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Investigation of Gross Motor Profiles and Proprioception Losses in Athletic and Non-Athletic Children: Cross-Sectional Research

Spor Yapan ve Spor Yapmayan Çocuklarda Kaba Motor Profillerinin ve Propriosepsiyon Kayıplarının İncelenmesi: Kesitsel Araştırma

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ABSTRACT Objective: The objective of this study was to compare the gross motor skills and proprioceptive sensory deficits of children aged 8 to 10 years who regularly participated in sports activities with those who did not engage in any physical activity. **Material and Methods:** The study participants were two groups of children aged 8-10 years: those who did not participate in any sports activity (n=15) and those who regularly participated in taekwondo and karate exercises for at least 2 years (n=15). A battery of motor skill tests was conducted, including bilateral coordination, balance, speed agility, and strength. These tests were administered using the Bruininks Oseretsky Motor Competence Short Form. Additionally, measurements of the knee joint at 45° and 60° of flexion and 10° of dorsiflexion-30° of plantar flexion of the ankle joint were taken, along with sensory losses using a digital goniometer which is one of the techniques used to measure joint position sense. **Results:** The results indicated that while there was no significant difference in bilateral coordination and balance between the two groups, the sports group exhibited significantly higher scores in speed agility, strength, and overall gross motor skill proficiency. Additionally, the sports group showed lower proprioceptive sensory losses compared to the non-sports group. **Conclusion:** These findings underscore the positive impact of regular physical activity on children's motor skill development and proprioceptive abilities, emphasizing the importance of encouraging children to engage in sports for their overall health and well-being.

Keywords: Motor skill; proprioception;
physical activity; children

ÖZET Amaç: Bu çalışmanın amacı, 8-10 yaş arası çocukların düzenli olarak spor aktivitelerine katılanları ile hiçbir fiziksel aktiviteye katılmayanların kaba motor becerileri ve proprioseptif duyu eksikliklerini karşılaştırmaktır. **Gereç ve Yöntemler:** Çalışma katılımcılarını 8-10 yaş arası herhangi bir spor aktivitelerine katılmayan (n=15) ve en az 2 yıldır düzenli olarak tekvando ve karate egzersizlerine katılan (n=15) çocuk katılımcılar oluşturmaktadır. Katılımcıların kaba kotor beceri değerlendirilmeleri bilateral koordinasyon, denge, hız-çeviklik ve kuvvet testlerini içeren Bruininks Oseretsky Motor Yeterlilik Kısa Formu kullanılarak gerçekleştirilmiştir. Ek olarak, diz ekleminin 45° ve 60° fleksiyonda, ayak bileği ekleminin ise 10° dorsifleksiyon-30° plantar fleksiyonda proprioseptif duyusal kayıpları dijital gonyometre ile eklem pozisyon hissini değerlendirme tekniğini kullanarak katılımcıların proprioseptif duyu kayıpları değerlendirilmiştir. **Bulgular:** Araştırmanın bulguları incelendiğinde; iki grup arasında bilateral koordinasyon ve denge açısından anlamlı bir fark olmadığı, ancak spor yapan grubun hız-çeviklik, kuvvet ve toplam kaba motor beceri puanlarında anlamlı derecede yüksek skorlar sergilediği ortaya çıkmıştır. Ayrıca, sportif olarak aktif olan grubun, proprioseptif duyusal kayıplarında spor yapmayan gruba göre daha düşük değerler gösterdiği görülmüştür. **Sonuç:** Sonuç olarak araştırmamızın bulguları, düzenli fiziksel aktivitenin çocukların motor beceri gelişimi ve proprioseptif yetenekleri üzerindeki olumlu etkilerini vurgulamakta ve çocukların genel sağlık durumları için spor yapmalarının teşvik edilmesinin önemini ortaya koymaktadır.

Anahtar Kelimeler: Motor beceri; propriosepsiyon;
fiziksel aktivite; çocuklar

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Motor skill competence is hypothesized to be an important factor in determining how physically active or inactive a child is.[1] Research has shown that the development of gross motor skills in early childhood is essential for overall physical health, cognitive development, and academic achievement.[2,3] When children have low levels of physical fitness that are not sufficient to perform an exercise, it will negatively affect their ability to engage in other physical activities in general and limit the further development of their motor skill competence. It is therefore proposed that physical fitness acts as a mediating variable in the relationship between motor skill competence and physical activity and that it is developmentally strengthened over time.[4] Research has shown that physical activity improves learning and memory in adults and that there is a significant positive association between physical activity and cognition in children aged 6-13 years.[5,6] Therefore, the promotion of healthy and age-appropriate physical activity behaviors is essential to promote long-term health benefits in young children. In addition, physical activity can cause neurochemical and morphological changes in brain regions associated with executive function in children aged 4-12 years.[7,8]

Motor skills and proprioception are closely related because the development and execution of motor skills depend on the ability to perceive the position and movement of the body in space. Proprioception, often referred to as the "6th sense", is the sensory feedback mechanism that allows us to know the position and movement of our body parts without looking directly at them. Goble et al. found that children initially develop the ability to perform motor skills accurately using information from multiple senses, making proprioception more subconscious, and over the years the accuracy of joint position matching increases. Proprioception is divided into 2 categories; the first is related to somatosensory sensations that represent the conscious appreciation of proprioception, including kinesthesia, joint position, and force sensation.[9] The 2nd is related to neuromuscular sensations, which reflect the unconscious control of joint proprioception, including postural control, joint stability, and muscle reaction times.[10] The lack of any type of proprioceptive ability in children can lead to difficulties in motor coordination and planning.[11,12]

In children, proper functioning of the proprioceptive sense is the basis for the development of balance, coordination, and general motor skills. Physical activity improves children's motor skills by supporting the development of proprioception, and regular physical activity helps children use proprioceptive feedback more effectively, increasing the precision of their movements. Some children may have difficulty developing gross motor skills and proprioception due to a lack of physical activity opportunities or underlying developmental or neurological conditions. This can affect children's ability to move more competently and safely in sports and their daily lives. Therefore, it is important to understand the relationship between proprioceptive sensations and motor skills, the benefits of developing gross motor skills, and strategies to promote their development. This study aimed to determine the difference in gross motor skill levels and proprioceptive sensory deficits between children living in rural areas who did not participate in any physical activity other than free activity and physical education classes in their school curriculum and children who regularly practiced Tae Kwon Do and Karate.

MATERIAL AND METHODS

PARTICIPANTS

The sample of the study was selected through purposive sampling and consisted of primary school children (n=30) aged 8-10 years living in Yalova, Türkiye. The inactive group of the study was intended to consist of children who were not enrolled in any physical activity other than the free activity periods in the school curriculum. In this direction, one of the villages in the rural areas of Yalova city was selected and forms were distributed to teachers and parents in a primary school to collect information about the physical activity status of the students, and according to the information obtained from these forms, n=15 children were selected on a voluntary basis for the inactive group. The regular physical activity group (n=15) was formed by contacting the coaches of the clubs affiliated to the Ministry of Youth and

Sports in Yalova and randomly selecting the children (n=15) who had regularly participated in Taekwondo and Karate activities for at least 2 years in the clubs and wished to be included in the study. Written consent was obtained from the parents, teachers and coaches of all study participants.

ETHICAL ASPECTS OF THE RESEARCH

The participants in the study were fully informed about the purpose and methods of the research, and parental and child consent forms were signed. The study was conducted with the approval of the Yalova University 2023 Human Research Ethics Committee (date: May 8, 2023; no: 2023/80), and participation was voluntary. The research was conducted in accordance with the principles of the Declaration of Helsinki. The 'Higher Education Institutions Scientific Research and Publication Ethics Directive' was adhered to during the current research.

RESEARCH DESIGN

This study aimed to investigate and compare the gross motor competence and proprioceptive sensory abilities of children who regularly participate in sports activities and those who do not. The personal information form recorded the age, gender, height, and weight values of the participants. All participants underwent the Bruininks-Oseretsky Motor Competence Test (BOT-2) motor skill test to determine their gross motor skill levels. The proprioception test was administered two days after the motor test and before the sports group's training.

DATA COLLECTION TOOLS

Bruininks Oseretsky Motor Competence Test-2 Short Form

Children's motor competence was assessed using the Bruininks Oseretsky Motor Competence Test-2 Short Form (BOT-2 SF) according to manual instructions. The 2nd version of the BOT-2 was developed to measure motor function in children between the ages of 4-21. It is a revised version of the 1st version developed by Bruininks and Oseretsky in 1978. The BOT-2 is a tool used by educators, therapists, and researchers to assess children's motor skills, to design and evaluate motor development programs, and to detect and evaluate various motor dysfunctions and developmental delays. The test materials are designed to capture children's attention, provide consistency of use, and facilitate administration and scoring. The test was standardized in a study conducted by Bruninks on 1520 students between the ages of 4-21, and the reliability coefficient was 0.70. The BOT-2 test consists of 8 subtests and 53 items, and there is a short form of the test consisting of 8 subtests and 12 items.[13]

This study included only four subtests of the BOT-2 SF test that assess gross motor skills. The subtests and items included are listed in Table 1.

Proprioceptive Sensory Measurements

This technique involves repositioning the knee and ankle joints and is one of the methods used to measure joint position sense.[14] The study measured joint position sense using a digital goniometer [Baseline 10044E Digital Absolute+Axis Goniometer 10044E SKU: CM10044E (Baseline, USA)] with a sensitivity of 1 degree (Figure 1). The goniometer was fixed to the knee joint of the subject's dominant foot with electromyography (EMG) bandages. Proprioception losses were calculated by taking the absolute values of the degrees of distance from the target angle.

Measurement of Knee Joint Proprioception

When measuring knee joint proprioception, the subject should be positioned with their feet on the ground and perpendicular to the tibia. The center point of knee rotation should be marked from the lateral side of the knee. The goniometer arms should be fixed with EMG bandages parallel to the femur and tibia bones. Measurements should be taken by extending the knee joint from a sitting position to angles of 45° and 60°. The knee joint of the subject is initially positioned at the target angle and instructed to maintain this position for 5 seconds. The subject is then asked to hold this position for 5 seconds. Next, the subject is instructed to close their eyes and ears and bring the knee joint extension to the target angle set by the expert at the beginning of the test. Three attempts are made for each angle.

Ankle Joint Proprioception Measurement

The subject lies horizontally on the stretcher for the ankle measurement. Ankle position sense is measured

TABLE 1: Subtests and items included in the study.

BOT-2 subtest	Items	Item's name	Explanation
Bilateral coordination	Item 1-(BC-1)	Touching The Tip of The Nose with The Index Finger-Closed Eyes (4 Touches)	On the line, arms out to the sides, eyes closed, touch the tip of the nose with the index finger. The touches should be one after the other. After touching with one hand, she returns to the starting position and performs the touch with the other hand. There are 2 applications and 4 touches for each application. The touches that he/she can make with the tip of his/her nose during the exercise are recorded. According to the point scoring on the evaluation scale, a score between 0-4 was given according to the best 2nd.
	Item 2-(BC-2)	Jamping Jack Bounce (5 Jumps)	The child stands with arms and legs closed. Then he/she performs the Jumping Jack movement in sequence by opening his/her hands and arms and jumping. There are 2 applications and 5 jumps for each application. The hands must be able to reach above the head during the application. According to the point scoring on the evaluation scale, a score between 0-3 was given according to the best 2nd.
Balance	Item 1-(B-1)	10 Sec Standing on A Balance Beam Heel to Toe-(Eyes Closed)	The child places his/her hands on the hips. The child should wait for 10 seconds on the balance beam with the toes of the back foot touching the heel of the front foot with closed eyes. If the child could not balance for 10 seconds in the 1st attempt, the test was repeated with a second attempt and the score was recorded in seconds. According to the point scoring on the evaluation scale, a score between 0-4 was given according to the best 2^{nd}.
	Item 2-(B-2)	10 Sec Standing on One Leg-Eyes Closed (Eyes Closed)	The preferred foot is placed on a line on the floor with eyes closed. Both hands are on the hips and the other (non-preferred) leg is bent at the knee. The raw score is the number of seconds (from 0 to 10) that the child maintains in this position, up to a maximum of 10 seconds. According to the point scoring on the evaluation scale, a score between 0-4 was given according to the best 2^{nd}.
Speed and agility	Item 1-(SA-1)	One-Legged Stationary Hop-15 sec	The child stands on one foot of their choice on the line with the other foot behind them at a 90-degree angle. The competitor jumps on one foot with hands on the waist for 15 seconds. If he/she removes the hand from the waist, falls, or the angle of the back foot is less than 90 degrees, the exercise ends. There are two drills and 15 seconds for each drill. According to the point scoring on the evaluation scale, a score between 0-10 was given according to the best second.
	Item 2-(SA-2)	Two-Legged Side Hop-15 sec	The child crosses from one side of the line to the other for 15 seconds by jumping with both feet, hands on waist, without stepping on the line. If he/she takes his/her hand off his/her waist, falls or stumbles, the contest is over. Jumps where she steps on the line are not counted. There are 2 attempts and 15 seconds for each attempt. According to the point scoring on the evaluation scale, a score between 0-10 was given according to the best 2^{nd}.
Strength	Item 1-(S-1)	Sit Up-30 second	About one exercise, regular push-ups for 30 seconds. The number of regular push-ups at the end of the time is scored. According to the point scoring on the evaluation scale, a score between 0-10 was given according to the best 2^{nd}.
	Item 2-(S-2)	Knee Push-Up (for girl)-Full Push-Up (for boy)- 30 sec	Knee Push-Up: For a single exercise, perform push-ups with knees on the floor and bent for 30 seconds. The number of regular push-ups at the end of the time is scored. Full Push-Up: About one exercise, regular push-ups for 30 seconds. The number of regular push-ups at the end of the time is scored. According to the point scoring on the evaluation scale, a score between 0-10 was given according to the best 2^{nd}.

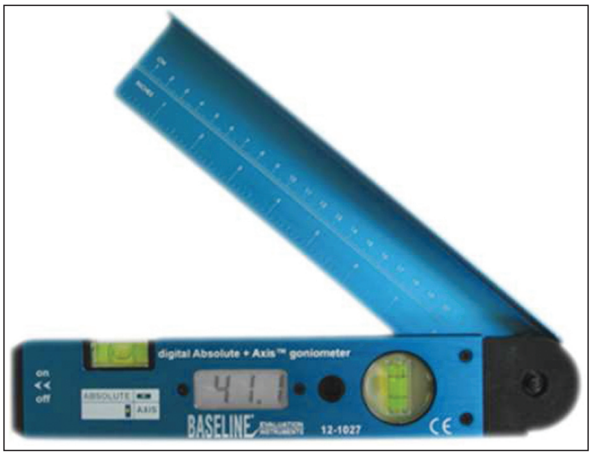

FIGURE 1: Baseline digital goniometer.

at 10° dorsiflexion and 30° plantarflexion. After the subject's foot is brought to the targeted dorsiflexion angle, they are asked to hold the position for 5 seconds to remember it, then return to the neutral position (0°). The participant is instructed to actively move their foot to the target angle. Three consecutive trials are performed at both angles (dorsiflexion and plantarflexion), and the mean values (in degrees) are used for analysis. Throughout the measurements, the participants' eyes are covered with an eye patch, and their ears with earplugs to minimize external stimuli.

STATISTICAL ANALYSIS

The research data were analyzed using the SPSS 26 package program (SPSS Inc. Chicago II, ABD). The normal distribution of the data was analyzed using the Shapiro-Wilk test results, as well as skewness and Kurtosis values. It was determined that the data did not fit the normal distribution, and as such, nonparametric tests were used for the analyses. Descriptive statistics, including mean, standard deviation, and percentage changes, were determined. The Mann-Whitney U test was used to compare the measured variables between groups which are bilateral coordination, speed-agility, strength, Bruininks-Oseretsky Test of Motor Proficiency Total Score, loss of proprioception of the knee joint at 45° at 10° of dorsiflexion of the ankle joint, loss of proprioception at 30° of plantar flexion of the ankle joint. A statistical significance level of $p \leq 0.05$ was applied.

RESULTS

The participants consisted of 30 children (female: 15; male: 15) with a mean age of 8.72±1.22 years, 15 of whom participated in sports and 15 of whom did not. The participants had a mean height of 134.50±11.12 and a mean weight of 30.64±7.31.

Table 2 shows the mean values of BOT-2 subparameters, BOT-2 total scores, ankle proprioception,

TABLE 2: Descriptive statistics of participants' motor skill test scores and proprioception losses.

	Athletes Groups				Non-athletes Groups				Total			
Variables	n	Minimum	Maximum	X̄±SD	n	Minimum	Maximum	X̄±SD	n	Minimum	Maximum	X̄±SD
BC-1	15	4.00	4.00	4.00±0.00	15	2.00	4.00	3.67±0.62	30	2.00	4.00	3.83±0.46
BC-2	15	2.00	4.00	2.93±0.59	15	0.00	4.00	2.33±1.11	30	0.00	4.00	2.63±0.93
B-1	15	3.00	4.00	3.87±0.35	15	3.00	4.00	3.73±0.46	30	3.00	4.00	3.80±0.41
B-2	15	3.00	4.00	3.60±0.51	15	1.00	4.00	3.33±0.90	30	1.00	4.00	3.47±0.73
SA-1	15	9.00	10.00	9.87±0.35	15	3.00	9.00	6.20±1.57	30	3.00	10.00	8.03±2.17
SA-2	15	8.00	10.00	9.47±0.74	15	3.00	7.00	4.80±1.15	30	3.00	10.00	7.13±2.56
S-1	15	4.00	7.00	5.80±0.86	15	0.00	5.00	3.67±1.72	30	0.00	7.00	4.73±1.72
S-2	15	3.00	600	4.47±0.99	15	1.00	5.00	2.93±1.03	30	1.00	6.00	3.70±1.26
BOT-total	15	40.00	47.00	44.00±1.96	15	26.00	38.00	30.67±3.15	30	26.00	47.00	37.33±7.26
LPKF-45°	15	0.30	15.80	4.01±4.02	15	0.33	19.00	10.82±5.87	30	0.30	19.00	7.42±6.04
LPKF-60°	15	0.93	13.55	4.20±3.17	15	0.70	24.43	10.40±6.72	30	0.70	24.43	7.30±6.05
LPAD-10°	15	0,55	9.40	4.15±2.10	15	0.10	13.77	5.34±3.86	30	0.10	13.77	4.75±3.11
LPAP-30°	15	3.15	18.10	11.27±4.61	15	0.23	21.13	6.95±6.50	30	0.23	21.13	9.11±5.96

SD: Standard deviation; BC-1: Bilateral coordination-1; BC-2: Bilateral coordination-2; B-1: Balance-1; B-2: Balance-2; SA-1: Speed-Agility-1; SA-2: Speed-Agility-2; S-1: Strength-1; S-2: Strength-2; BOT-total: Bruininks-Oseretsky Test of Motor Proficiency Total Score; LPKF-45°: Loss of proprioception of the knee joint at 45° at 10° of dorsiflexion of the ankle joint; LPKF-60°: Loss of proprioceptiton af the knee joint at 60°; LPAD-10°: Loss of proprioception of dorsiflextion of the ankle joint at 10°; LPAP-30°: Loss of proprioception of plantarflextion of the ankle joint at 30°.

TABLE 3: Comparison of motor control test scores and proprioception loss values in the athlete and non-athlete groups.

Variables	Groups	n	Mean rank	Sum of ranks	U	Z	p value
BC-1	Athletes	15	17.50	262.50	82.500	-2.108	**0.035***
	Non-athletes	15	13.50	202.50			
BC-2	Athletes	15	17.83	267.50	77.500	-1.624	0.104
	Non-athletes	15	13.17	197.50			
B-1	Athletes	15	16.50	247.50	97.500	-0.898	0.369
	Non-athletes	15	14.50	217.50			
B-2	Athletes	15	16.40	246.00	99.000	-0.638	0.523
	Non-athletes	15	14.60	219.00			
SA-1	Athletes	15	22.93	344.00	1.000	-4.847	**p<0.001**
	Non-athletes	15	8.07	121.00			
SA-2	Athletes	15	23.00	345.00	0.000	-4.766	**p<0.001**
	Non-athletes	15	8.00	120.00			
S-1	Athletes	15	21.53	323.00	22.000	-3.883	**p<0.001**
	Non-athletes	15	9.47	142.00			
S-2	Athletes	15	20.73	311.00	34.000	-3.348	**0.001***
	Non-athletes	15	10.27	154.00			
BOT-total	Athletes	15	23.00	345.00	0.000	-4.678	**p<0.001**
	Non-athletes	15	8.00	120.00			
LPKF-45°	Athletes	15	10.60	159.00	39.000	-3.049	**0.002***
	Non-athletes	15	20.40	306.00			
LPKF-60°	Athletes	15	11.13	167.00	47.000	-2.717	**0.007***
	Non-athletes	15	19.87	298.00			
LPAD-10°	Athletes	15	14.20	213.00	93.000	-0.809	0.419
	Non-athletes	15	16.80	252.00			
LPAP-30°	Athletes	15	19.20	288.00	57.000	-2.302	**0.021***
	Non-athletes	15	11.80	177.00			

*p<0.05. BC-1: Bilateral coordination-1, BC-2: Bilateral coordination-2, B-1: Balance-1, B-2: Balance-2, SA-1: Speed-Agility-1, SA-2: Speed-Agility-2, S-1: Strength-1, S-2: Strength-2, BOT-total: Bruininks-Oseretsky Test of Motor Proficiency Total Score, LPKF-45°: Loss of proprioception of the knee joint at 45° at 10° of dorsiflexion of the ankle joint, LPKF-60°: Loss of proriocepiton of the knee joint at 60°; LPAD-10°: Loss of proprioception of dorsiflextion of the ankle joint at 10°; LPAP-30°: Loss of proprioception of plantarflextion of the ankle joint at 30°.

and knee proprioception angle losses for the groups who did and did not participate in sports.

Table 3 presents the statistical test results regarding the differences in motor control test scores and proprioception losses between the groups who participated in sports and those who did not. No significant difference was found in BC-2, B-1, B-2, or LPAD-10° values between the 2 groups (p>0.05). However, a significant difference was observed in BC-1, SA-1, SA-2, S-1, S-2, and BOT-total values in favor of the exercising individuals (p<0.05). When analyzing the difference in proprioception loss scores, a significant difference was found between the groups for LPKF-45° (Loss of proprioception of the knee joint at 45°), LPKF-60° (Loss of propriocepiton of the knee joint at 60°), and LPAP-30° (Loss of proprioception of plantarflextion of the ankle joint at 30°) scores (p<0.05). This difference was attributed to the fact that children who did not participate in sports had more proprioception loss than those who did.

DISCUSSION

The objective of this study was to examine the correlation between gross motor skills and proprioceptive sensory loss in children aged 8-10 years old, with and without a history of participation in sports. In this study, the "Touching the nose with index fingers-eyes closed-BC-1" and "Jumping jack-BC-2" subtests of the BOT-2 test battery were employed. A significant difference was identified between the groups who did and did not engage in sports activities with respect to the BC-1, with the children who participated in sports activities exhibiting a higher score. However, no significant difference was observed in terms of the BC-2.

A review of the relevant literature revealed that Stanković et al. observed an increase in all values of the bilateral coordination test of the BOT-2 test battery for the experimental group following a 12-week exercise program for children aged 5-6 years.[15] However, no significant difference was observed in the "Touching the tip of the nose with the index finger with eyes closed" test. In a separate study, a significant difference was identified in the bilateral coordination values of the experimental group in the jumping jack test, yet no significant difference was evident in the "Touching the tip of the nose with the index finger, eyes closed" test following 8-weeks of sports school practices among preschool children. In a study conducted by Stojmenovic et al. no statistically significant difference was found between the two groups in BOT-2 upper extremity coordination results.[16] The study involved 9-year-old children, some of whom were sportively active and some of whom were inactive. In general, the bilateral coordination findings of these studies, which applied the BOT-2 test and performed on active and inactive groups, do not align with the bilateral coordination findings of our study. The lack of a difference between physically active and inactive groups in BC scores in BOT-2 tests in the relevant literature reviewed may be attributed to the fact that the skill tests applied to children for bilateral coordination parameters are at a level that can be performed by children without any health problems without doing sports. Indeed, some studies have proposed that the BC subtests of the BOT-2 test battery lack sufficient complexity for children with well-developed motor skills, and that these tests are performed at an exemplary level in children from preschool age to older age groups.[17-19]

In this study, an evaluation of the balance parameter (B-1 and B-2 test results, which are the subtests of the BOT-2 test battery) revealed no significant difference in balance (B-1, B-2) values between the groups who engaged in sports and those who did not. When the literature is reviewed, Faigenbaum et al. highlighted that 10-week BNA applications applied to 7-year-old children had the potential to enhance their fundamental motor abilities.[20] However, they did not identify a notable outcome in the balance parameter. They proposed that the exercise program in the study lacked sufficient content about stabilization. These findings of the researchers were as unexpected as the results obtained in our study, which did not demonstrate a significant difference. Many studies in this field have indicated that improvements in balance parameters can be observed following exercise interventions. Özsaydı et al. is a notable example of this, with the researchers identifying a significant difference in balance values between 2 groups of children: those who regularly practiced sports in a basketball infrastructure and sedentary children.[21] Similarly, Chaouachi et al. emphasized that an 8-week training program with combinations of plyometric and balance training resulted in higher values for the child participants in the experimental group, aged 12-15 years.[22] These results appear to be at odds with our findings. This discrepancy can be attributed to the inadequacy of the balance assessment method employed in the test battery, which fails to adequately differentiate the diverse stabilization abilities exhibited by the child participants, who engage in regular sports.

In the present study, speed and agility parameters were evaluated using the SA-1 (Stationary jump on one leg-15 sec) and SA-2 (Double foot right-left jump -15 sec) tests, which are subtests of the BOT-2 test battery. The results indicated a significant difference in speed-agility values in favor of the sports group. Özsaydı et al. found a significant difference between the 2 groups in the speed-agility values in the BOT-2 test in a study conducted between children who regularly practiced sports in the basketball substructure and sedentary children.[21] The group practicing sports demonstrated higher values. In a study conducted by Faigenbaum et al. was found that an 8-week integrative neuromuscular training program, conducted for 15 minutes twice a week, resulted in positive effects on speed and agility values in the experimental group.[23] The results of these studies are comparable to those observed in our own investigation into speed-agility. It can therefore be concluded that regular participation in sports has a beneficial effect on speed and agility parameters, which are motor characteristics.

In our study, an examination of the S-1 (sit-ups-30 seconds) and S-2 (push-ups-30 seconds) values, which are the subtests of the BOT-2 test battery of the strength parameter, revealed significant differences in favour of the children who engaged in sports. Upon examination of the study, it was determined that there was a statistically significant difference in the strength quotient scores of the children in the experimental group on the BOT-2 motor competence tests following the implementation of gymnastics training for 5-6 year old children, with a p-value of less than 0.01 and a preference for the intervention group.[24] In another study conducted by Uçan et al. it was observed that children who engage in sports with a license tend to exhibit higher values in shuttle push-up tests.[25] Similarly, Faigenbaum et al. reported a notable increase in upper extremity and abdominal strength data in children in the experimental group after 8-weeks of integrated neuromuscular training.[23] These studies appear to align with the findings of our study.

In our study, we observed a notable difference in the BOT-total values of the children who engaged in sports activities and those who did not. The group who did sports exhibited higher BOT-total values. In his study, titled "Investigation of the effect of gymnastics training program applied to children aged 5-6 years on motor development", Mülazimoğlu Ballı found a significant difference in favor of the treatment group at the $p<0.01$ level in balance, bilateral coordination, strength, and total gross motor composite scores in BOT-2 motor competence tests of children in the experimental, control, and placebo groups.[24] The previous research suggested that children's general fitness performance may have improved after the training applied by the researchers.[23] In another study although data collection methods were not identical to those used in our study, it was similarly observed that neuromuscular training yielded positive results in motor coordination and general fitness levels in children.[26] These findings are consistent with other research indicating that motor skill level positively correlated with physical activity level. Therefore, children with the highest motor test scores tend to have the greatest physical activity levels.[27,28]

It is hypothesized that interventions aimed at improving proprioception may have a positive effect on motor function. To illustrate, a strength training program for a child with developmental coordination disorder led to improvements in muscle strength, gross motor function, and proprioception. This evidence suggests that targeted interventions may mitigate some of the negative effects of proprioceptive loss on physical development.[29] As a matter of fact, considering that in the current study, the losses in proprioception values of children who do not do sports are higher than those who do sports, the importance of physical activity becomes evident. When the relevant literature is reviewed, it appears that Silva-Moya et al. observed a notable reduction in the positional errors of the shoulder, elbow, wrist, hip, knee, and ankle in the experimental group following the neuromuscular training intervention.[30] Shen and Liu observed that after 16 weeks of soccer training applied to children aged 5-6 years, the exercise group exhibited improved knee extension, ankle plantarflexion, and dorsiflexion kinesthesia compared to the control group.[31] Chatzopoulos observed that 7-year-old girls demonstrated higher knee flexion and extension values than the control group after 3 months of regular ballet training.[32] It is thought that proprioception is transmitted to all levels of the central nervous system, where it provides a unique sensory component to optimize motor control. Additionally, proprioception is essential for the performance of complex motor tasks. In a study comparing clumsy children (those with developmental coordination disorders) with their peers, proprioceptive tasks were found to predict performance in more complex motor skills. This suggests that proprioceptive deficits may lead to difficulties in tasks requiring dexterity, ball skills, and balance, which are essential for physical development.[33] Moreover, proprioceptive information is believed to be essential for neuromuscular control of dynamic movement constraints. Considering this information, we believe that better proprioceptive sensory values in sportively active children may contribute to better function of their musculoskeletal system and better protection from possible injuries. The findings of the study demonstrate notable discrepancies in gross motor abilities and proprioceptive deficiencies between children engaged in athletic pursuits and those who are not. Nevertheless, future research utilizing a larger sample size will enhance the generalizability of these findings to a broader population, facilitate a more comprehensive investigation of individual variations, and improve the reliability of the results.

CONCLUSION

This study comparatively analyzed gross motor skills and proprioceptive sensory deficits between children who participated in regular sports activities and children who did not participate in physical activity. The study revealed that physical activity positively affects motor skill development and that the proprioceptive sensory values of children engaged in sports were better, and they used proprioceptive feedback more effectively to increase movement accuracy. In addition, it was determined that protecting joint receptors during sports activities increases musculoskeletal system functionality and supports protection from injuries. However, the study has limitations, including the relatively small sample size, the exclusion of data from distinct sporting disciplines, and the recruitment of non-sporting children from rural areas. Future studies should consider expanding the sample size, incorporating diverse exercise modalities, and employing alternative measurement techniques to assess fine motor development and other physiological parameters.

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Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

***Idea/Concept:** Şeyma Öznur Gökşin, Burçak Keskin, Sema Arslan Kabasakal; **Design:** Burçak Keskin, Şeyma Öznur Gökşin; **Control/Supervision:** Özlem Kırandı, Şeyma Öznur Gökşin; **Data Collection and/or Processing:** Sema Arslan Kabasakal, Şeyma Öznur Gökşin; **Analysis and/or Interpretation:** Şeyma Öznur Gökşin, Sema Arslan Kabasakal; **Literature Review:** Şeyma Öznur Gökşin; **Writing the Article:** Şeyma Öznur Gökşin, Sema Arslan Kabasakal; **Critical Review:** Burçak Keskin, Özlem Kırandı; **References and Fundings:** Burçak Keskin, Özlem Kırandı, Şeyma Öznur Gökşin; **Materials:** Şeyma Öznur Gökşin, Sema Arslan Kabasakal.*

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