Test and dynamic balance assessment was performed with the Y Balance Test. The data obtained for each sport branch were compared between groups. There was no statistically significant difference in terms of demographic characteristics among groups. A statistically significant difference was found between boxing, basketball, and swimming branches in terms of FPI score, right and left static balance results, and foot posture class parameters ($p<0.05$). The mean values for variables were as follows; for FPI it was 1.40±0.48 in boxing, 0.77±0.34 in basketball and 3.08±0.50 in swimming; for Static Balance-R it was 8.80±0.62 in boxing, 7.54±0.85 in basketball and 6.00±0.34 in swimming; for Static Balance-L, it was 9.30±0.62 in boxing, 7.22±0.93 in basketball and 6.33±0.46 in swimming. While neutral foot posture was dominant in basketball players, pronated foot posture was more frequent in boxers and swimmers. FPI score was statistically higher in swimming compared to basketball group; static balance score was superior in boxing group than other disciplines. According to the results, foot posture and static balance in child athletes may vary according to the sport discipline. Dynamic balance and foot function do not seem to have a significant difference in child athletes compared into the different sport disciplines.

Keywords: Balance, children, foot posture, sports.

Introduction

A better understanding of the health benefits of performing sports has led people to perform sports at an increasing rate. In addition to adults, engaging in sports has started from early childhood. Although the cost-benefit balance of early specialization in sports is still a controversial issue due to factors such as

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immature tissues being more vulnerable to injury and early exhaustion, benefits have also been reported in terms of providing sport-specific anatomical gains (Feeley et al., 2016; Popkin et al., 2019). Early specialization in sports will bring early adaptive changes. Early adolescence has been noted as a unique period in which dynamic balance disturbances increase with the interaction of the immature neuromuscular system, peak maturation growth rates, and the emergence of sex-specific differences (Greenberg et al., 2019). In this age group, participation in sports is likely to shape adaptive changes. The most important effects of sport-specific adaptive changes are seen on posture (Paillard, 2017). The proper and balanced alignment of the skeletal elements that provide posture in a way that protects the support structures of the body from injury and progressive deformation starts with the foot. The complex structure and function of the foot, consisting of twenty-six bones and thirty-three joints, makes it an important system that provides the relationship between the body and the ground during standing, walking, and other activities of daily living (Fukano & Fukubayashi, 2009; Dawe & Davis, 2011; Rodgers, 2009). Functionally, the foot as a whole requires the foot to be flexible to absorb the ground reaction forces generated during walking and running and prevent them from reaching more proximal segments, but also rigid to support body weight (Leardini, 2014). The flexible structure of the foot allows it to adapt to different surfaces throughout the gait process, while its rigid structure forms the lever arm needed to transfer body weight forward during the push-off phase of the gait (Nicola & Jewison, 2012; Periyasamy & Anand, 2013). It has been reported that rearfoot eversion, which is an important type of foot posture in adolescent athletes, even affects the gait (Fujishita et al., 2023). The fact that this dynamic structure is affected by the sport practiced has also been a topic of research. Studies show that there may be differences in foot posture in athletes from different disciplines (Martínez-Nova et al., 2014). It has been shown that some postural changes may occur in the foot and sole of the foot, even with an acute effect, due to fatigue, muscle tone changes, and other neuromuscular factors that occur while absorbing ground reaction force, especially during physical activities that require running (Boyer et al., 2014; Willems et al., 2012). It is known that being interested in different sports branches causes the development of different motoric characteristics in children. Boxing is a sport in which more motoric features are prominent than basketball, and swimming requires better neuromuscular features such as flexibility and mobility (Aktug & Irı, 2018). Comparing sports that require different motoric features and neuromuscular competencies raises the question of how these different requirements might also affect biomechanical and balance skills.

The foot is a key part of the biomechanical system that maintains the body in an upright position against gravity in the postural control mechanism. There is an increasing need for research on foot biomechanics, posture, and function in the maintenance of balance and coordination. Studies on sport-specific functional adaptive changes in the foot are mostly conducted in the adult population (Martínez-Nova et al., 2014; Boyer et al., 2014; Willems et al., 2012). It has been frequently reported in the literature that the sport shapes balance skills and postural control (Perrin et al., 1998; Vuillerme et al., 2001; Bringoux et al., 2000; Golomer et al., 1999; Paillard, 2019). However, the effect of performing sports especially in childhood on foot posture and function and their contribution to balance skills seem to be in need of further research. According to our current knowledge, there is no other study that examines foot posture and function in pediatric athletes and reveals its effect on balance skills. Therefore, this study aimed to examine the effect of foot posture and function on dynamic-static balance skills in children performing different sport disciplines.

This study aimed to examine the effects of performing different sports disciplines on foot posture and function in children and to reveal the contribution of this to balance skills. The hypothesis of the study is that different foot posture, foot function scores and balance testing scores may be obtained in children participating in different sports disciplines.

Methods

Participants

The study included volunteer child athletes aged 6-16 years who had been engaged in a sports discipline for at least 3 months. The sample size was calculated using the G-Power 3.1.7 package program (Heinrich-Heine-Universität, Dusseldorf, Germany) with type I error 0.05 and type II error 0.2. The power of the test was determined as 0.8. Based on the FPI value, the minimum number of subjects required to be included in the study for a 1-unit difference to be significant was determined as 51. The study was completed with the participation of a total of 66 athletes. 54.55% of the participants were female and 45.45% were male athletes. Athletes who had a disease affecting the musculoskeletal system and who had been engaged in sports for less than 3 months were excluded from the study, and those who wanted to leave the study voluntarily and could not complete the tests were excluded from the study.

Ethical Aspect of the Research

Ethics committee approval required for conducting the study was obtained from the Inönü University Health Sciences Non-Interventional Clinical Research Ethics Committee (Decision No: 2021/2856). The study was conducted in accordance with the Principles of the Declaration of Helsinki. Parents/Guardians of the children included in the study were informed in detail about the study and their written consents were obtained.

Procedure

The study was carried out within the Provincial Directorate of Youth and Sports. All measurements and evaluations were made by an experienced physiotherapist. Participating athletes were assisted by the sports coach.

Evaluation of sociodemographic and sport specific characteristics

The children's age, height, weight, age of starting sports, duration of being engaged in sports (months/days), frequency of performing regular sports (days/weeks), the sports discipline they were engaged in, and the presence of existing musculoskeletal diseases were questioned with an 11-question case report form prepared in physical format, and measurements were recorded.

A measurement device (Harpender Anthropometer, Holtain Ltd.) with a precision of 0.1 m was used for height measurement. Body weight was measured using an electronic scale (Tanita TBF 401 A, Japan) with an accuracy of ± 100 g. The obtained value was recorded in kg. Body Mass Index (BMI) was calculated using the formula weight (kg)/height (m)^2 (Tamer, 2000).

Assessment of foot posture

Foot posture assessment was performed using the FPI. The FPI was developed by Evans et al. (2003) to determine deformities in the foot and its validity and reliability study was performed. Redmond et al. (2006, 2008) revised this practical method to determine foot deformities and conducted a validity-reliability and normative values study. During the evaluation, all individuals were asked to stand in a relaxed position in which they felt comfortable. In the forefoot, ballooning in the talonavicular joint area, the status of the medial longitudinal arch, and abduction/adduction of the forefoot compared to the hind foot; in the hind foot, 6 items consisting of palpation of the talus head, inclination both above and below the lateral malleolus, and eversion/inversion of the calcaneus were evaluated between -2 and +2 points. Foot posture classification (FPC) total score of 0 indicated that the foot was in neutral position, positive values indicated pronation, and negative values indicated supination (Redmond et al., 2006; Redmond et al., 2008).

Assessment of foot function

Foot function assessment was performed using the FFI. The index was developed by Budiman et al. (1991) in 1991 and its Turkish validity and reliability study was performed by Külünkoğlu et al. (2018). The FFI was developed as a questionnaire form to measure the effects of foot pathologies on pain, disability, and activity limitation, and was developed as an inquiry form that examines foot function from different perspectives based on the widely used patient-centered assessment (Budiman-Mak et al., 1991).

Although it was first applied in patients with rheumatoid arthritis, its use is not limited to this population and its validity and reliability in non-systemic foot and ankle problems was demonstrated by Agel et al. (2005).

The sub-parameters of the FFI are: pain (FFI-P), disability (FFI-D), and activity limitation (FFI-AL). It is a scale with a total of 23 items. The pain subscale contains nine items and measures the severity of foot pain in different situations. The disability subscale contains 9 items and assesses the severity of difficulty in performing functional activities due to the person's foot problems. The activity limitation subscale contains 5 items and measures the person's activity limitations due to foot problems. People answer the questions with a Visual Analog Scale (VAS), taking into account their foot condition in the previous week. A higher score indicates more pain, disability, and activity limitation. While answering the foot function index, participants were asked to answer by taking into account the symptoms they had experienced during the past week (Budiman-Mak et al., 1991).

Assessment of balance

The balance assessment of the children participating in the study was performed statically and dynamically. The Flamingo Balance Test was used for static balance assessment and the Y Balance Test was used for dynamic balance assessment.

In 1988, the Committee for the Development of Sport of the Council of the Europe developed the Eurofit test battery for the assessment of physical fitness in children and young people. The reliability of the Eurofit test battery was established by Tsigilis et al (2002). For the Flamingo Balance Test, a balance board made in the standard dimensions specified by Eurofit was used. The balance board is made by mounting two wooden beams of 2 cm width and 15 cm length under two wooden beams of 4 cm thickness, 3 cm width, and 30 cm length, intermittently and vertically. The participants' time to stand on one leg on the balance board was tested. The participant stands on the balance board with one foot and bends the knee with the free foot held by the hand on the same side. Meanwhile, their free hand is supported by the person performing the test. As soon as the participant feels that they have achieved balance, they release the tester's hand and at that moment the stopwatch is started. If the foot is released or the balance is disturbed and the foot leaves the balance board, the stopwatch is stopped and the time is recorded. If the tested person does not lose balance for 60 seconds, the test is terminated (Barabas et al., 1996). The Flamingo Balance test was repeated 3 times by each participant and mean of the repeated test results was taken for the score.

The Y dynamic balance test was developed by Plisky et al. (2006) instead of the Star dynamic balance test and its Turkish reliability was conducted by Türkeri et al. (2020). The Y Balance Test was used to evaluate the lower quarter dynamic balance of the children. The test was performed on the Y Balance Test platform. Before the test, the participants were asked to remove their shoes and socks. The test was demonstrated by the researchers and they were allowed to perform 4-6 trials. After the trials, the lower extremity length was measured from the pelvic-Spina Iliaca Anterior Superior to the lower border of the medial malleolus. They then tried to reach the last possible point with the contralateral lower limb in the anterior (ANT), posteromedial (PM), and posterolateral (PL) directions. Composite balance score (Comp.) was obtained by taking the average of the extension in 3 directions. The test was performed sequentially for both lower limbs. After 3 successful tests for each limb, the maximum distance reached was recorded in cm. The scores were then normalized using the formula "Maximum Reach Distance / Leg Length) x 100 = % maximum reach distance" (Plisky et al., 2009; Kinzey & Armstrong, 1998).

Data Analysis

The analysis of the data included in the study was carried out with SPSS 26.0 (Statistical Program in Social Sciences). Since the number of participants in the groups was less than 50, the normality distribution was tested with the Shapiro Wilk Test (Alpar, 2020).

Table 1

Comparison of the groups in terms of demographic characteristics.

Features (n=66)	Box (n=20) Mean±SD Median (Min-Max)	Basketball (n=22) Mean±SD Median (Min- Max)	Swimming (n=24) Mean±SD Median (Min- Max)	Kruskal-Wallis H Test and p^a value
Age (Years)	12.65±0.50 13 (9-16)	13.72±0.37 13.5 (11-16)	13.16±0.46 13 (9-16)	2.355 p=0.308
BMI (kg/m^2)	21.30±0.66 21.23 (15.79- 25.48)	20.04±0.78 19.46 (14.76- 26.29)	21.05±0.58 20.71 (16.23- 25.88)	1.770 p=0.413
Duration of Participation to sports (Months)	12.85±2.37 7.5 (6-36)	16.04±2.29 12 (4-36)	22.79±3.73 15.5 (5-36)	5.587 p=0.061
Frequency of participation to Sports (day/weeks)	3.35±0.34 2 (2-5)	3.22±0.32 2 (2-5)	3.5±0.31 3.5 (2-5)	0.379 p=0.827

Gender		Box	Basketball	Swimming	Total	χ2	p^b value
Female	n	9	15	12	36		
	%	45.00%	68.20%	50%	45.45%	0.545	0.460
Male	n	11	7	12	30		
	%	55.00%	31.80%	50%	54.55%		

*n: Sample size; %: Percentage; BMI: Body Mass Index; p^a: Kruskal Wallis test; Mean: Mean; SD: Standard deviation; p^b: Chi-square Test value (χ2) p value; *: There is a statistically significant difference between the groups (p<0.05).*

Since the variables were not normally distributed (p>0.05), the analysis was made with nonparametric test methods. Independent multiple group comparisons were made with the Kruskal Wallis H test for numerical data and Chi-Square analysis for categorical data. Post-Hoc analysis was performed using Dunn's test to determine which group caused the difference between the groups (Pairwise Comparisons) in the variables that differed after non-parametric tests (Dinno, 2015). Data are presented as Mean±SD, Median (Min-Max) and %. The significance level (p) was set as 0.05 for comparison tests.

Results

There was no statistically significant difference between the groups in terms of age, gender, BMI, duration of participation to sports, and frequency of participation to sports (p>0.05; Table 1).

Table 2

Comparison of the groups in terms of evaluated parameters.

Measurements/Evaluations	Box (n=20) Mean±SD Median (Min-Max)	Basketball (n=22) Mean±SD Median (Min-Max)	Swimming (n=24) Mean±SD Median (Min-Max)	Test and p^a value
FPI	1.40±0.48 1 (-2-6)	0.77±0.34 0 (-2-4)	3.08±0.50 4 (-2-6)	11.240 0.004*
FFI-P	10.47±2.48 6.6(0- 38.8)	15.14±2.60 11.35 (0-35.5)	14.92±1.92 12.45 (3.3-37.7)	3.686 0.158
FFI-AL	10.85±1.82 10 (0-29)	8.81±2.16 6 (0-32)	5.95±1.50 3 (0-26)	4.866 0.088
FFI-D	10.74±1.89 6.6 (2.2-25.5)	13.01±3.02 8.25 (0-44.4)	13.52±2.16 11.65 (0-42.2)	1.045 0.593
Static Balance-R	8.80±0.62 8 (4-14)	7.54±0.85 7 (2-15)	6.00±0.34 6 (3-9)	8.885 0.012*
Static Balance-L	9.30±0.62 9 (4-15)	7.22±0.93 6 (2-15)	6.33±0.46 6 (4-9)	11.544 0.003*
YBalance-R-ANT	81.30±3.52 79(60-115)	79.86±2.12 81 (62-104)	77.75±1.69 75.5 (66-94)	0.465 0.793
YBalance-R-PL	86.20±3.45 84 (65-119)	84.59±2.13 86 (67-109)	82.62±1.68 80.5 (70-98)	0.416 0.812
Ybalance-R-PM	91.30±3.52 89 (70-125)	89.86±2.12 91 (72-114)	87.75±1.68 85.5 (76-104)	0.475 0.813
Ybalance-R-Comp.	86.26±3.50 84 (65-119.67)	84.77±2.12 86 (67-109)	82.70±1.68 80.5(70.67-98.67)	0.430 0.807
YBalance-L-ANT	83.05±3.71 80.5 (60-120)	84.36±2.11 84.5 (65-113)	80.83±2.07 78 (62-100)	1.397 0.497
YBalance-L-PL	87.85±3.65 85(65-124)	89.36±2.08 89.5 (70-116)	85.95±2.05 83 (67-106)	1.496 0.473
Ybalance-L-PM	93.05±3.71 90.5 (70-130)	94.36±2.11 94.5 (75-123)	90.83±2.07 88 (72-110)	1.487 0.478
Ybalance-L-Comp.	87.98±3.69 85.5 (65-124.67)	89.36±2.10 89.5 (70-117.33)	85.87±2.06 83 (67-105.33)	1.379 0.502

FPC		Box	Basketball	Swimming	Total	χ2	p^b value
Foot in Supination	n	2	1	1	4		
	%	10.00%	4.5%	4.2%	6.1%	11.174	0.025
Notr Foot	n	6	15	6	27		
	%	30.00%	68.2%	25%	40.9%		
Foot in Pronation	n	12	6	17	35		
	%	60.00%	27.3%	70.8%	53%		

*N: Number of samples; %: Percentage; FFI: Foot Function Index; P: Pain; AL: Activity Limitation; D: Disability; FPC: Foot Posture Classification; R: Right; L: Left; ANT: Anterior; PL: Posterolateral; PM: Posteromedial; Comp: Composite; p^a: Kruskal Wallis test; SD: Standard Deviation; p^b: Chi-square Test value (χ2) p value; *: There is a statistically significant difference between the groups (p<0.05).*

Table 3
Pairwise comparison of the sports disciplines.

Groups	FPI		FPC		Static Balance-R		Static Balance-L	
	Test	p value	Test	p^c value	Test	p^c value	Test	p^c value
Basketball-Box	6.570	0.750	9.300	0.229	9.564	0.314	16.527	0.015*
Swimming-Basketball	-18.025	0.003*	-13.562	0.020*	7.657	0.522	1.460	1.000
Swimming- Box	-11.454	0.122	-4.263	1.000	17.221	0.009*	17.988	0.005*

*FPI: Foot Posture Index; FPC: Foot Posture Classification; R: Right; L: Left; p^c value: Post Hoc Test (Bonferroni- Dunn's test); * There is a statistically significant difference between the groups (p<0.05).*

There were statistically significant differences in foot posture score, right and left static balance, and foot posture class in boxing, basketball, and swimming (p<0.05). There was no significant difference between the groups in terms of parameters related to foot function and parameters related to dynamic balance assessment (p<0.05; Table 2).

In pairwise comparisons between groups, there was a significant difference between swimming and basketball groups in terms of foot posture score and foot posture class (p=0.003). While there was a significant difference between swimming and boxing groups in terms of right (p=0.009) and left (p=0.005) static balance parameters, there was a statistically significant difference between basketball and boxing groups in terms of left static balance (p=0.015; Table 3).

Discussion

In our study, foot posture and function were compared between child athletes playing sports in different 3 disciplines; box, basketball and swimming. A statistically significant difference was found between boxing, basketball, and swimming disciplines in terms of FPI score, right and left static balance results, and foot posture class parameters (p<0.05). While neutral foot posture was dominant in basketball players, pronated foot posture was more frequent in boxers and swimmers. FPI score was statistically higher in swimming compared to basketball group; static balance score was superior in boxing group than other disciplines.

Foot posture is known to affect the mechanical alignment and dynamic function of the lower limb. The feet, together with the ankle, knee, and hip joints form a lower limb kinematic chain that regulates balance in the standing position. The feet are located at the lowest part of the body and this allows the foot to act as the base of support for the kinematic chain. Any dynamic change in the feet is thought to affect the postural control of the whole body (Cote et al., 2005).

Differences in the development of motor skills in children from the age of 10 cause children to tend to any sports discipline, or vice versa, directing children to different sports disciplinees may cause differences in motor skill performances depending on the requirements of the sport discipline (Aktuğ & Irı, 2018). When the literature is examined, there are studies that associate motor skills with technical skills specific to different disciplinees (Aktug et al., 2018; Söğüt et al., 2017). Opstoel et al. (2015) identified motor skill differences in dancing, ball spotrs, gymnastics, racket spotrs, and swimming. Bencke et al. (2002) reported that 11-year-old gymnasts showed better jumping abilities compared to swimmers, handball players and tennis players of the same age group. Balance is a motoric feature that stands out not only in daily life activities, but also in all kinds of sports disciplines. While static balance is important in sports such as shooting and archery, dynamic balance plays a major role in the performance of freestyle sports such as snowboarding, skateboarding and windsurfing. Failure to maintain balance with rapid movements in sports such as basketball, football, softball, table tennis, handball and volleyball can lead to injuries (Zemková 2011). In disciplines such as soccer and basketball, the type of muscle activity specific to the discipline has an effect on balance performance (Zemková, 2014). Kariyawasam et al. (2019) compared the static balance parameters of basketball and soccer players and stated that the balance performance of basketball players was better than that of soccer players. Bressel et al. (2007) reported that athletes who become professionals in sports that require bipedal stance generally have better static balance than those who play sports that require unipedal stance. In their study, basketball players showed lower static balance compared to gymnasts and lower dynamic balance compared to soccer players. Gökdemir et al. (2012) compared the dynamic and static balance performances of sedentary and athletes in different disciplines and found that the dynamic balance performance of basketball players was higher than volleyball and soccer players, while the static balance performance of basketball players was lower than soccer and volleyball players. In our study, the best static balance values were observed in the boxing group, followed by basketball and swimming, respectively. Static balance is of great importance for achievable performance in sports. Basic motor skills such as throwing, kicking, jumping, and striking require a correctly adjusted balance in order to achieve maximum performance in sports and to minimize lower extremity injuries.

In our study, the rate of pronated feet (53%) was higher than that of supinated feet (6.1%), while the rate of feet with neutral posture was 40.9%. These findings are consistent with other studies in the literature (Gijon-Nogueron et al., 2015; van der Giessen et al., 2001). In a study by Martínez-Nova et al. (2014), reported that runners and basketball players have neutral feet, while handball players have supinated feet. According to their study, differences in foot posture seem to be mainly determined by two criteria: talar head position and talonavicular prominence. In our study, similar to this study, discipline differences revealed a difference in foot posture. While neutral foot posture was dominant in basketball players, pronated foot posture was more frequent in boxers and swimmers. FPI score was statistically higher in swimming compared to basketball group. Pradhan et al. (2021) investigated the relationship between foot posture and dynamic balance and pelvic tilt in healthy runners and found that there was no significant relationship between foot posture index and dynamic body balance, while there was a minimal relationship between foot posture index and anterior pelvic tilt angle. This result suggests that the hyperpronated foot does not directly affect balance or posture significantly. Lubetzky & Kramer (2015) evaluated the relationship between various foot morphologies and dynamic balance and concluded that people with reduced medial longitudinal arch height were able to reach farther in the Star Balance Test in all directions except the anterolateral direction and that no such balance deficit was noted. Similarly, Cote et al. (2005), who measured the effect of various foot postures on static and dynamic balance, reported that the pronated or supinated foot did not differ in terms of static balance compared to the control group. As can be seen from the results obtained from the literature, although the pronated foot is moderately related to body structures or anatomy, it does not significantly affect body mechanics or functions and thus balance. According to our study results, the box group and swimming pronation feet were dominant, but the static balance skill was superior only in the box group.

Conclusion

As a result, participating in sports in different disciplines seems to affect foot posture in children. While neutral foot posture was dominant in basketball players, pronated foot posture was more frequent in boxers and swimmers. Foot posture, balance ability and foot functionality differ between athletes with the effect of the characteristics required by the sports discipline. It can be said that different sports disciplines show different competencies in order to adapt to challenging situations depending on specialization in the sports branch, for example, boxing athletes need more static balance ability, basketball players need appropriate balance skills and foot posture while bouncing a ball, and swimming athletes who require rotational movements and regulation of the center of mass need appropriate balance skills and postural abilities. Supination foot posture seems to have an insignificant frequency in these 3 disciplines. The static balance skills of children in boxing seem to be superior than swimming and basketball sports. Box training can improve static balance skills of athletes who engage different disciplines. It is concluded that participation in sports from different disciplines within box, swimming and basketball disciplines does not affect foot function and dynamic balance in children. These results suggest that sport-specific skills of athletes should be improved with appropriate exercise and rehabilitation programs. The anatomical, functional and biomechanical differences of the analyzed sports branches may support the findings of our study in a way to give clues to other studies. The extent to which sport-specific postural differences and other motoric characteristics affect the athlete's skills and achievements when supported by appropriate exercise programs can be supported by future studies.

Some of the limitations of the study are that it was a single-centered study, the low sample size could be reached. In our study, we compared 3 sports disciplines with different requirements in terms of neuromuscular characteristics. It is clear that there is a need for studies in which more sports branches will be examined and biomechanical, postural, anthropometric and proprioceptive properties will be compared in future studies.

Authors' Contribution

Study Design: FK, BB; Data Collection: BB, YA; Statistical Analysis: FK, TB; Manuscript Preparation: FK, BB, YA, TB; Funds Collection: BB, YA, TB.

Ethical Approval

Ethics committee approval required for conducting the study was obtained from the Inönü University Health Sciences Non-Interventional Clinical Research Ethics Committee (Decision No: 2021/2856). The study was conducted in accordance with the Principles of the Declaration of Helsinki. Parents/Guardians of the children included in the study were informed in detail about the study and their written consents were obtained.

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Conflict of Interest

The authors hereby declare that there was no conflict of interest in conducting this research.

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