SEX DIFFERENCES IN THE BALANCE OF PRESCHOOL CHILDREN

POLNE RAZLIKE U RAVNOTEŽI DECE PREDŠKOLSKOG UZRASTA

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ABSTRACT

During the preschool age, children continue to develop the basics of movement and motor skills, that is, to a great extent, they develop balance, stability and posture control. The aim of the study is to determine the differences between preschool boys and girls in the conducted balance tests. The study sample included a total of 63 subjects, of which 26 girls and 37 boys, 6.5 years of age (±0.6 months). The children attended the „Čukarica" kindergarten in Belgrade. A battery of four tests was used: Standing on one leg with closed eyes (MRAV), Standing on reversed balance bench (MSOK), Standing on one leg longitudinally on the balance bench (MSUK) and Balancing on one leg standing on a low beam of set dimensions „Flamingo" test. Using the MANOVA analysis, no statistically significant difference was found between boys and girls in the applied variables used to evaluate the balance. Analysing the applied variables individually, in ANOVA analysis, no statistically significant differences were found between boys and girls. Based on the arithmetic mean values, girls performed better in the MRAV, MSUK and Flamingo tests, where boys achieved better results in the balance tests compared to the girls in the MSOK test. The results show that additional questionnaires should be included the in the study of balance in order to obtain information on children's sports engagements which could contribute to differences in results. In addition to that, tests have to be performed and conducted on a both dominant and a non-dominant leg so that the obtained results are not misinterpreted.

Keywords: preschool age, boys, girls, differences, balance

APSTRAKT

U razdoblju predškolskog uzrasta, deca nastavljaju da razvijaju osnove kretnih i motoričkih veština, odnosno, u velikoj meri razvijaju ravnotežu, stabilnost i posturalnu kontrolu. Cilj istraživanja jeste da se utvrde razlike između dečaka i devojčica predškolskog uzrasta u primenjenim testovima ravnoteže. Uzorak istraživanja je obuhvatio ukupno 63 ispitanika, od čega je bilo 26 devojčica i 37 dečaka, uzrasta 6.5 godina (±0,6 meseci). Deca su pohađala vrtić „Čukarica" iz Beograda. Korišćena je baterija od četiri testa: Stajanje na jednoj nozi sa zatorenim očima (MRAV), Stajanje na obrnutoj klupi za ravnotežu (MSOK), Stajanje na jednoj nozi uzduž klupice za ravnotežu (MSUK) i Balansiranje u stavu na jednoj nozi na niskoj gredi određenih dimenzija „Flamingo" test. Primenom MANOVA analize nije utvrđena statistički značajna razlika između dečaka i devojčica u primenjenim varijablama za procenu ravnoteže. Analizirajući primenjene varijable pojedinačno, putem ANOVA analize, između dečaka i devojčica takođe nisu utvrđene statistički značajne razlike. Na osnovu vrednosti aritmetičkih

sredina devojčice su bile bolje u testovima MRAV, MSUK i Flamingo, dok su dečaci ostvarili bolji rezultat u testovima ravnoteže u odnosu na devojčice u testu MSOK. Rezultati pokazuju da je u istraživanju ravnoteže potrebno uključiti dodatne upitnike, kako bi se dobile informacije o sportskoj angažovanosti dece koja može da doprinese razlikama u rezultatima. Pored toga potrebno je date testove izvoditi i dominantnom i nedominantom nogom kako se dobijeni rezultati ne bi pogrešno interpretirali.

Ključne reči: predškolski uzrast, dečaci, devojčice, razlike, ravnoteža

INTRODUCTION

Preschool childhood spans over the age of two to six years of life and is very dynamic. The development of motor skills can be monitored through its stages and is manifested in the improvement of posture (postural control), movement (locomotion) and handling of things (manipulation). Motor development of preschool children occurs in a certain order, and after completing basic motor development in the first two years of life, preschool age is characterized by learning complex skills, and at the end of that period, all the basics of motor skills are mastered and acquired (Berk, 2008; Pomeshchikova, Shevchenko, Yermakova, Paievskyi, Perevoznyk, Koval, et al., 2016). As part of a child's motor development, a vestibular apparatus is developed, located in the inner ear, which has a role in balancing of the whole organism, motor control and motor planning and in movement coordination (Sylvette, Wiener-Vacher, Hamilton, & Wiener, 2013; Rine & Wiener-Vacher, 2013). In relation to vestibular and visual information, vestibular apparatus allows maintenance of stability and efficient movement of body segments, in order to effectively complete tasks in a specific environment (Ogard, 2011).

Balance is the ability to stand upright, to move, to sit, to change the position of the body in relation to the force of gravity (Di Stefano, & Clark, 2009). Balance can be static, which can be assessed by keeping the individual in a stationary position while standing on one or both legs (Gribble, & Hertel, 2003), and dynamic that can be assessed by maintaining the centre of gravity of the body, that is, maintaining a stable body position while performing a task or moving (Gribble, Robinson, Hertel, & Denegar, 2009). Balance reaches its maximum around the age of 25, whereas its greatest impact on the human body is in childhood, from the age of 4 to 8. The coefficient of genetic innate balance is very high (Malina, Bouchard, & Bar-Or, 2004), and a longer exercise period is needed to improve this level of motor ability. Altnkök (2007) found a positive effect of a four-week programme for improving static balance, in a sample of preschool children, between 5 and 6 years of age. The most important factors for maintaining balance are genetic determination, condition of the vestibular apparatus, age, support surface, height of the centre of gravity, number of motor habits, training, strength, coordination, flexibility and emotional state (Kayapnar, 2011). During preschool years, children continue to develop the basics of movement and motor skills, that is, to a great extent, develop balance, stability and postural control (Shumway-Cook & Woollacott, 2012). Balance, both static and dynamic, can be seen as a motoric skill acquired through training or playing and development (Fong, Fu, & Ng, 2012).

Earlier studies conducted on preschoolers found that girls were better at balance tests than boys (Morley, Till, Ogilvie, & Turner, 2015a). When selecting tests for balance evaluation, one must consider age the maturity of subjects and their experience in kinesiological activities, as well as the requirements of the assigned task (Hatzitaki, Zisi, Kollias, & Kioumourtzoglou, 2002). The differences between boys and girls are attributed to influences of the environment, depending on how active the child is, but also the motor maturation of the individual (Orlić, Cvetković, & Jakšić 2010). As balance depends on the central nervous system as well as the sensory system, fatigue also affects the motor ability to maintain balance (Wilkins, McLeod, Perrin, & Gansneder, 2004).

Following the learning about the findings of previous researches, the dimorphic differences in the area of balance in older school age were clearly established, but the lack of research would be reflected in an attempt to determine the limit of the manifestation of significant differences in children. This study should provide answers to the questions whether the age of children of 6 and 7 is the beginning of the manifestation of differences and if the maturation of children, on one hand, is crucial for qualitative motor skills such as balance, since they depend a lot on maturation of CNS. This would provide the opportunity to plan new teaching methods in elementary school education in the field of physical and health education.

The aim of the study is to determine the differences between preschool boys and girls in the conducted balance tests. According to the results in previous researches, we started from the presumption (H_1) that girls will achieve better results in balance tests than preschool boys, given that they enter the puberty stage earlier and are more mature.

METHOD

Sample

The study sample included a total of 63 subjects, of which 26 girls and 37 boys, 6.57±0.35 years of age. The children attended the „Čukarica" kindergarten in Belgrade. All subjects were medically fit and were free of injuries at the time of the test. The children's parents were given a survey questionnaire prior to the implementation of the research, outlining the plan and the course of the study, and they authorized the research on their children with their signatures (Declaration of Helsinki 2013). Testing was conducted on the premises where physical training is conducted in the said kindergarten, in the morning, after breakfast, so the children would be rested and thus valid research results would be obtained. The test room was pre-prepared, well-lit with temperatures up to 22º C. Workplaces and measurers were also pre-prepared. The children were dressed in their P.E. gear, shorts and T-shirts, barefoot. They warmed up for 15 minutes before the test, which included light running, sprinting exercises and stretching.

The subjects, their teachers and parents were informed in advance about the aim of the research, the used methods, benefits and potential risks, and signed the consent for their children to participate in the research, in accordance with the Helsinki Declaration on the Rights of the Child.

Instruments and procedure

The following motor tests were used in the measurement:

1. Standing on one leg with closed eyes (MRAV test)

Instruments: A Stopwatch 1/10 sec. *Task:* The subject stands barefoot on an arbitrary leg while his other foot is resting on the knee of the leg he is standing on. The test lasts a maximum of 60 seconds and is performed three times. The subject may not change the designated position with his fists placed on his thighs. The arms have to be fixed and the legs as in the starting position. *Evaluation:* The total number of seconds scored in all three attempts to maintain a designated position (maximum of 180s) is evaluated. The measurement of time starts as soon as the subject closes his eyes (rounding up to 0.5 seconds to a lower value, 0.5 and more to a higher value). *Note:* Performance mistakes are moving arms, moving the leg resting on the supporting leg, moving the supporting leg and opening of eyes. Practicing is not allowed.

2. Standing on reversed balance bench (MSOK)

Instruments: A balance bench (board 2 cm wide, 4 cm high, 60 cm long, fixed on a thick board with dimension 60x30 cm in the middle), a stopwatch 1/10 sec. *Task:* Leaning on the shoulder of the measurer with his right arm, the subject establishes a balance on the reversed balance bench, standing with his legs spread on the bench. When the subject feels he has established balance, he raises his arm from the shoulder of the measurer, who starts the stopwatch. The subject should stay on the balance bench for as long as possible. The test is repeated twice. *Evaluation:* Time is measured in the tenths of a second from the moment the subject raises his hand from the shoulder of the measurer until he falls off the bench or until one end of the bench touches the ground. The result is the sum of the times of both performances. *Note:* Each subject has to have a trial attempt. The subject must be barefoot.

3. Standing on one leg longitudinally on the balance bench (MSUK)

Instruments: a balance bench (a board 2 cm wide, 4 cm high, 60 cm long fixed on a thick board with dimension 60x30 cm in the middle), a stopwatch 1/10 sec. *Task*: The subject stands with his foot longitudinally on the board, his hands on his thighs. The other leg is on the ground. The measurement starts when he raises his leg from the ground, and stops when he lowers his leg, falls off the board or moves his arms. It is performed three times for a maximum of 20 seconds. *Evaluation:* The total number of seconds in the tenths is evaluated in all three attempts. *Note:* The subject has to be barefoot.

4. Balancing on one leg standing on a low beam of set dimensions „Flamingo" test. *Instruments:* A small metal beam 50 cm long, 4 cm high and 3 cm wide. The beam is covered with carpet or a rubber band of a maximum thickness of 5 mm. The stability of the beam is ensured by two transverse stabilizers 15 cm long and 2 cm wide. A stopwatch 1/10 seconds. *Task:* Leaning on the shoulder of the measurer with his right arm, the subject establishes balance on the beam. The subject, with his dominant (better) leg steps on the beam so that his (better) leg so his longitudinal axis of the foot is parallel to the beam. The free leg, bent at the knee, to be grasped by the hand at the ankle. When he feels that he has established balance, he raises his hand from the shoulder of measurer, who starts the stopwatch. While standing on one leg, the subject tries to maintain the balance for as long as possible. When he loses his balance or lowers his free leg, it is resumed, when he leaves the beam (falls off), the timing is always stopped. After each timing interruption, it is resumed when the subject regains the correct balanced position, until one (1) minute elapses. *Evaluation:* the number of attempts used to keep the balance over the period of one minute is evaluated. *Note:*

Each subject is entitled to one trial. If the subject loses his balance 15 times in the first 30 seconds, the test is ended, and the subject is given a "zero" which means he is not able to perform the test.

Stastistics

Statistical data processing was performed in the SPSS statistical package (Statistical Package for the Social Sciences, V.23; SPSS Inc, Chicago, Illinois, USA). The normality of data distribution was determined by the Wilk-Shapiro test. Statistical analysis of the data included the calculation of descriptive statistics of variables: arithmetic mean (AS), standard deviation (Sd), minimum (Min) and maximum (Max) values of measurement results and coefficient of variation (KV%). Statistically significant differences between boys and girls, determined by application of multivariate analysis of variance (MANOVA) and univariate analysis of variance (ANOVA). Statistical significance was set at level of $p < 0.05$.

RESULTS

The normality of distribution of obtained results was confirmed by the Shapiro-Wilk test for all analysed variables in the study. Preliminary testing verified assumptions about normality, linearity, univariant and multivariant atypical points, homogeneity of the variance and covariance matrices and multicollinearity and a serious disruption of the assumptions was not disturbed.

Table 1 shows the mean values, standard deviation, as well as minimum and maximum values for each tested variable with respect to sex, and for all subjects. Based on the values obtained, it is concluded that in the standing on one leg with closed eyes (MRAV) girls were more successful than boys and achieved a better mean value on this test by 0.6 seconds. For both sexes a wide range of results is noticed in the MRAV test. In boys, this range is between 2 and 27 seconds, with the expected high coefficient of variation and therefore a great heterogeneity of results. For the group of girls, it was also noticed a range of results that was even higher than that of the boys (Min. 3s, Max. 29s), with high values of coefficient of variation (67.54%). However, the boys were standing on the reversed balance bench (MSOK), on average, longer than the girls (AS=3.57 s vs. AS=3.50 s), meaning they were better. The worst result, or the shortest one, was achieved by a box keeping his balance on the bench (1.06 s), whereas the longest balance was achieved by a girl (7.73 s). Inspection of the table shows a great range of minimum and maximum results, with high values of the coefficient of variation, but again lower compared to the MRAV test.

On average (AS=4.40 s), the girls managed to keep the balanced position longer than the boys (AS=4.16 s) when testing standing on one leg longitudinally on the balance bench (MSUK). It is noticed (Table 1) that the girls had better values of minimum (2.16 s) and maximum (12.34 s) results in this test than the boys (Min. 1.66 s, Max 8.40 s). The range of results in this variable is also large with a relatively high coefficient of variation (43.28%) for both sexes.

In the „Flamingo" test, based on the arithmetic mean, it is concluded that the girls (AS=13.73 s) fell fewer times off the beam on average, compared to the boys (AS=15.30 s). The girl with the fewest number of falls off the beam did so 5 times,

whereas the best boy's result was a boy who fell 7 times off the beam. The maximum result, that is, the highest number of falls, was recorded in the male sex (N=26). The results of the coefficient of variation indicate a smaller heterogeneity of results in relation to other tests used.

Table 1. Central and dispersion indicators of the distribution of applied balance variables
Tabela 1. Centralni i disperzioni pokazatelji distribucije primenjenih varijabli ravnože

Variable	Sex	AS	SD	Min	Max	KV%	N
MRAV	Male	7.78	5.01	2	27	64.40	37
	Female	8.38	5.66	3	29	67.54	26
	Total	8.03	5.25	2	29	65.37	63
MSOK	Male	3.57	1.39	1.06	6.41	38.93	37
	Female	3.50	1.65	1.47	7.73	47.14	26
	Total	3.54	1.49	1.06	7.73	42.09	63
MSUK	Male	4.16	1.70	1.66	8.40	40.86	37
	Female	4.40	2.08	2.16	12.34	47.27	26
	Total	4.26	1.85	1.66	12.34	43.28	63
FLAMINGO	Male	15.30	5.41	7	26	35.36	37
	Female	13.73	4.87	5	23	35.47	26
	Total	14.65	5.21	5	26	35.56	63

Legend: AS – arithmetic mean, SD – standard deviation, Min – minimum result, Max – maximum result, KV% - coefficient of variation, N – number of subjects.

Using a multivariate analysis of variance (MANOVA), no statistically significant difference (F=0.41; p=0.80; Wilks' Lambda=0.97) was found between boys and girls. The value of the partial eta square (0.027), that is, of influence, is very small according to generally accepted criteria (Cohen, 1988). This means that sex accounts for only 2.7% of the common variance in the measurement results of motor balance skills (Table 2).

Table 2. Analysis of differences between boys and girls according to the MANOVA analysis
Tabela 2. Analiza razlika između dečaka i devojčica prema MANOVA analizi

Wilks' Lambda	F	Partial Eta Squared	p
0,97	0.41	0.27	0.80

Key: Wilks' Lambda – indicator value Wilks lambda, F – value of F test, Partial Eta Squared – value of partial eta of the square, p – significance of indicators Wilks lambda.
Legenda: Wilks' Lambda - vrednost pokazatelja Vilks lambda, F – vrednost F testa, Partial Eta Squared – vrednost parcijalnog eta kvadrata, p – značajnost pokazatelja Wilks lambda.

There is no difference between boys and girls in any of the used balance tests. Although in the MRAV test, the girls had better mean values than the boys (Table 1), no statistically significant difference (p=0.66) (Table 3) was found between them. The boys achieved better mean values in standing on the reversed balance bench (MSOK) (Table 1), however, the results achieved were not sufficient to achieve statistical significance (p=0.86) (Table 3). The female subjects (AS=4.40s) managed to keep their balance longer on one foot longitudinally on the balance bench (MSUK) compared to

the male sex (4.16s), but the average difference of 0.24 seconds did not lead to a statistically significant difference (p=0.61) in this test, by sex.
Balancing on one leg standing on a low beam of set dimensions, that is in the „Flamingo" test, the girls, on average, (AS=13.73) were more successful compared to the boys (AS=15.30). However, although more successful, there was no statistically significant difference (p=0.24) between them and the boys in this balance test (Table 3).

Table 3. Analysis of differences between boys and girls in each variable tested according to ANOVA analysis
Tabela 3. Analiza razlika između dečaka i devojčica u svakoj testiranoj varijabli prema ANOVA analizi

Variable	F	p
MRAV	0.20	0.66
MSKOK	0.03	0.86
MSUK	0.26	0.61
FLAMINGO	1.38	0.24

Legend: F – value of univariant F test, p – significance of univariant F test.

DISCUSSION

The aim of this study was to examine the performance of balance in four motor tests in children 6 years of age, and to determine the sex differences between boys and girls in these tests. Many studies have shown that there are significant differences in performances between boys and girls and that these differences are age-related and that girls outperform boys in static and dynamic balance (Franjoine, Darr, Held, Kott, & Young, 2010). This study has shown that in three out of four used tests of balance, girls were more successful than boys, but no statistically significant difference was found between them. Undoubtedly, girls have a better balance than boys, as confirmed by the research findings (D'hondt, Deforche, Vaeyens, Vandorpe, Vandendriessche, Pion, et al., 2011; Olesen, Kristensen, Ried-Larsen, Grøntved, & Froberg, 2014; Morley, Till, Ogilvie, & Turner, 2015b) and that differences are due to the influence of the environment and the activities of the children (Orlić, Cvetković & Jakšić 2010). However, there is a very wide range of ages for children involved in these studies of balance, and the balance and sex differences of children between 5 and 6 years of age cannot be compared with older children, as it must be taken into account that this motor ability develops rapidly after the age of seven, that is, the most significant transition in motor development occurs in the first decade of life, with the balance control being established usually from 7 to 10 years of age (Roncesvalles, Woollacott & Jensen, 2001). The results of a study confirm an improvement in balance performance especially after 7 to 8 years of age (Condon & Cremin, 2014). Another reason for this conclusion is that older children achieve better results than younger children, except for cardio exercises in boys and flexibility in girls (De Miguel-Etayo, Gracia-Marco, Ortega, Intemann, Foraita, Lissner & Molnár, 2014). On the other hand, the boys in this study showed higher values in the variable Standing on the reversed balance bench (MSOK), which implies static balance on both legs. Australian authors (Mickle, Munro & Steele, 2011) also found that boys had better static stability than

girls, that is, they were more successful in performing such tasks. According to the results of the study, girls performed better in single leg tests. However, it was not determined if the subject performed tests on one leg with a dominant or a non-dominant leg, it cannot be said with certainty what percentage of girls performed these tests with a dominant leg, so this factor conditioned their successful completion.

The limitation of the study presents a small sample of subjects by sex on one hand, and on the other hand, the study did not include a questionnaire which would include information on the kinesiological activities of children they were involved in, types of activities, that is, of sports and the duration of these activities. The said information would certainly provide the answer to the question why the differences in this study did not occur, as the balance, both static and dynamic, can be seen as motor ability acquired through training or playing and development (Fong, Fu, & Ng, 2012). Therefore, it is not known whether girls would be better than boys if they did not engage in some physical activity, if they were engaged in, and if certain sports, in which boys were active (if any), have contributed to such research results, that is, that between them and girls there are no significant differences in balance.

Much earlier researches indicate that persons of female sex in all age groups are less active than men (Pate, Matthews, Alpert, Strong & DuRant,1994). A meta-analysis conducted by Sallis, (1993), concluded that children aged 6-7 years were more active when it came to moderate to intense physical activity (46 minutes per day) in comparison to children aged 10 to 16 years (16-45 minutes per day). Boys were approximately 20% more active than girls, and the average level of physical activity decreased with age by 2.7% per year for boys and 7.4% for girls, respectively. In the reviewed study of current patterns of physical activities of children (Corbin, Pangrazi & Le Masurier, 2004) it is stated that boys, at all ages, were more active than girls during school years, regardless of how physical activity was assessed and what type of activity was examined. Research shows that in all European countries, boys are more active than girls, regardless of age category. Physical activity in young people decreases with age, although the decline varies depending on the country and region, it is girls that are less likely to exercise (Currie, Roberts, Morgan, Settertobulte, Smith, Samdal & Rasmussen, 2002).

Based on the results of the research, it can be concluded that during the period of preschool age, there are no significant differences with respect to sex, although boys demonstrate somewhat better results in balance tests, which may be due to different socio factors (before all lifestyles), which should be followed in further studies of this type regarding the area of balance. The hypothesis of the research must be rejected. The limitation of the study was the neglect of morphological characteristics in this research. The authors suggest, as a recommendation for further works on this topic, to mandatory include longitudinal features of skeleton and volume and body mass as well as the subcutaneous adipose tissue in the results of the research, as this could provide a better explanation for the expressed sex differences.

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