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ORIGINAL RESEARCH

Sports performance in 10-year-old children participating in multi-skills movement program: a pilot study

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Abstract

The aim of this study was to investigate the relationships between sprint, change of direction, and jumping parameters in primary school boys and girls participating in the multi-skill movement program. 10 girls (age: 10.87±0.70 years, height: 140.10±0.03 cm, body weight: 42.01±10.49 kg) and 10 boys (age: 10.37±0.46 years, height: 134.60±0.08 cm, body weight: 36.00±10.58 kg) volunteered in the study. To test the sprint speed; 5m, 10m, 20m sprint tests, to test change of direction performance; 505 Change of Direction Test, T Test, Pro Agility Test, and Hexagon Test, and lastly to test the jump performance; Counter Movement Jump Test and Triple leg-hop for distance test were applied. Mann Whitney U -Test and Spearman Correlation Test were used in the analysis of the data obtained in the study. When the data were examined, a statistically significant relationship was found between the 5m, 10m, and 20m sprint tests ($p<0.05$). In addition, a statistically significant relationship was found between T-Test and Triple leg-hop for distance test ($p<0.05$). However, no significant relationship was found between other parameters ($p>0.05$). As a result at the end of multi-skills training, regardless of gender differences, there was a relationship in some sprint and directional abilities in preadolescent children. It is suggested physical education teachers and sports scientists take this into consideration when making their plans.

Keywords: Children, performance, physical fitness, primary education.

Introduction

The school age is a crucial time that covers critical age periods where the child must acquire the necessary skills in order to become a healthy individual. It has been determined that physical activities have serious effect on child development during this period (Foley & Maddison, 2010). In addition, children participating in movement training programs, which include physical activities improve motor development (basic movement skills, coordination, physical fitness, body awareness, sports habits etc.) and move their bodies by using their muscles and joints, thus spend energy. As a result of performing such training at different intensities, their heart and respiratory rate increase (Martone et al., 2014).

The relationship between motor performance and movement training in the development of children mostly depends on the performance test factor. The training to be applied to children should aim to develop motor features such as endurance, strength, speed, dexterity, and mobility starting from childhood and adolescence in the desired manner with purposeful applications, and to reinforce them in adulthood and to bring them to a higher level. Performance tests are applied in order to observe all these developmental stages. In addition, these tests are important in terms of

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early orientation to sports and achieving high-level success in sports. Directing children to appropriate branches at the right time means that they can achieve high success (Hammami et al., 2017).

When directing children to a branch, various movements such as change of direction, short sprints, jumps as well as the technical skills performed with or without the ball are intensely performed during the game in individual or team sports (De Villarreal et al., 2009; Chelly et al., 2011; Zapartidis et al., 2018). All these movements appear while sprinting, changing direction, and jumping. It is stated that muscle strength should be used together and in coordination in many sports branches (Bencke et al., 2002).

It is essential to regularly evaluate athletes using valid and reliable measures and instruments to optimize training strategies and monitor training loads (Ferrauti et al., 2018). Consistent evaluations will provide trainers with valuable information about the strengths and weaknesses of players in the long-term athlete development process (Fernández-Fernández et al., 2014). After completing an individualized training program, tests should be repeated at regular intervals to detect changes in physical performance and adjust subsequent training programs (Ferrauti et al., 2018). Therefore, 20m linear sprint test, change of direction (COD) tests (e.g., T-Test and 5-0-5), and jumping ability tests [e.g., countermovement jump (CMJ)] are frequently used to achieve this (Cooke et al. 2011; Fernández-Fernández et al., 2014; Myburgh et al., 2016; Ferrauti et al., 2018).

When the foreign literature was examined, it was observed that Farlinger et al., (2007) could not find any significant correlation between quickness (hexagon test) and various physical performance parameters (e.g., Wingate, vertical jump, specific on-ice sprint) in hockey players. Similarly, Myburg et al. (2016) found no significant correlation between hexagon test and some functional measures in young tennis players. However, Pauole et al. (2000) found a significant relationship between quickness (hexagon test), and both change of direction (t-test) and speed in athletes in different sports branches. Therefore, there is inconsistency in the actual contributions and relationships of different physical components in test performance. When the literature in Türkiye was examined, it was reported that there was an improvement in the motor performance of children who received multi-skill movement training in the 5-6 age range (Canlı et al., 2021). However, in this study, the effect of multiple movement training on motor performance parameters was examined. Similarly, in their study with 4-6-year-olds, Özbar et al. (2015) reported that the experimental group in which movement training was applied was positively affected by the program, and the participants showed an improvement above the usual in terms of body composition elements. We also focused on the correlations between motor parameters in our study as in the foreign literature; moreover, our study is the first one investigating this in Türkiye.

Bakhtiari et al. (2011) observed that the experimental group which consisted of third year primary school girls participating in the 8-week movement program aiming for motor development showed a higher level of motor development compared to control group. In addition, Foweather et al. (2008) revealed that although 9-week training was seen as an appropriate time to develop mobility skills in children who were in the club that provided multi-skill training after school, a longer period of training should be designed to evaluate whether such a program was effective or not.

Considering this information, the aim of our study was to examine the relationship between sprint, change of direction, and jump performances of primary school girls and boys who participated in the multi-skill movement training program for 12 weeks. Therefore, the hypothesis of our study is that there is a relationship between sprint, change of direction, and jump performance parameters of primary school girls and boys.

Methods

Participants

In the study, the children participating were selected from among the children studying in secondary education of public schools and who did not object to participating in physical activities throughout the year. Twenty children voluntarily participated in the study. Both girls (n: 10, age: 10.87±0.70 years, height: 140.10±0.03 cm, body weight: 42.01±10.49 kg) and boys (n: 10, age: 10.37±0.46 years, height: 134.60±0.08 cm, body weight: 36.00±10.58 kg) volunteered. The G-Power 3197 package program was used to determine the number of participants. The study's alpha error rate was 5%, and the power was 85%. Based on these values, the minimum number of participants in a group was calculated to be 9 individuals (Kang, 2021). The study was approved by Bilecik Şeyh Edebali University Ethics

Committee (2022-88170). The research was conducted in agreement with the Declaration of Helsinki. After all volunteers were verbally informed before they were included in the study, their written voluntary permissions were obtained. Children and their families were informed about the tests, and voluntary participation consent forms were signed by the children and families who agreed to participate in the study.

The inclusion criteria for the study were determined as follows: 1) Having no history of musculoskeletal, neurological, or cardiorespiratory injury in the last six months, 2) Having no muscle or ligament injury to the lower extremities limiting normal activity for more than 48 hours in the two years preceding the test.

Exclusion criteria for the study were determined as follows: Experiencing physical injury, illness, etc. that prevents participation in training.

Program Design

This study lasted 12 weeks with volunteer girls and boys who participated in the multi-skill movement training program for two days a week and an hour a day. The physical education program based on multi-skill movement training was prepared by the faculty members and expert trainers involved in the study. The tests were applied after the multi-skill movement training program was completed. Before each test, during the warm-up period, the participants ran for 10 minutes from a low to moderate intensity, followed by 5 minutes of dynamic warm-up exercises and 5 minutes of stretching exercises. The children included in the study were asked to meet their toilet needs 30 minutes before the test, not to consume solid and heavy foods for 3 hours before the test, and not to have a tiring program in the form of intense exercise and games for 12 hours before the test. The measurements were taken over a week in the last week, and they were applied in the hall where participants regularly trained between 10:00-12:00 due to the circadian rhythm. All tests were performed by the same researchers using the same measurement tools.

Program Procedure

The multi-skill movement training program of the children participating in the study is presented in Table 1 in detail. While the basic special skills of sports branches such as gymnastics, football, basketball, volleyball, and handball were taught within the scope of the movement training program, a program for the development of the participants' motor characteristics such as strength, speed, endurance and agility was implemented in the educational game format.

The following measurements were taken within the scope of the study:

Body Composition

A stadiometer with an accuracy of ±1 cm (SECA, Germany) was used to measure the body height of the subjects, and an electronic scale (SECA, Germany) with an accuracy of ±0.1 kg was used to measure body weight.

Sprint Tests (5m, 10m, and 20m)

This measurement was taken by placing digital photocell doors at 0, 5, 10 and 20 meters (Fusion Sport). The athlete started the test 0.5 meters behind the starting line. They completed the 0-20m distance at maximum speed with their preferred foot in front. The test was performed twice with a at least 2-minute rest, and the best score was recorded for the analysis (Fernández-Ferández et al., 2018).

5-0-5 Change of Direction Test

The modified 5-0-5 test was used (stationary start) in the study, and to test a quick 180° change of direction performance over 5 meters, this test was applied (Gallo-Salazar et al., 2017). The participants placed their preferred foot behind the starting line and moved forward at an increasing speed at maximal effort until they reached a line placed at 5 m, then they were asked to pivot using their left and right feet at two different trials between which the participants had two minutes of rest, and the fastest time recorded to the nearest 0.01 sec (Fusion Sport) for the data analysis. The following formulate was used to calculate the COD deficit: modified 505 time – 10-m time (Nimphius et al., 2016).

Mod T-Test

This assessment was used to determine agility and change of direction with multiple locomotion actions (i.e., sprinting, backpedaling and side shuffling). From the protocol described by Sassi et al., participants were instructed to begin at the starting line then sprint forward 5 yards to the center cone and touch this cone with the right hand. Upon touching the center cone the participant immediately shuffled 2.5 yards to their left and touched the corresponding cone with the left hand before shuffling 5 yards to the right and touching a cone with the right hand. The participant then shuffled 2.5 yards back to the center cone, touched this cone with the left hand, then backpedaled to the starting line to complete the test.

Table 1
Procedure and timeline of the study.

Days of the Week	1st Week	2nd Week	3rd Week	4th Week	5th Week	6th Week	7th Week	8th Week	9th Week	10th Week	11th Week	12th Week
Sunday	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day
Monday	Basic Movement and Skill Training	Basic Movement and Skill Training	Basic Movement and Skill Training	General Gymnastics and Basic Movement Training	Rhythmic Coordination and Educational Game	Special Football training	Special Football training	Special Basketball training	Special Basketball training	Special Volleyball training	Special Handball training	Test data collection
Tuesday	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day
Wednesday	Basic Movement and Skill Training	Basic Movement and Skill Training	Basic Movement and Skill Training	General Gymnastics and Basic Movement Training	Rhythmic Coordination and Educational Game	Special Football training	Special Football training	Special Basketball training	Special Basketball training	Special Volleyball training	Special Handball training	Test data collection
Thursday	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day
Friday	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day	Test data collection
Saturday	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day	Resting Day

The difference in protocols for the normal T test and the modified T-test was also described by Sassi et al., stating the modified test uses half the distances from the original test, requiring participants to only cover a total distance of 20 m, rather than 40 m. The test was performed three times with each participant with a 2-minute passive rest in between. The best attempt was used in the data analyses.

Pro Agility Test

The participants started on a centreline facing the researcher. The participants sprinted 4.57 m (5 yards) to the left, then 9.14 m (10 yards) to the right, and 4.57 m (5 yards) back to finish the test as they crossed the centreline. Three trials within each testing session were used to gather averaged performance data. Three minutes of passive rest was provided between trials to limit performance fluctuations resultant from fatigue and decrease risk of injury. The instructions provided were to, stand in a 3-point stance with their left foot 30 cm behind the start/finish line. Once the participant was stable a “go” command was given. Timing started when the turned 90 degrees to the left and ran through timing gate 1. Touched the COD line with their left hand, the participant then turned and ran to the other side and touched the COD line with their right hand, the test was then finished by turning and running back through the middle line. To ensure the participants touched the line, the researchers observed each trial. In the case the athlete did not touch the line, slipped or had a mistrial, they were given a retrial after three minutes of passive rest. The best attempt was used for the analysis (Forster et al., 2021).

Hexagon Test

In our research, a modified version of the hexagon test (e.g., including two sequences instead of three) was used (Beekhuizen et al., 2009). In the test, the participant stood upright with feet together and hips facing forward in the middle of a hexagon measuring 60 cm per side and with 120° angles. They were asked to jump forwards and backwards without changing this posture following a clockwise pattern. They performed this procedure for each six sides of the hexagon. The performance of the participants was recorded using a mobile phone (iPhone 8 plus; Apple Inc., Cupertino, CA, the USA) running iOS 13.7 which was attached to a small tripod with a mount (GripTight Mount Pro, Joby, the USA) a meter away from the hexagon. The test was performed twice by the participants, and each was recorded at 240 Hz. They were given 45 sec to test in between. When they touched a line during the test, 0.5 sec penalty was applied; when they were unable to follow the correct test procedure, 1.0 sec penalty was applied. Before the actual test, the participants were given a chance to do a practise trial. The fastest time from the two attempts was used for the analysis. The analysis of performances was done using a video analyses software (Kinovea version 0.8.15, available for download at http://www.kinovea.org).

Jump Tests

Counter Movement Jump Test

Fusion sport jump mat was used to measure the jumping height of each participant. They were instructed to jump vertically using their both feet as high as possible, and while doing so, they were allowed to bend their knees and put their hands on their waist. Using their maximum power, they performed the test three times with a 2-min break in between. The best score they got was recorded in centimetres (Chelly et al., 2014; Ramirez-Campillo et al., 2015).

Triple Leg-Hop for Distance Test

In this test, the participants were required to perform 3 consecutive hops reaching the furthest distance using the same leg (Williams et al., 2017). Each participant started the test placing their feet right behind the starting line. The distance that was covered from the point zero to the point their heels touched the ground after the final hop was recorded in meters. The test was performed two times for each leg and 45 sec passive recovery in between. The larger distance covered was later used for analysis.

Data Analyses

The statistical analyses were performed using Statistical Package for the Social Science (SPSS 17.00). The Shapiro-Wilk test was used to analyse the normality of the data, and homogeneity of variance was analysed with the Levene test. In the statistical analysis of the data, Mann Whitney U-Test and Spearman Correlation Test were used for the nonparametric data. Statistical significance was set at $p<0.05$.

Table 2. Cohen’s Correlation Table (Cohen, 1998).

Correlation	Negative	Positive
Low	-0.29 to -0.10	0.10 to 0.29
Moderate	-0.49 to -0.30	0.30 to 0.49
High	-0.50 to -1.00	0.50 to 1.00

Results

Table 3, it can be seen that the mean age of females were 10.87±0.70 years, the mean height were 140.10±0.03 cm, and the mean body weight were 42.01±10.49 kg. Furthermore, the mean age of males were 10.37±0.46 years, the mean stature was 134.60±0.08 cm, and the mean body weight was 36.76±10.58 kg.

In Table 4, it can be seen that no statistically significant difference was found between the boys and girls in terms of the sprint, change of direction, and jump test results.

Table 3. Descriptive Characteristics of the Participants (n=10).

Variables		Mean	SD	Z	p
Age (years)	Female	10.87	0.70	-1.61	0.11
	Male	10.37	0.46		
Height (cm)	Female	140.10	0.03	-1.74	0.08
	Male	134.60	0.08		
Body Weight (kg)	Female	42.01	10.49	-1.25	0.21
	Male	36.00	10.58		

SD: Standard deviation.

Table 4
Sprints, change of direction and jump values of the participants.

Variables	Gender	Mean	SD	Z	p
Sprints					
5m Sprint (sec)	Female	1.54	0.20	-0.30	0.76
	Male	1.56	0.28		
10m Sprint (sec)	Female	2.73	0.49	-0.53	0.60
	Male	2.55	0.43		
20m Sprint (sec)	Female	4.80	0.66	-0.15	0.88
	Male	4.87	0.48		
Change of Directions					
505 COD (sec)	Female	4.54	0.26	-1.70	0.09
	Male	4.37	0.19		
T-Test (sec)	Female	13.88	0.52	-1.25	0.21
	Male	13.76	0.24		
Pro Agility Test (sec)	Female	6.80	0.51	-1.74	0.08
	Male	6.31	0.16		
Hexagon Test (sec)	Female	9.91	1.19	-1.51	0.13
	Male	10.08	0.10		
Jumps					
CMJ (cm)	Female	19.04	3.59	-0.53	0.60
	Male	19.57	2.67		
Triple leg-hop for distance (m)	Female	3.53	0.33	-1.59	1.11
	Male	3.72	0.35		

SD: Standard deviation.

Table 5
The correlation between results from the sprints, change of directions, and jumps test.

Variables		5m Sprint	10m Sprint	20m Sprint	505 Change of Direction Test	T-Test	Pro Agility Test	Hexagon Test	Counter Movement Jump Test	Triple leg-hop for distance
5m Sprint	rho	1	0.567	0.456	0.381	-0.132	0.114	0.295	0.170	-0.005
	p		.001**	0.043*	0.097	0.578	0.631	0.237	0.466	0.985
10m Sprint	rho		1	0.498	0.215	0.014	0.438	0.164	0.048	0.069
	p			0.026*	0.363	0.955	0.053	0.489	0.840	0.774
20m Sprint	rho			1.	0.378	-0.080	0.434	0.157	-0.97	-0.022
	p				0.101	0.737	0.056	0.510	0.685	0.928
505 Change of Direction Test	rho				1	-0.343	0.327	-0.261	-0.221	0.112
	p					0.139	0.160	0.266	0.350	0.639
T-Test	rho					1	0.298	0.056	0.032	-0.582
	p						0.202	0.814	0.892	.007**
Pro Agility Test	rho						1	-0.329	-0.223	-0.192
	p							0.157	0.344	0.416
Hexagon Test	rho							1	0.278	-0.120
	p								0.236	0.613
Counter Movement Jump Test	rho								1	-0.140
	p									0.555

There can be seen a positive significant ($p<0.01$) high correlation (rho:0.56) between the 5m sprint and 10m sprint values, a positive significant ($p<0.05$) moderate relationship between the 5m sprint and 20m sprint values (rho:0.45), a positive significant ($p<0.05$) moderate correlation (rho:0.49) between 10m sprint and 20m sprint values, and a negative significant ($p<0.01$) high correlation (rho:-0.58) between t-test and Triple leg-hop for distance. It is also seen that there was no statistically significant correlation between other parameters ($p>0.05$; Table 5).

Discussion

The purpose of this study was to examine the relationships between some motoric parameters of primary school aged girls and boys who participated in a sports training program that included multiple skills for 12 weeks. Sprint, change of direction, and jump tests were used to measure motor parameters. In the study, no significant difference was found in terms of the descriptive characteristics of the participants which are height, body weight, and age (Table 4). Similarly, no statistically significant difference was found between the boys and girls in terms of the sprint, change of direction, and jump test results (Table 4). These results have shown that the two groups were comparable in terms of these parameters, which meant that the boys and girls had a homogeneous distribution. The main finding of the study was that at the end of multi-skills training, regardless of gender differences, there was a relationship in some sprint and directional abilities in preadolescent children. Therefore, biomotor test results were assessed as a single group, and correlation analyses were performed (Table 5). When Table 4 is examined, there seen a significant relationship between sprint parameters (5m, 10m, and 20m) ($p<0.05$), and a significant relationship between T-Test and Triple leg-hop for distance was observed ($p<0.05$). There was no correlation between other parameters ($p>0.05$).

When the previous studies with similar age groups were examined, there found no relationship between the hexagon test and the jump performance (Farlinger et al., 2007; Myburgh et al., 2016) and linear sprint time (Myburgh et al., 2016). A particular study found a significantly weak correlation (r=0.22-0.40) between linear sprint, horizontal jump, and hexagon test performances in young girls (Pauole et al., 2000). In our study, a negative significant ($p<0.01$) high correlation (rho: -0.58) was found between T-Test and Triple leg-hop for distance, and no correlation, except for sprints, was found between other parameters. The primary physiological requirements for both parameter performances are the lover limb stretch-shortening cycle, motor unit synchronization, and motor unit recruitment (Tottori & Fujita, 2019). The results obtained suggest that the multi-skills motor training may positively impact these physiological mechanisms.

Moreover, Farlinger et al. (2007) reported that they did not find a meaningful relationship between the 30m sprint and the hexagon tests in ice hockey players, which corresponds with the results of this study in terms of sprint and change of direction parameters. Although these inconsistencies were close in number between the sample groups, it was thought that these were due to age differences. Therefore, differences in maturity status (anthropometric and physiological characteristics) should also be taken into account. In light of this information, the study results indicate that multi-skills program applications in children aged 10 can yield similar developmental outcomes regardless of gender differences.

In addition, Hazır et al. (2010) examined the relationships between agility, body composition, and anaerobic power in young football players. They determined that body composition was not a determinant in agility performance in young football players. In addition, since the Illinois Agility Test is strongly associated with anaerobic power, it was concluded that the 5-0-5 agility test was a more valid test for the evaluation of agility in young football players. Moreover, in a study conducted with 133 young male handball players aged from 10 to 17, anthropometric parameters such as height, sitting height, stroke length, leg length and body mass, and basic and special motor skills [30-m run from standing position, vertical jump with hands on hip and with arm swing, medicine ball (1 kg) overhead throw with dominant hand from sitting position, and handgrip strength] were studied on. It was concluded that anthropometric characteristics were poor indicators/predictors for basic and special motor skill tests in young handball players (Visnapuu & Jürimae, 2009).

When the results of the following studies were examined, it was seen that performance improves with growth and maturation. In a study, advanced adolescent football players aging from 13 to 15 showed better performance in 30m sprint and CMJ tests (Malina et al., 2004). In another study with 13.5±0.4-year-old elite football players, early maturers outperformed less mature players in CMJ, sprints (10m, 20m, 40m), and leg strength (Carling et al., 2012). Furthermore, in a study by Figueiredo et al. (2009) with 11-12- and 13-14-year-old football players with different maturity status, the observations were more variable. While CMJ and SJ performances did not differ in 11–12-year-old players, it was better in 13–14-year-old early maturing players (Figueiredo et al., 2009). Finally, in a study with U14 female tennis players, early maturing girls outperformed their timely and late maturing peers in terms of grip strength and upper body strength (Van Den Berg et al., 2006). Supported by the literature, the results obtained in this study suggest that multi-skills training during the preadolescent age is an ideal method for the fundamental sports skill development in children. Instead of repeating similar movement patterns extensively, implementing programs with different movement patterns may provide greater contributions to children's physiology. Multi-skills training supports holistic motor development in preadolescent children.

Limitations

This research had some limitations. First, according to the g power analysis result in the study, a sufficient number of participants was reached. However, future studies with larger participant groups are needed. Second limitation is that we did not standardize or measure participants' sleep duration and their diet either.

Conclusion

As a result, although sprint, change of direction, and jump parameters do not seem to be closely related to each other, we can say that sprint begins to develop along with others, and changing direction performance begins to be linked with jumping performance around the age of 10. Considering the individual differences in growth and development, our sample group, which was in their pre-adolescence period, just began to be affected by the training they received. The findings reported here could have important implications for both talent identification and training purposes. To obtain more satisfactory results, it is recommended to carefully monitor the maturity level of young athletes and make evaluations accordingly.

Authors' Contribution

Study Design: MS, RZ; Data Collection: MS, RZ; Statistical Analysis: MS, RZ; Manuscript Preparation: MS, RZ.

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Ethical Approval

The study was approved by the Bilecik Şeyh Edebali University of Ethical Committee (2022/88170) and it was carried out in accordance with the Code of Ethics of the World Medical Association also known as a declaration of Helsinki.

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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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