Goran Vještica[1],
Association for pre-school sport and physical education of Serbia, Belgrade
Aleksandar Gadžić[2],
Faculty of Physical Education and Sports Management, Singidunum University, Belgrade
Dušan Nikolić[3],
Academy of Applied Studies of Southern Serbia, Department for Preschool Teachers, Bujanovac

Original scientific paper
UDC: 373.2:796
http://doi.org/10.5937/IstrPed2502386V

==========

COMPARATIVE ANALYSIS OF MOTOR SKILLS AND MORPHOLOGICAL CHARACTERISTICS OF PRESCHOOL CHILDREN

Abstract: Child development in the preschool period is characterized by integrality, meaning that the motor, cognitive, and morphological segments of a child's development are strongly interconnected. The aim of this study was to determine the differences in morphological characteristics and motor skills between girls and boys aged 4, 5, and 6 years, with the goal of aligning physical education with the dynamics of growth and development, as well as with sex differences. The total sample consisted of 219 preschool children, including 103 girls and 116 boys. Multivariate analysis of variance showed that statistically significant differences in anthropometric and motor characteristics exist between boys and girls at the ages of 4 and 6, while no significant differences were observed at age 5. Univariate analysis of variance indicated a statistically significant difference in 4-year-olds only in speed and agility test, in 5-year olds significant difference was observed in the standing long jump for 5-year-olds, and in 6-year-olds, significant differences were found in the speed/agility, abdominal strength and coordination/explosive leg power. The findings of this study have practical implications in preschool education and physical education since they emphasize the necessity of programs that equally stimulate all motor abilities, and the importance of individualization and adaptation of activities to mitigate sex differences and support improvements in weaker areas. Future studies should be conducted on larger populations of preschool children across multiple geographical regions in Serbia in order to obtain more valid indicators and improve the generalizability of findings.

Keywords: childhood motor development, anthropometric indicators, preschool physical education, early childhood physical activity.

Introduction

The development of children in preschool age represents a complex and interactive phenomenon in which different aspects - morphological, motor, cognitive, socio-emotional, and linguistic - intertwine. In this sense, the preschool period, covering ages three to seven, is considered critical for establishing the foundations of healthy and balanced development. One of the key aspects of this development is precisely the interconnection between morphological characteristics and motor abilities, as well as their mutual conditioning and the influence of various factors such as age, gender sex, and level of physical activity (De Toia et al., 2009; Malina et al., 2004; Rico-González et al., 2024).

[1] predskolskisport@yahoo.com; ORCID: 0009-0004-6414-1109
[2] agadzic@singidunum.ac.rs; ORCID: 0000-0002-1611-6855
[3] nikolicdusan287@gmail.com; ORCID: 0009-0000-7222-0668

Physical activity plays a major role in children's health, especially given the detrimental impact of today's lifestyle. Modern technological achievements, particularly computers and smartphones, have led to children's alienation, as they increasingly spend time alone indoors, sitting in front of screens. Due to numerous obligations, children are drifting away from nature and significantly reducing their physical activity, thereby risking the onset of various lifestyle-related diseases such as hypokinesia and obesity (Vještica, 2022).

Physical activity is closely connected with motor development, which in the broadest sense refers to mastering the ability to control the body in space through different forms of movement. During preschool age, motor development is most intensive, and precisely in this period crucial neuromuscular adaptations occur, enabling children to achieve better coordination, speed, strength, and flexibility (Gallahue & Ozmun, 2006). On the other hand, morphological characteristics - such as body height, body mass, and body composition - not only accompany but also significantly influence motor development. Research shows that certain morphological characteristics, such as body mass index (BMI), are often negatively correlated with motor abilities such as agility and explosive power (D'Hondt et al., 2011).

Motor functioning of children during this period is of a general type (Bala et al., 2007), which means that at this age motor abilities are not yet differentiated, as children react with their whole body and overall motor skills. The integrality of development at this stage indicates the necessity of comprehensively monitoring and analyzing children's growth and development, especially considering that uneven development in one area may lead to difficulties in another. For example, insufficiently developed flexibility or muscular strength can limit a child in everyday activities and affect his or her overall psychophysical status. Likewise, morphological changes that deviate from normative values may indicate risks of obesity, posture disorders, or other health problems (De Miguel-Etayo et al., 2014).

Sex differences in morphological and motor aspects of child development also represent an important subject of scientific interest. Research suggests that boys generally achieve higher results in strength and speed tests, while girls often score better in tasks requiring flexibility and precision (Barnett et al., 2010; Thomas & French, 1985). Although these differences are partly conditioned by biological factors, cultural and social influences also contribute, particularly through early play patterns.

Preschool institutions play an important role in shaping healthy lifestyle habits and creating the foundation for optimal motor development. During this period, children undergo rapid changes in height, weight, and body structure, and the dynamics of these changes require carefully adjusted physical activities that correspond to age and gender specifics (Stodden et al., 2008). In the Serbian preschool system, although structured physical activity is present, its alignment with developmental characteristics can vary across institutions, which reinforces the relevance of research that identifies specific developmental needs in early childhood.

Research that analyzes morphological and motor characteristics across ages 4, 5, and 6 can therefore help identify developmental patterns and sex differences that may influence the design of appropriate physical activity programs.

The purpose of this study was to examine sex-based differences in morphological characteristics and motor abilities in preschool children aged 4, 5, and 6 years, with the goal of supporting the development of developmentally appropriate physical education practices.

Hypotheses

H1: Boys will show higher performance in speed-, agility-, and strength-related motor tasks.
H2: Girls will perform better in flexibility-related tasks.
H3: Sex differences in motor performance will vary across ages rather than follow a linear pattern.
H4: No substantial sex differences will appear in morphological characteristics in this age range.

Method

The study was conducted as a cross-sectional study. The methods used combine both qualitative and quantitative approaches. The qualitative approach includes observation and description, while the quantitative approach involves measurement and testing.

Sample of participants

The study included 219 preschool children from Belgrade and Nova Varos. The first group consisted of 32 children aged 4 (17 girls and 15 boys), the second group of 95 children aged 5 (46 boys and 49 girls), and the third group of 92 children aged 6 (38 girls and 54 boys).

Sample of variables

For the purposes of the study, three variables were analyzed to assess morphological characteristics and five to assess motor abilities. The morphological variables included: BH – body height, BM – body mass, and BMI – body mass index, while the motor variables included: sit-ups (repetitive strength of trunk muscles), standing long jump (coordination/explosive leg power), shuttle run (agility and speed), sit-and-reach (hamstring flexibility), and hand tapping (speed of alternative arm movements).

Data analysis

A comparative analysis of motor abilities and morphological characteristics of preschool children aged 4, 5, and 6, required appropriate inferential statistical methods to perform comparisons between age groups (4, 5, and 6 years), between genders (girls and boys), and to establish correlations between morphological and motor variables. Before applying parametric tests, the normality of distribution was checked using the Shapiro–Wilk and Kolmogorov–Smirnov tests. Differences between genders in motor abilities and morphological characteristics of each group were calculated using appropriate statistical procedures depending on the distribution (ANOVA or Mann–Whitney), with a significance level of $p \leq 0.05$, using SPSS software version 29. Gender differences by age groups were also tested at the multivariate level using multivariate analysis of variance (MANOVA).

Research instruments

Anthropometric measurements for assessing morphological characteristics and motor tests for assessing physical abilities of children were conducted according to established standards and guidelines (Ivanic, 1996), using the following tests, instruments, and measurement techniques:

Anthropometric measurements for morphological characteristics: body height (BH) – stadiometer with accuracy to 0.1 cm; body mass (BM) – portable scale accurate to 0.1 kg; body mass index (BMI) – calculated using the formula BMI = BM/BH (kg/m^2). Field tests for motor abilities: sit-and-reach (cm), hand tapping (number in 30 s), sit-ups (number in 30 s), standing long jump (cm), shuttle run 4 × 5 m (sec).

Ethical approval was obtained from the Ethics Committee of the Serbian Association for Preschool Sport and Physical Education (Approval No. 12/2024). Written informed consent was obtained from all parents/legal guardians.

During testing, the authors of the study were assisted by expert associates from the Serbian Association for Preschool Sport and Physical Education. The measurements were conducted in physical education halls of preschool institutions. All participants were dressed in sportswear.

Results

Multivariate analysis of variance (MANOVA) showed that statistically significant differences in anthropometric and motor characteristics exist between boys and girls at the ages of 4 and 6, while no significant differences were observed at age 5. Univariate analysis of variance (ANOVA) indicated whether there were differences between genders in each individual variable. In 4-year-olds, a statistically significant difference was found only in the shuttle run test ($p = 0.002$). Significant statistical differences were observed in the standing long jump for 5-year-olds ($p = 0.026$). In 6-year-olds, significant statistical differences were found in the shuttle run ($p = 0.007$), sit-ups (abdominal strength) ($p = 0.003$), and standing long jump ($p = 0.014$).

Table 1. *Descriptive statistics and differences in arithmetic means of tested variables between boys and girls aged 4*

Variable	Boys		Girls		test	p
	M	SD	M	SD		
Body height (cm)	109.47	4.17	108.47	3.47	ANOVA	0.466
Body mass (kg)	18.55	1.92	17.66	1.46	ANOVA	0.148
BMI (kg/m^2)	15.44	0.74	15.01	1.01	ANOVA	0.184
Shuttle run 4x5m (sec)	12.67	1.48	14.47	1.51	Mann-Whitney	**0.002**
Sit-ups 30 sec	9.40	2.69	7.88	2.83	ANOVA	0.132
Standing long jump (cm)	69.20	12.94	66.12	13.58	ANOVA	0.517
Sit-and-reach (cm)	20.67	3.64	22.41	4.64	ANOVA	0.250
Hand tapping 30 sec	25.40	3.07	23.71	3.64	ANOVA	0.168

Legend: M – mean; SD – standard deviation; BH – body height; BM – body mass; BMI – body mass index.

The results of the MANOVA analysis ($F = 3.63$, $p = 0.011$) showed that there is a significant difference between boys and girls aged 4 in motor abilities when all variables are observed together. The Wilks' λ value of 0.6304 for the sex factor indicates that sex explains about 37% of the total variance in motor variables.

In children aged 4, a statistically significant difference was found in the shuttle run category ($p = 0.002$), indicating early sex differences in motor abilities such as agility and speed.

Table 2. *Descriptive statistics and differences in arithmetic means of tested variables between boys and girls aged 5*

Variable	Boys		Girls		test	p
	M	SD	M	SD		
Body height (cm)	117.09	4.93	116.69	4.94	Mann-Whitney	0.291
Body mass (kg)	21.47	2.61	22.13	3.07	Mann-Whitney	0.342
BMI (kg/m^2)	15.61	1.12	16.19	1.22	Mann-Whitney	0.342

Shuttle run 4x5m (sec)	10.85	1.29	11.29	1.03	Mann-Whitney	0.074
Sit-ups 30 sec	12.28	3.347	3.06	3.70	ANOVA	0.260
Standing long jump (cm)	90.30	16.36	82.98	13.83	ANOVA	**0.026**
Sit-and-reach (cm)	17.26	6.69	15.78	8.25	Mann-Whitney	0.250
Hand tapping 30 sec	32.65	5.42	33.92	5.85	Mann-Whitney	0.204

Legend: M – mean; SD – standard deviation; BH – body height; BM – body mass; BMI – body mass index.

The results of the MANOVA analysis ($F = 1.84$, $p = 0.132$) indicated that there was no statistically significant effect of sex on motor abilities at age 5 at the multivariate level. However, the results of the univariate ANOVA for 5-year-olds showed a statistically significant difference in the standing long jump ($p = 0.026$), suggesting that boys may already be developing somewhat better coordination and explosive motor abilities at this age.

Table 3. *Descriptive statistics and differences in arithmetic means of tested variables between boys and girls aged 6*

Variable	Boys		Girls		test	p
	M	SD	M	SD		
Body height (cm)	122.76	5.48	122.34	5.55	ANOVA	0.722
Body mass (kg)	25.33	4.38	24.16	4.59	Mann-Whitney	0.158
BMI (kg/m^2)	16.72	1.94	16.05	2.20	Mann-Whitney	0.158
Shuttle run 4x5m (sec)	9.76	1.00	10.39	1.19	ANOVA	**0.007**
Sit-ups 30 sec	14.72	3.88	12.63	4.61	ANOVA	**0.003**
Standing long jump (cm)	100.56	17.10	92.68	17.75	ANOVA	**0.014**
Sit-and-reach (cm)	16.46	6.90	15.05	8.22	Mann-Whitney	0.377
Hand tapping 30 sec	38.69	6.99	37.39	6.73	Mann-Whitney	0.332

Legend: M – mean; SD – standard deviation; BH – body height; BM – body mass; BMI – body mass index.

The results of the MANOVA analysis ($F = 2.96$, $p = 0.0284$) showed statistically significant differences in motor abilities between boys and girls aged 6 when all variables were considered together. The Wilks' λ value of 0.6543 suggests that sex explains approximately 34.6% of the variance in motor abilities at this age.

At the univariate level (ANOVA), significant statistical differences between boys and girls at age 6 were found in the following variables: shuttle run ($p = 0.007$), sit-ups ($p = 0.003$), and standing long jump ($p = 0.014$).

Discussion

The results of this study indicate that there are significant gender sex and age differences in morphological and motor characteristics of preschool children, but that these differences do not follow a linear developmental pattern. This irregularity is consistent with research showing that early childhood motor development is marked by periods of rapid gains, temporary plateaus, and fluctuations in inter-individual differences (Gallahue & Ozmun, 2006; Malina et al., 2004).

At age 4, boys displayed higher agility performance. This finding aligns with research suggesting that early neuromuscular maturation and sex-linked play behaviors can produce small but noticeable differences even before school age (Thomas & French, 1985).

At age 5, multivariate analyses showed no significant sex differences. Rather than contradicting the previous findings, this temporary convergence can be understood as:

- natural variability in developmental timing,
- the influence of similar preschool activity environments in Serbia at this age,
- the absence of strong biological divergence before age 6–7,
- and measurement sensitivity that may reveal subtle differences at some ages but not others.

Thus, the developmental pattern observed in this study is fully compatible with a non-linear trajectory of motor development.

At age 6, boys again outperformed girls in agility, abdominal strength, and explosive power. This reappearance of differences corresponds to the beginning of more pronounced neuromuscular differentiation and increasingly sex-differentiated play behaviors. These results are consistent with studies indicating that as children approach school age, sex differences in physical abilities become more pronounced due to both morphological growth (greater muscle mass in boys) and early psychosocial influences (Barnett et al., 2010; Stodden et al., 2008;).

The findings emphasize the need for:

- balanced stimulation of all motor abilities,
- individualized approaches for children with lower performance,
- attention to potential developmental lags regardless of sex.

This does not imply inadequacy in the Serbian preschool system but highlights the importance of continuously aligning programming with developmental evidence.

Conclusion

This study, conducted on a sample of 219 preschool children (ages 4, 5, and 6) from Belgrade and Nova Varos, examined sex differences in morphological and motor characteristics.

In accordance with the study's unified aim and hypotheses, the results show:

- minimal sex differences in morphological characteristics,
- significant sex differences in selected motor abilities at ages 4 and 6,
- temporary convergence at age 5,
- evidence for a non-linear pattern of early motor development.

The findings may assist educators in designing age-appropriate motor activities that support the needs of all children.

Future studies should include larger and more regionally diverse samples to improve generalizability.

The results highlight preschool age as a critical period for establishing foundational motor skills with long-term implications for health and physical literacy.

References

Bala, G., Stojanović, M. V., & Stojanović, M. (2007). Merenja i definicija motorickih sposobnosti dece. Novi Sad: Fakultet sporta i fizičkog vaspitanja.

Barnett, L. M., van Beurden, E., Morgan, P. J., Brooks, L. O., & Beard, J. R. (2010). Gender differences in motor skill proficiency from childhood to adolescence: A longitudinal study. *Research Quarterly for Exercise and Sport, 81*(2), 162–170. https://doi.org/10.1080/02701367.2010.10599663

D'Hondt, E., Deforche, B., De Bourdeaudhuij, I., & Lenoir, M. (2008). Childhood obesity affects motor skill performance under different postural constraints. *Neuroscience Letters, 440*(1), 72–75. https://doi.org/10.1016/j.neulet.2008.05.056

De Miguel-Etayo, P., Gracia-Marco, L., Ortega, F. B., Intemann, T., Foraita, R., Lissner, L., … & Moreno, L. A. (2014). Physical fitness reference standards in European children: The IDEFICS study. *International Journal of Obesity, 38*(S2), S57–S66. https://doi.org/10.1038/ijo.2014.136

De Toia, D., Rüter, J., Jekauc, D., Worth, A., Fuchs, R., & Wagner, M. O. (2009). Relationship between anthropometry and motor abilities in preschool age. *Obesity Facts, 2*(4), 221–225. https://doi.org/10.1159/000228155

Gallahue, D. L., & Ozmun, J. C. (2006). *Understanding motor development: Infants, children, adolescents, adults* (6th ed.). McGraw-Hill.

Ivanic, S. (1996). *Metodologija*. Beograd: Gradski sekretarijat za sport i omladinu Grada Beograda.

Malina, R. M., Bouchard, C., & Bar-Or, O. (2004). *Growth, maturation, and physical activity*. Human Kinetics.

Rico-González, M., Los Arcos, A., Nakamura, F. Y., & Clemente, F. M. (2024). Anthropometric influence on preschool children's physical fitness and motor skills: A systematic review. *Journal of Functional Morphology and Kinesiology, 9*(2), 95. https://doi.org/10.3390/jfmk9020095

Stodden, D. F., Goodway, J. D., Langendorfer, S. J., Roberton, M. A., Rudisill, M. E., Garcia, C., & Garcia, L. E. (2008). A developmental perspective on the role of motor skill competence in physical activity: An emergent relationship. *Quest, 60*(2), 290–306. https://doi.org/10.1080/00336297.2008.10483582

Thomas, J. R., & French, K. E. (1985). Gender differences across age in motor performance: A meta-analysis. *Psychological Bulletin, 98*(2), 260–282. https://doi.org/10.1037/0033-2909.98.2.260

Vještica, G. (2022). Uključenost dece predškolskog uzrasta iz projekta "Vezbaj pravo budi zdravo" u fizičko vaspitanje i sport. Beograd: Fakultet za sport.

Biographical note:

Goran Vještica, rođen 1977. godine, otac dvoje dece. Krajem 2022. godine završio je Master akademske studije na Fakultetu za sport u Beogradu, a trenutno je na trećoj godini Doktorskih studija na Fakultetu za sport i psihologiju u Novom Sadu. Organizator je velikog broja stručnih seminara i radionica namenjenih edukaciji i usavršavanju sportskih radnika i zaposlenih u prosveti. Od 2000. godine je na rukovodećim mestima u više sportskih klubova i saveza, a od 2010. godine je predsednik Savez za predškolski sport i fizičko vaspitanje Srbije.

Aleksandar Gadžić, rođen 1971. godine. Magistarsku tezu odbranio 2008. godine, a doktorsku disertaciju 2011. godine na Fakultetu sporta i fizičkog vaspitanja, Univerzitet u Nišu. Od 2014. godine zaposlen na Fakultetu za fizičku kulturu i mendžment u sportu, Univerzitet Singidunum, Beograd kao vanredni profesor na predmetima Teorija i metodika fizičkog vaspitanja, Antropomotorika i Dečije igre i sport. Autor je većeg broja radova u istaknutim inostranim i domaćim časopisima.

Dušan Nikolić je doktor nauka iz oblasti sporta i fizičkog vaspitanja. Doktorirao je na Fakultetu sporta i fizičkog vaspitanja Univerziteta u Nišu. Zaposlen je na Akademiji strukovnih studija Južna Srbija, Odsek Visoka škola za vaspitače u Bujanovcu, u svojstvu predavača. Autor je mnogobrojnih naučnih i stručnih radova iz oblasti fizičkog vaspitanja i razvoja motorike dece predškolskog uzrasta. U slobodno vreme bavi se snimanjem putopisnih emisija, a autor je serijala Putevima sveta – Dušan Nikolić.