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BOT-2 Evaluation of Gender Differences in Upper Limb Coordination among Children 7 to 9 Years Old

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ABSTRACT

Numerous recent studies indicate the significant impact of fundamental motor skills on the psychological and social development of young boys and girls. However, it is not well-known if there are differences between boys and girls aged 7 to 9 in terms of the fundamental development of motor skills.

Purpose: The aim of this study is to address the question of the fundamental issues between boys and girls using upper limb coordination evaluated by the Bruininks-Oseretsky test of motor proficiency (BOT-2), including seven sub-scales of measurement.

Method: The participants (n=79) were 41 boys and 38 girls aged 7 to 9 years old. BOT-2 test scores were used for upper limb coordination (ULC) differences by gender.

Results: The BOT-2 measurements of upper limb coordination show a significant difference in favor of the boys only for 6ULC=7±2.77 relative to 5.66±2.66, (d=.49, ES=.24, p=.03) and 7ULC=2±1.45, relative to 1.32±1.21, (d=.51, ES=.25 p=.02), while for the other tests there are no significant differences. The magnitude of the impact was on the values of the alternate hand dribble, p=.23, while the little effect was achieved for throwing a ball at a target, p=.25. Conclusion: Our results showed that there are no significant differences between boys and girls in terms of the fundamental development of motor skills, indicating a strong biological determinant of homogenous development.

Keywords: upper limb coordination, motor skills, sex differences, school children, motor development.

INTRODUCTION

Motor development is considered an exceptionally important area in the integral development of children and is therefore the focus of numerous studies (Cairney et al., 2005; Goodway, Ozmun, & Gallahue, 2019). It is well-known that the theory of integral development indicates an association between motor, cognitive, and emotional development (Ismail & Gruber, 1971) and states that progress in one area impacts progress in other areas (Trajkovski, Tomac, & Maric, 2014). Therefore, numerous researchers have pointed out the importance of problems in the motor development of children, especially in the age of modern technology, where children spend half of their waking hours seated, which results in a very low level of physical activity (Colley et al., 2013; Rajović, Berić, Bratić, Živković, & Stojiljković, 2017). It has been proven that a sedentary lifestyle, along with hypokinesis and a low-quality diet, lead to numerous health problems among children such as obesity, diabetes mellitus type 2, asthma, hypertension, psycho-social problems, early onset atherosclerosis, etc. (Mendonca & Anjos, 2004; Planinšec & Matejek, 2004; Dikanović

& Vignjević, 2009). Also, researchers have determined that physical inactivity in childhood has a negative impact on motor development as well (Lubans, Morgan, Cliff, Barnett, & Okely, 2010). Numerous studies indicate that the level of motor performance is associated with the level of physical activity and is reversely proportionate to the sedentary lifestyle of children (Wrotniak, Epstein, Dorn, Jones, & Kondilis, 2006), whereby children with the best motor performances have the highest level of physical activity (Cairney et al., 2005; Goodway et al., 2019). Therefore, the World Health Organization (WHO) adopted a Global Strategy on Diet, Physical Activity and Health to preserve health and proper physical and motor development, whereby the recommendation for children aged 5 to 17 is 60 minutes of physical activity daily (WHO, 2021).

Motor development refers to the gradual process during which a child achieves coordination of large muscle groups of the legs, torso, and arms, and of the smaller muscle groups, such as the hand (Ghosh, Chonjdhury, Chandra, & Ghosh, 2013), which renders motor coordination an essential element of motor development. Coordination is a motor skill that involves the control and management of movements of the entire body or body parts in space, as well as the precise and quick performance of complex motor tasks (McGinnis, 2013). In other words, when the movements of several parts of the body are combined in a flowing, well-organized and successful movement in the context of performing a task, then coordinated movement is achieved (Salter, Vishart, Lee, & Simon, 2004). It should be pointed out that coordination is linked with at least one motor system and that it is always used when studying differences in terms of gender, while it also plays a key role in cognitive development (Chraif & Dumitru, 2015).

Upper limb coordination is included in the BOT-2 test, which is the seventh sub-test from the group of tests used to evaluate gross motor skills. The system of evaluation depends on each test, and the evaluation ranges from zero points to a maximum of five. The number of attempts during testing also varies depending on the test itself. A difference is made between the number of measured dribble examples and the overall grade evaluation based on the number of successful dribbles (Bruininks, 1978). The upper limb coordination test is used to evaluate the level of coordination development and is harmonized with hand and arm movement, virtually control of the object itself (Dighe et al., 2017). The factors studied by researchers, which they concluded do have an impact on the development of coordination and the motor development of children, include age, gender, frequency of sports recreational activity, diet, hormone status, and socio-demographic characteristics (Hassan, 2001; Barnet, van Beurden, Morgan, Bruks, & Berd, 2010; Vandendriessche et al., 2011; da Silva Pacheco, Gabbard, Ries, & Bobbio, 2016).

A literature review focusing on the problem of coordination as a motor skill indicated a gap in white hat research solely with the influence of gender on the development and differences in coordination among children of young school age. As a result, there is the question of whether there are any significant differences in the levels of development of upper limb coordination among children and just how functional the changes between the genders are. Therefore, the study aimed to determine the differences in upper limb coordination between boys and girls of young school age, aged 7 to 9.

METHODS

Participants

The total number of participants, 79, comprised school children of the "Mika Antic" elementary school in Nis. The age of the participants was 7 to 9. A total of 41 boys and 38 girls took part in the study; a detailed overview of their basic characteristics is shown in Table 1.

Table 1. **Sample characteristics in morphological characteristics and age**

Variables	Boys (n=41) Mean SD	Girls (n=38) Mean SD
Body height (cm)	135.2 ± 8.7	135.2 ± 8.4
Body weight (kg)	33.5 ± 8.5	37.4 ± 9.3
BMI (score)	18.1 ± 3.0	18.1 ± 3.7
Age (year)	8.1 ± 1.0	8.3 ± .9

Measurements

To obtain the variables which were later analyzed, the Bruininks-Oseretsky test of evaluation of motor proficiency BOT-2 (Bruininks, 1978) was used. This consists of 46 parts which are grouped into eight different sub-tests for the evaluation of the motor proficiency of children aged between 4 and 15: four sub-tests for the evaluation of gross motor

skills, three for the evaluation of fine motor skills, and one test for the combined evaluation of gross and fine motor skills (Duger, Bumin, Uyanik, Aki, & Kayihan, 1999). The variables analyzed included gender, so the participants were grouped into two groups (Boys and Girls). Based on the data for body height, weight, and BMI, variables obtained using the BOT-2 test include: Releasing and catching a ball–both hands (0–5 score); Catching a ball in flight – both hands (0–5); Releasing and catching a ball-dominant arm (0–5); Catching a ball in flight–dominant arm (0–5); Dribble–dominant arm (0-10); Dribble – alternate hands (0–10); Throwing a ball at a target (0–5), Full upper limb coordination (0–45).

Experimental design and course and measurement procedures

Seven experienced researchers were tasked with conducting the experimental transversal study at the "Mika Antic" elementary school in Nis. The testing was carried out at four different times in November 2019. The tasks of the seventh BOT-2 sub-test were used to evaluate upper limb coordination among younger school-age children. Prior to the study, in accordance with the Declaration of Helsinki, agreement from the parents was sought and obtained for participation in the study. Testing on all four occasions began at 11 am and lasted for 1.5 hours, or two school classes. The temperature in the gym was within the prescribed 22 to 26°C. Each researcher had a previously prepared set of two tests and explained and outlined the test in detail to the participants, after which the given test was also demonstrated. For each student, a repeated oral explanation of the test was given in order to assure better concentration. In addition, stimulating verbal support was given by the researcher to each participant equally during testing. The measuring instruments which were used in the study to obtain data include digital scales (Tanita Body Composition Analyzer, BC-418MA), measuring tape, a stopwatch, and a tennis ball.

Data analysis

The data analysis and evaluation of upper limb coordination were carried out using the program for statistical analysis SPSS (IBM Corp. Released 2020. IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp.). A descriptive analysis was used to distribute data based on the number of participants, means, and standard deviation. An Independent-Samples T-test was used to determine differences in terms of gender among the first and third-grade students together. For effect size, Cohen's d was used. Criteria for determining the magnitude of the impact were 0.2 = small effect size; 0.5 = medium effect size; 0.8 = large effect size (Cohen, 1988). Matrices containing data in the program were coded with numbers for the demographic, and general data of the participants, while the columns included variables that were used during measurement, with the aim of protecting privacy. Statistical significance was accepted at $p<0.05$.

RESULTS

A detailed overview of the basic characteristics of the participants (Descriptive statistics) is shown in Table 2.

The results of the Independent-Samples t-test were used to determine the differences between the groups (boys and girls) and determined a statistically significant difference at the $p<.05$ level in favor of the boys for the variables of upper limb coordination (Dribble – alternate hands boys

Table 2. **Differences between groups (Descriptive statistics and Independent-Samples T-test)**

Variables	Girls		Boys		T-test		
	Mean	SD	Mean	SD	t	p	d
Releasing and catching a ball – both hands	4.5	1.08	4.66	.76	.756	.45	.17
Catching a ball in flight – both hands	4.29	1.18	4.07	1.33	-.761	.45	.17
Releasing and catching a ball – dominant arm	3.87	1.73	4.27	1.23	1.179	.24	.27
Catching a ball in flight – dominant arm	2.89	1.86	2.56	1.78	-.817	.42	.18
Dribble – dominant arm	6.95	2.62	7.54	2.45	1.033	.3	.23
Dribble – alternate hands*	5.66	2.66	7	2.77	2.152	.03	.49
Throwing a ball at a target*	1.32	1.21	2	1.45	2.268	.02	.51
Full upper limb coordination	29.47	9.14	32.07	8.87	1.283	.2	.29

Legend: *=statistical significance at p<.05; t=T-test; p=statistical significance; d=Cohen's d

7±2.77 and girls 5.66±2.66, p=.03; and Throwing a ball at a target boys 2±1.45 and girls 1.32±1.21, p=.02), while the remaining results do not show any statistical significance.

For half of the participants the values of the dribble test with alternate hands (Dribble – alternate hands, d=.49, ES=.24) have a small effect size, and throwing a ball at a target (Throwing a ball at a target, d=.51, ES=.25) has a medium effect. This indicates that boys of both grades were better at the dribble with alternate hands and throwing a ball at a target compared with girls of both grades (Table 2).

DISCUSSION

The results of this study indicate that there is no statistically significant difference between boys and girls for Full upper limb coordination obtained from the results of the seven BOT-2 tests. Even though there are not many studies that focused solely on differences in terms of gender in upper limb coordination, over the past few years that number has increased. Several studies focused on comparing the total coordination based on the results of the BOT-2 test for boys and girls of younger school age, which in addition to these differences, studied other samples to track the development of the motor system in children. The development of coordination as a motor skill is considered one of the most important skills in a child's development and is usually used to evaluate differences in terms of gender, and cognitive abilities, and to help determine more adequate exercises for proper growth (Barnett, van Beurden, Morgan, Brooks, & Beard, 2010; Chraif, & Dumitru, 2015). The aim of this study was to apply the BOT-2 sub-test to evaluate upper limb motor coordination and determine the level of development of coordination among younger school-age children attending the first and third grades

In terms of the individual results of the tests for the evaluation of the level of upper limb coordination, statistically significant differences were found which indicate differences in the Dribble with alternate hands test and Throwing a ball at a target in favor of the boys, for which a small effect size was determined. The results for which no differences in the tests (Releasing and catching a ball – both hands, Catching a ball in flight – both hands, Releasing and catching a ball – dominant arm, Catching a ball in flight – dominant arm, Dribble – dominant arm). These findings align with those of the study of Balakrishnan and Rao (2007), who did not, working on a sample of participants from India, obtain statistically significant results. Furthermore, very similar findings were obtained by authors in a more recent study by Samara et al. (2015) who obtained results which do not indicate differences between boys and girls in Full upper limb coordination. The age groups of the participants, which completely align with this study, are found in the work of Al-Thumali (2016), who also obtained statistically insignificant differences between boys and girls on the Full upper limb coordination. An advantage can still be determined in favor of the boys on the catch test, releasing and catching a ball with the dominant and both hands. At the same time, claims which are consistent with these results were made by Duger et al. (1999). By analyzing the tests individually, results were obtained with indicate differences in the sub-tests of BOT-2 six (Dribble – alternate hands), and seven task (Throwing a ball at a target), in favor of the boys. Prescribed norms of coordination are being used with increasing frequency, defined based on gender and age, which provide the best guidelines for comparing results, as in the study by Dighe et al. (2017). Their findings indicate that boys have an advantage over girls in terms of upper limb coordination by 8.87%. The girls scored results below the prescribed values, while only 1.87% of the boys had results below the average prescribed values.

Results which differ from the claims made based on differences in upper limb coordination can be noted in the work of Chow, Henderson, and Barnett (2001). In their findings, girls are better on four tests of fine motor skills compared with boys, while boys are better on tests of upper limb coordination involving the dribble with the dominant hand. It should be mentioned that the researchers had a great number of participants, 1,234 children from Hong Kong, which might have provided more precise results for the differences between boys and girls. Support for these findings can be found in a claim made in older studies, a meta-analysis by Thomas & French, (1985) which also indicates a difference between boys and girls in favor of girls on tests of fine motor skills, but also shows that boys are better on tests with a ball and upper limb coordination tests.

In order to assess whether boys had better results on the dribble with alternate hands test and throwing a ball at a target test, it was necessary

to obtain data on the physical activity of children outside of class. These include whether and how much they take part in sports training, as well as which ones, whether their training sessions include games and exercises with a ball which might lead to better results on these tests of upper limb coordination. Based on these findings, a precise explanation could be given which would confirm or negate the claim that boys take part in more exercises with a ball, which are more similar to the BOT-2 tests of upper limb coordination. An analysis and explanation of the differences in terms of gender could be based on certain metabolic and physiological differences among children, which are determined by age. It should be mentioned that this study was to a great extent limited by the number of participants, which made it impossible to carry out a more precise analysis and provide results that could give a true representation of upper limb coordination among younger school-age children.

Limitations of the study

A limitation of the study is reflected in the small number of participants, which decreases the effect size of the results.

CONCLUSION

This study has determined the level of coordination of the upper extremities in the population of younger school age children, and indicated that there are no differences in Full upper limb coordination, based on seven motor tasks, among boys and girls at this age.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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