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Gender differences in dynamic postural control and lower extremity muscular strength among children

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Abstract
The purpose of this study is to examine gender differences in dynamic postural control and lower muscular strength among children. A total of 92 children (68 girls and 24 boys) who exercise regularly in different sports, participated in this study. First, the following anthropometric measures were taken and each participant completed a standing long jump test and a Star Excursion Balance Test (SEBT), and reaches in the anterior (ANT), medial (PM), and posterior (PL) directions. In order to analyze the collected data, separate independent t-tests and multiple linear backward regression test were used. Significant gender differences were observed in dynamic postural control ($p<0.05$). However, no significant difference was found in the standing long jump (SLJ) performance between genders ($p>0.05$). While age, body mass, and height were not significant contributors to SEBT performance, it was observed that these factors were significant in standing long jump performance. These differences and similarities between girls and boys should be considered by coaches and sport specialists in assessing the risk of lower extremity injuries and in preparing the training program.

Keywords: Star excursion balance test, standing long jump, tennis, gymnastics, taekwondo, volleyball

1. Introduction
Children's physical fitness level is commonly assessed, and these results obtained from these measurements can be used in order to evaluate physical fitness level, track progress, and promote physical activity [1]. Physical activity capacity can also be defined as physical fitness or motor fitness. Motor fitness, which is also called motor skills, is known as the individual's performance skills, which are influenced by factors, such as speed, flexibility, agility, balance, coordination, and strength [2]. Balance is indicated as one of the fundamental movement skills for physical development, participation in activities and to improve motor skills for children [3]. Postural control is the process of coordinating corrective movement strategies and movements at the selected joints to remain in postural equilibrium [4]. Postural control or balance is commonly grouped under two categories as static balance, which is the ability of keeping the body balance in a certain place or location, and dynamic balance, which occurs when the external forces are neutralized by the soft tissues around the muscles and joints [5]. It is also considered to be more important for many sports skills in terms of injury prevention and has been identified as a risk factor for lower extremity injuries [6].
The ability to generate force with a muscle is defined as muscular strength [7]. Studies have shown that the muscular strength has important effects on health in youth [8], and it may help strengthening of the bones, improving the body composition, and reducing sports injuries [9]. The children typically show a gradual linear increase in muscular strength and power from 3 years of age until puberty for boys, and until about 15 years for girls [10].
Studies have shown that neuromuscular and biomechanical differences between genders were observed during functional tasks [11]. The purpose of this study is to examine the gender differences in dynamic postural control performance and lower muscular strength of children between the ages of 8 and 9, who exercise regularly. We hypothesized that a) girls have better dynamic postural control than boys and b) boys have better lower extremity strength than girls.

2. Materials and Methods
A total of 92 children (68 girls and 24 boys) who exercise regularly (at least three times a week) in different sports (gymnastics, tennis, volleyball, and taekwondo) participated in this

study. All children were free from significant musculoskeletal, cardiovascular, neurological, and vestibular disorders, had not suffered any lower extremity injuries within the past 6 months and muscle fatigue on the day of the assessment. The study was carried out by the principles of the Helsinki Declaration. The parents of all children were notified by a letter and asked for their child's participation in this study. The measurements were taken randomly for dominant and non-dominant legs. Before balance test, each participant was requested to kick the ball and the foot used to kick the ball was recorded as dominant leg.

2.1 Anthropometric Data

Subjects' body masses were measured by using an electronic measuring scale, and height to the nearest centimeter was taken. Body mass index was calculated as weight (kg) divided by height (m^2) squared.

2.2 Dynamic Postural Control Measurements

The SEBT was designed as a lower-extremity reach test on 8 designated lines on the ground. The test later was simplified as to include only 3 directions as anterior, posteromedial, and posterolateral [12]. Internal consistency reliability of this scale was (ICC: 0.86–0.9) [13]. Bilateral reach distance was measured by using a tape measure fixed on the ground, and the reached point was marked on the tape measure for each direction of SEBT. The tape measures were positioned in connection with each other with 135° angle opposite to the anterior points of posterior medial and posterior lateral areas. Leg lengths of each participant were measured bilaterally in centimeters at supine position from anterior superior iliac point to the distal part of medial malleolar. Anterior reach was measured from the toe tip at the center, posteromedial, and posterolateral were measured as the distance between the heel and the remotest point reached. The test required the participants to be unshod in order to reach maximum distance with their free leg when their other leg was on the point of intersection of the star pattern on the floor. During the test process, the participants were required to keep their hands on iliac and keep their heels on the ground and to touch the remotest point with their toe tip. An experienced researcher made brief demonstration about the test before the measurement process, and the participants were asked to try to reach each direction at least 4 times [14]. When the participants put their body weights on their reaching legs during measurements, when they disconnected their stance heels from the ground, or ceased to touch their hips, the process was repeated after the participant was verbally warned. All reach distances were recorded in centimeters. The average of reach-out scores for each direction was taken and normalized in accordance with the leg length values [15]. Normalized scores are shown as percentages of stance leg length (LL%). Normalized anterior, posteromedial, and posterolateral scores were averaged and combined score was found. Composite reach distance was calculated by the sum of the three reaching direction by averaging the normalized anterior, posteromedial, and posterolateral scores. The average values of normalized anterior, posteromedial, posterolateral, and composite scores from the right limb and left limb were used for statistical analysis.

2.3. Standing Long Jump Test

The participants were asked to stand behind the starting line in feet together position, and they were pushed off vigorously and jumped forward as far as possible. The distance was measured from the take-off line to the point where the back of the heel nearest to the take-off line lands on the mat or non-slippery floor. The test was carried out twice, and the best scores of each participant were recorded (in cm) [16].

2.4. Statistical Analyses

Statistical analysis of the values obtained from the study was performed using the IBM SPSS (version 23) analysis program. The arithmetic means, standard deviation values of the data were calculated. Data normality was verified and confirmed by the Skewness and Kurtosis Tests. Separate independent t-tests were used to evaluate gender differences between ANT, PL, PM, COMP scores of the SEBT, and standing long jump performance. Separate multiple linear backward regression model was applied to determine the amount of variance in the measurements obtained from SEBT reach distances, and SLJ performance was explained by age, body mass, and body height of the children. The 95% confidence interval for each variable was calculated. The significance level for all calculations was interpreted as $p<0.05$.

3. Results

There were no significant gender differences between descriptive statistics of the study sample (Table 1). Significant gender differences were observed in ANT, PM, PL and COMP distance ($p<0.05$). Compared with boys, girls had higher ANT, PM, PL, and COMP scores. But no significant difference was found in the SLJ performance between genders (Table 2).

Using multiple linear backward regression analysis, a pool of common covariates (age, body mass, and height) was included in adjusted analyses. Age was not found to be a significant adjustment variable in the SEBT scores and body mass was not found to be a significant adjustment variable in the SLJ distance and they were removed from the models. The remaining models using the variances in body mass and height were very weak, explaining only 2–7% of the variances in SEBT scores. R^2 values for age and height were accounted for 30% of the variance with SLJ distance (Table 3).

3.1 Tables

Table 1: Descriptive data (mean ± standard deviation (SD); 95% confidence intervals [CI]) of the study sample by gender.

	Girls (n= 64) Mean ± SD [95% CI]	Boys (n= 28) Mean ± SD [95% CI]
Age (years)	9.08±0.24 [8.66-9.55]	8.93±0.34 [8.29-9.57]
Height (cm)	137.5±1.13 [134.4-140.8]	136.6±2.76 [131.5-142.1]
Body mass (kg)	32±1.13 [29.7-34.2]	32.5±1.76 [29.2-36]
Body mass index (kg/m^2)	16.5±0.29 [15.9-17]	17.1±0.4 [16.3-17.9]
Training age (years)	3.08 ±0.22 [2.66-3.3]	3.32 ±0.42 [2.54-4.25]
Leg length (cm)	74.8±0.96 [73-76.7]	74.4±1.67 [71.2-77.5]

Table 2: Normalized Star Excursion Balance Test reach and long jump distance (collapsed across gender; mean ± SD) for each group.

Groups	ANT*	PM*	PL*	COMP*	SLJ
Girls (n= 64)	51.6±8.93	72.3±13.8	54.8±14.5	59.6±10.4	129.5±23.1
Boys (n=28)	47.4±8.76	60±15.6	45.3±19.6	50.9±13.3	129.2±25.1
*Statistically significant (*p<0.05*).					

Table 3: Regression models examining influence of age, height, body mass, on SLJ distance and SEBT scores.

SEBT scores	Covariates included	R^2
ANT	Age, height, body mass	0.016
PM		0.072
PL		0.061
COMP		0.063
ANT	Body mass, height	0.016
PM		0.070*
PL		0.060
COMP		0.063
Long Distance	Age, height, body mass	0.307*
	Age, height	0.295*
ANT = anterior; PM = posteromedial; PL = posterolateral; COMP = composite.*Statistically significant regression model (*p<0.05*).		

4. Discussion

This study's primary findings were significant gender differences between boys and girls in dynamic postural control; no significant differences were found in the standing long jump performance between genders. When compared with boys, girls also had higher ANT, PM, PL and COMP scores. The findings of the present study are in agreement with previous studies showing that females had higher dynamic postural control than males [17-19]. In line with the present study, Paniccia *et al*. (2017) [20], investigated the role of gender on postural stability performance in child athletes (9- to 12-year-olds). They reported that girls had better postural stability than the boys. Humphriss *et al*. (2011) [21] found that boys at 7 years of age had significantly poorer test results on the heel-to-toe walking test when compared to the girls. In addition, boys took 0.3 s longer on the beam-walking test on average. Holden *et al*. (2016) [22] examined SEBT performance in adolescents (mean age = 13 ± 0.34 years), and they found significant longitudinal gender-specific differences between female and male adolescents. Females showed superior performance on the ANT direction across all time-points. Since it is necessary to achieve both new postures and more complex motor skills in early life, postural control plays an important role in child development [4–6]. Overall motor development will be influenced, if postural control does not develop adequately [23].

The other findings of this study also showed that the performances of girls and boys were similar in terms of lower muscular strength. Chung *et al*. (2013) [24] conducted comprehensive physical fitness assessments on 12.712 school students. The SLJ performances were significantly different between boys and girls (all age groups). The gender differences in lower muscular strength were lower in children between 8 and 11 years of age. Similarly, Gontarev *et al*. (2014) [25] found the same results in a large sample of 12.618 school children between 6 and 18 years of age from Macedonia. They found that boys showed statistically better results in all age categories in the standing long jump test than girls. The differences between studies in terms of findings may be explained by anthropometric characteristics. The changes in overall adiposity are negatively related to decreases in muscular strength from childhood to adolescence, and levels of muscular strength in adolescence seems to continue in adulthood [16].

It was also observed in this study that the differences in age, body mass, and body height were expected between girls and boys. It was also important to examine if this is why SEBT scores and SLJ are different. The regression analyses showed that less than 10% of the variance in SEBT performance and approximately 30% of the variance in SLJ were explained by variances in age, body mass, and body height.

5. Conclusion

In conclusion, the results of this study showed that girls had higher dynamic postural control than boys. On the other hand, they showed similar performance in terms of lower muscular strength. This differences and similarities between girls and boys should be considered by coaches and sport specialists in assessing the risk of lower extremity injuries and in preparing the training program.

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