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Association Between Body Morphology and Motor and Functional Abilities in Preschool Children

Mirela Sunda[1], Magdalena Brkic[1], Iva Blazevic[2]

[1]University of Osijek, Faculty of Kinesiology, Osijek, Croatia, [2]University of Pula, Faculty of Educational Science, Pula, Croatia

Abstract

The main aim of this study was to determine the association between morphological characteristics and the motor and functional abilities of preschool children. An additional objective was to examine whether differences exist in morphological characteristics, motor, and functional abilities between girls and boys. The study included 120 children (55 girls and 65 boys) aged 4 to 6 years (4.88±0.86), all enrolled in the regular preschool education system of the Republic of Croatia. The assessment of morphological characteristics and motor and functional abilities was carried out using the PREFIT test battery. Morphological variables included: body height, body mass, body mass index, and waist circumference. Motor abilities were measured using the following tests: handgrip, standing long jump, one-leg stance, and 4x10 meter run, and functional abilites with 20-meter shuttle run test. Significant positive correlations were found between body height and handgrip strength (right hand: r=0.68; left hand: r=0.69), as well as standing long jump (r=0.56), while height correlated negatively with the 4×10 m run (r=–0.60). Body mass showed similar associations, positively with handgrip strength (right: r=0.61; left: r=0.64) and standing long jump (r=0.47), and negatively with the 4×10 m run (r=–0.42). Waist circumference was positively correlated with handgrip strength (right: r=0.32; left: r= 0.34) and standing long jump (r=0.31), and negatively with the 4x10 m run (r=–0.19). No differences were found between gender. The results of this research highlight the importance of monitoring the physical and motor development of preschool children in order to foster healthy life habits and improve the level of physical literacy and physical activity from the earliest age.

Keywords: *physical activity, physical literacy, physical fitness, kindergarden, health*

Introduction

One of the tasks of educational work with children is to ensure their optimal growth and development, as well as the proper development of morphological characteristics. In order for the process of growth and development to proceed appropriately, educators should carefully plan their work to achieve the integrated development of all morphological features (Horvat, 2010). Physical activity, as well as movement and play, contribute significantly to the health and development of preschool children (Tomac, Vidranski, & Ciglar, 2015). Through regular and quality physical activity, it is possible to positively influence the morphological characteristics of children, and consequently the changes in motor skills, while taking into consideration the individuality of each child (Findak, 1999). A lack of adequate physical activity negatively affects the growth and development of children and endangers the normal functioning of all organs, organ systems, and overall health (Tomac et al., 2015). Morphological characteristics refer to physical features such as body height, body weight, the circumference of various body parts, and

Correspondence:

Mirela Sunda
University of Osijek, University of Osijek, Faculty of Kinesiology, Drinska 16a, 31000, Osijek, Croatia
E-mail: msunda@kifos.hr

the thickness of skinfolds (Neljak, Novak, Sporiš, Višković, & Markuš, 2011). During the preschool period, morphological characteristics undergo major and significant changes. In preschool children, these characteristics differ substantially from those of adults due to ongoing growth and development processes. Preschool children's bones are softer and more elastic because they contain more cartilage tissue, which makes them more resistant to fractures, but also more susceptible to deformities.

The development of motor abilities during preschool age is crucial for later participation in more complex physical activities and sports, as well as for performing everyday activities (Sekulić & Metikoš, 2007). From early preschool age, children actively develop certain abilities: coordination, overall precision, balance, general endurance, general strength, flexibility, and the speed of reaction to auditory and visual stimuli (Neljak, 2009). These abilities develop in an integrated manner; that is, they do not develop individually but rather the development of one ability often brings about the development of another. For example, coordination is often developed alongside precision. Thus, a child who plays with a ball—throwing, catching, and targeting it—develops both coordination and precision simultaneously. Accordingly, motor abilities are not separate and independent; they are always interconnected with each other or with several others (Kosinac, 2011).

Physical literacy refers to an individual's ability to take responsibility for maintaining purposeful physical activity throughout life, supported by motivation, confidence, physical competence, knowledge, and understanding (Whitehead, 2013). Physical literacy is closely related to motor abilities, as these provide the foundation for movement competence, while morphological characteristics such as body composition, height, and strength can either facilitate or hinder the development and performance of motor skills. Together, these elements form an integrated framework that supports not only children's participation in physical activity but also their long-term engagement in active and healthy lifestyles.

It is well known and numerous studies have confirmed that physical activity in preschool children is crucial for their development because it reduces the incidence of chronic non-communicable diseases, the risk of obesity, and promotes and develops good physical and mental health (Rodriguez-Ayllon et al., 2019; Sprengeler et al., 2021). The World Health Organization (WHO) and countries such as Canada and Australia have published 24-hour movement guidelines for early childhood, recommending that children aged 3 to 5 years should be physically active for at least 180 minutes daily, including at least 60 minutes of energetic play (physical activity of moderate to vigorous intensity) (Draper et al., 2023; Tremblay et al., 2017; World Health Organization, 2019).

Previous research indicates a significant relationship between morphological characteristics and motor skills in preschool and younger school-age children, with marked differences with respect to gender, age, and body composition. For example, Kosinac (2011) found that five-year-old boys achieve better results in most motor tests, whereas girls show greater success in balance and flexibility and have more pronounced skin folds. Similarly, Bala, Jakšić and Popović (2009) confirmed these differences and further emphasized changes in the relationship between morphological and motor characteristics over time. Furthermore, Prskalo, Badrić and Kunješić (2015) showed that excessive body weight negatively affects motor skills, especially in girls. In addition, Horvat and Sindik (2016) highlighted the connection between motor skills and school readiness, while Vlahović and Babin (2018) confirmed the importance of a favorable body composition for success in performing specific motor tasks. Moreover, Atiković et al. (2023) demonstrated the influence of age on strength and skills, and more recent works (Pelemiš et al., 2024; Rico-González, Ardigò, Ramírez-Arroyo, & Gómez-Carmona, 2024) emphasized that height and muscle mass are key to strength and coordination. These recent studies also confirmed the advantage of girls in motor coordination, probably due to earlier maturity. In this study we used body mass index (BMI) and waist circumference because they are simple, reliable, and do not require expensive or specialized equipment. BMI is a widely recognized indicator of relative body mass, while waist circumference reflects fat distribution and potential risks associated with overweight (Silventoinen et al., 2025). Compared to methods such as skinfold thickness measurement, these indicators offer quick, standardized, and practical assessment suitable for preschool children.

Overall, all these findings indicate the need to monitor the morphological and motor development of children. This helps to better understand gender and developmental differences and to provide adequate support for motor development. The primary aim of this research was to examine the association between the morphological characteristics of preschool children and their motor and functional abilities. The secondary aim was to investigate gender differences in the kinanthropological characteristics of preschool children.

Methods

Patricipants

This study involved 120 children (55 girls, 65 boys) aged 4 to 6 years (4.88±0.86) enrolled in the regular preschool education system of the Republic of Croatia. A total of 52 four-year-olds (21 girls, 31 boys), 30 five-year-olds (13 girls, 17 boys), and 38 six-year-olds (19 girls, 19 boys) were included. The research was conducted in two kindergartens in the Osijek-Baranja County. Prior to the study, the children's parents or legal guardians were informed about the purpose and protocol of the research and signed informed consent forms granting permission for their child's participation. The study included children in good health who, at the time of measurement, had no illnesses or injuries. The study was approved by the ethical board University of Osijek, Faculty of Kinesiology.

Description of tests

The assessment of morphological characteristics as well as motor and functional abilities of preschool children was conducted using the PREFIT test battery, whose validity and reliability have been confirmed elsewhere (Ortega et al., 2015). All tests are standardized and adapted for preschool-aged children. This test battery also helps monitor children's progress and plan activities that contribute to their healthy development (Ortega et al., 2015). An advantage of this test battery is that it requires minimal equipment and can be easily administered. It includes measurements of body height and body mass, necessary for determining the body mass index (BMI), as well as waist circumference, handgrip strength, standing long jump, 4x10 meter shuttle run, one-leg standing test (for 6-year-olds), and the 20-meter progres-

sive shuttle run test. These tests have demonstrated a strong correlation with current and future health status in children, adolescents, and adults (Ortega et al., 2015). During the measurements, children were dressed in light, breathable sportswear and appropriate sports shoes.

Variables

In this study, the following variables were analyzed and used: gender, age, body height (cm), body mass (kg), body mass index (kg/m^2), waist circumference (cm), upper limb muscle strength (kg), explosive strength of the lower limbs (cm), speed and agility (sec), balance (sec), and cardiorespiratory fitness (level).

Description of protocol

Before the start of the study, all parents/legal guardians of the participants were informed about the purpose and protocol of the research by the preschool institution's director, educators, and/or the researchers. The parents or legal guardians received a consent form outlining the research protocol in detail, and by signing it, they confirmed their consent for their child's participation in the study. Measurements were conducted over two weeks in April 2025 within preschool institutions as part of the children's regular activities, and all measurements were performed according to standardized protocols. First, morphological characteristics were measured in the following order: body height, body mass, after which BMI was calculated, followed by waist circumference measurement. After that, muscle strength and the balance test for six-year-olds were assessed. Following the balance test, the standing long jump and the 4x10 meter run tests were conducted. The last test administered was the 20-meter progressive shuttle run, which was conducted on the outdoor sports playground of a nearby elementary school. The other tests were conducted in the kindergarten's sports hall, preceded by warming up and mobility exercises adapted to the preschool age group.

Dana analysis

Data were analyzed using descriptive statistics to present the basic characteristics of the sample and the distribution of data (arithmetic mean, standard deviation, maximum, and minimum). The Kolmogorov–Smirnov test was used to assess the normality of the distribution. Pearson's correlation was used to examine the correlation between morphological characteristics and motor and functional abilities. The independent samples t-test was used to determine differences based on gender. Data were processed using the statistical software Statistica 14.1.

Results

The prerequisites for parametric analyses were tested using the Kolmogorov–Smirnov test, skewness and kurtosis indices, as well as visual inspection of histograms. Skewness values can range between ±2, and kurtosis values between ±7 (Kim, 2013; Mishra et al., 2019; West, Finch, & Curran, 1995). The skewness and kurtosis values in this study fall within the recommended limits. According to these criteria, all variables are normally distributed (Table 1).

Table 1. Descriptive Statistics of Examined Variables

Variables	N	Min	Max	M	SD	maxD	K-S	Sk	Ku
AGE	120	4.00	6.00	4.88	0.86	0.28	p<0.01	0.23	-1.62
BH	120	97.90	132.00	113.64	7.82	0.07	p>0.20	0.14	-0.70
BM	120	14.90	34.50	20.46	3.64	0.09	p>0.20	1.09	1.93
BMI	120	12.76	20.54	15.72	1.34	0.08	p>0.20	0.84	1.56
WC	120	46.20	71.90	54.31	3.86	0.08	p>0.20	1.22	3.56
SRT	117	4.00	46.00	13.51	7.48	0.19	p<.001	1.65	3.72
RHS	115	5.00	17.00	8.31	2.35	0.15	p<0.05	0.97	0.90
LHS	115	5.00	16.40	8.26	2.32	0.11	p<0.15	1.26	1.90
SLJ	118	35.00	140.00	82.37	21.59	0.07	p>0.20	0.29	-0.40
T40	116	12.88	25.12	16.83	2.51	0.16	p<0.01	1.39	2.20
BR	35	1.40	71.17	22.00	17.59	0.14	p>0.20	1.04	0.55
BL	35	1.33	96.31	17.69	20.12	0.27	p<0.05	2.37	6.36

Note. N: number of participants; M: arithmetic mean; SD: standard deviation; Max: achieved maximum; Min: achieved minimum; K-S: Kolmogorov-Smirnov test; Sk: skewness index; Ku: kurtosis index; BH: body height; BM: body mass; BMI: body mass index; WC: waist circumference; RHS: right handgrip strength; LHS: left handgrip strength; SLJ: standing long jump; SRT: shuttle run test; T40: 4x10 m run; BR: balance on right leg; BL: balance on left leg; *p<0.05; **p<0.01

The obtained results indicate that most morphological characteristics are significantly associated with motor and functional abilities. Table 2 reveals a statistically significant correlation between body height and grip strength of both the left and right hands, with a correlation value of r=0.67 for the right hand and r=0.69 for the left hand. A statistically significant correlation is also observed between body height and standing long jump, where r=0.56. A negative correlation was identified with the T40 test (4x10 meter run), with r=-0.599. There is a statistically significant correlation between body mass and grip strength of the right and left hands (r=0.61, r= 0.63), as well as with the standing long jump variable, where r=0.467. Additionally, a statistically significant negative correlation exists between body mass and the 4x10 meter run (r=-0.42). Waist circumference is statistically significantly positively correlated with grip strength of the right hand (r= 0.32), grip strength of the left hand (r=0.34), and standing long jump (r=0.31), and negatively correlated with the T40 test (r=-0.19).

Analysis of differences by gender shows that differences are not statistically significant (Table 3).

Table 2. Correlations of Morphological Characteristics with Motor and Functional Abilities

	BM	BMI	OS	SRT	RHS	LHS	SLJ	T40	BR	BL
BH	0.85**	0.16	0.48**	0.23*	0.67**	0.69**	0.56**	-0.60**	-0.14	0.01
BM		0.65**	0.69**	0.16	0.61**	0.64**	0.47**	-0.42**	0.04	0.08
BMI			0.60**	0.00	0.18	0.19*	0.08	0.06	0.02	0.12
WC				0.03	0.32**	0.34**	0.31**	-0.18*	0.12	0.22
SRT					0.23*	0.26**	0.34**	-0.44**	-0.12	-0.08
RHS						0.87**	0.62**	-0.47**	-0.03	0.04
LHS							0.62**	-0.54**	-0.05	0.01
SLJ								-0.79**	0.25	0.16
T40									-0.11	0.02
BR										0.60**

Note. BH: body height; BM: body mass; BMI: body mass index; WC: waist circumference; RHS: right handgrip strength; LHS: left handgrip strength; SLJ: standing long jump; SRT: shuttle run test; T40: 4x10 m run; BR: balance on right leg; BL: balance on left leg; *p<0.05; **p<0.01.

Table 3. Differences in morphological, motor, and functional characteristics by gender

Variables	M (N=55) (boys)	SD	M(N=65) (girls)	SD	t	P
AGE	4.82	0.86	4.96	0.86	0.94	0.35
BH	113.59	8.16	113.70	7.46	0.08	0.94
BM	20.19	3.40	20.77	3.91	0.86	0.39
BMI	15.54	1.25	15.93	1.41	1.59	0.12
WC	54.42	3.62	54.19	4.14	-0.33	0.74
SRT	14.31	8.21	12.55	6.43	-1.27	0.21
RHS	8.56	2.22	8.15	2.29	-0.94	0.35
LHS	8.38	2.61	8.12	1.94	-0.59	0.55
SLJ	85.10	23.71	79.25	18.59	-1.47	0.14
T40	16.98	2.81	16.66	2.10	-0.68	0.50
BR	20.97	26.9	22.86	17.73	-0.31	0.76
BL	22.52	26.07	13.62	12.64	-1.32	0.20

Note. M: arithmetic mean; SD: standard deviation; BH: body height; BM: body mass; BMI: body mass index; WC: waist circumference; RHS: right handgrip strength; LHS: left handgrip strength; SLJ: standing long jump; SRT: shuttle run test; T40: 4x10 m run; BR: balance on right leg; BL: balance on left leg.

Discussion

In line with the main objective, a significant association was found between morphological characteristics (body height, body mass, waist circumference, body mass index) and motor and functional abilities of preschool children. The positive relationship between body height, body mass, and waist circumference with handgrip strength (right and left) and standing long jump can be explained by the fact that a larger and stronger body has a greater capacity to generate force, which results in better performance in tests requiring muscular strength. On the other hand, the negative association between body height, body mass, and waist circumference with performance in the 4x10 meter run test, as well as between body height and mass and the one-leg standing test, can be linked to biomechanical limitations. Children with greater body mass may have more difficulty accelerating, stopping, and changing directions due to increased inertia force; a heavier body is harder to "turn" and "stop."

Regarding the balance test, it is possible that children with greater body mass exhibit poorer balance, which can be associated with a phase of rapid growth. During this phase, the muscles responsible for maintaining balance may still be insufficiently coordinated, which can further affect postural control and lead to poorer results in balance tests. However, the results indicate that there is no significant relationship between morphological characteristics and balance, which aligns with research linking balance primarily to the functionality of sensorimotor systems rather than anthropometric characteristics (Horvat, Babić, & Miholić, 2013; Kuterovac, 2022). The obtained findings confirm the results of previous studies (Kondrič, Mišigoj-Duraković, & Metikoš, 2002), which also indicated a significant association between morphological characteristics and motor abilities.

The upper limb muscle strength test showed a strong association with height, body mass, and waist circumference. Upper limb muscle strength refers to the ability of the arm and shoulder muscles to voluntarily generate the force needed to overcome resistance through maximal contraction. Greater height and body mass are often associated with higher overall muscle mass, which can result in greater maximum force that the arm can produce, including grip strength.

Explosive power of the lower limbs, measured by the standing long jump, also showed a strong relationship with morphological characteristics. Similar findings exist in the lit-

erature linking anthropometric measures with motor abilities in children, where it has been found that body mass and height play an important role in the development of muscle strength and motor function (Rico-González et al., 2024). Such a correlation can be explained by the influence of body build on the ability to generate force in the lower limbs. Children with greater height and longer limbs have a biomechanical advantage in producing more force, which also contributes to greater jump distance (Rico-González et al., 2024).

In the 4x10 m running test, the negative relationship with height and mass can partly be explained by the nature of the speed variable (lower value = better result) as well as the biomechanical advantages of children with longer strides and stronger push-off. However, in children with excessive body mass, especially fat tissue, speed and agility may be impaired (Lopes, Stodden, Bianchi, Maia, & Rodrigues, 2012; Malina, Bouchard, & Bar-Or, 2004).

Finally, when analyzing the correlation between morphological characteristics and functional abilities, the results indicate a slight positive association only between body height and results in the 20-meter progressive running test. Aerobic capacity depends on a number of factors, including hereditary traits, sex, age, and activity level (Bouchard et al., 1999; Reisberg, Riso, & Jürimäe, 2021), which is likely the reason for the relatively low relationship with morphological characteristics.

Besides the main goal, the additional aim was to determine whether there are differences in morphological, motor, and functional abilities by gender. Based on the obtained results, it can be concluded that no differences were found between boys and girls. This is consistent with earlier research indicating that gender at the preschool age does not yet play a key role in the development of physical and motor characteristics and that biological and hormonal differences affecting muscle mass and strength become more pronounced only in later stages of development (Horvat, 2010; Hraste, Đurović, & Matas, 2009). Moreover, the sample composition, limited to a relatively narrow age range, may have reduced variability and masked potential differences. In addition, it is possible that the sensitivity of the applied measurement tools was not sufficient to detect subtle differences between boys and girls at this developmental stage.

It is important to emphasize that the cross-sectional design of this study does not allow for causal conclusions regarding the relationship between morphological characteristics and motor-functional abilities. Although the findings cannot establish causality, the observed associations provide valuable insights, and longitudinal studies that follow children over time are needed to clarify developmental mechanisms and directions of influence. Furthermore, these associations may be regarded as a foundation of physical literacy, since optimal physical development facilitates the acquisition of fundamental motor skills (Cairney et al., 2019; Cools et al., 2011). Highlighting this connection underscores the importance of promoting physical activity and fostering balanced morphological and motor development in preschool children, ultimately contributing to lifelong physical literacy.

Conclusion

The obtained results indicate that morphological characteristics are an important predictor of motor and functional abilities in preschool children. This further emphasizes the importance of systematically monitoring the development of children's physical characteristics and implementing well-designed physical activities in preschool institutions. The inclusion of kinesiologists in the teams of preschool professionals is particularly important, as it ensures expert guidance and supervision of children's overall development. Through regular, health-oriented, and age-appropriate physical activities, accompanied by education for both children and parents, it is possible to positively influence physical development. Furthermore, by connecting preschool institutions with local sports clubs and continually educating preschool educators, it is possible to enhance children's physical literacy, which in the long term contributes to a healthier lifestyle. The results of this research highlight the importance of monitoring the physical and motor development of preschool children in order to foster healthy life habits and improve the level of physical literacy and physical activity from the earliest age. Future research should aim to determine the level of physical literacy and activity among preschool children, the relationship between physical literacy, physical fitness, and physical activity in children, as well as the possible connection between the level of physical literacy of parents and that of their children. Also, they should aim to expand these findings through longitudinal studies that track the development of morphological characteristics, motor abilities, and physical literacy over time. Additionally, integrating standardized assessments of physical literacy and physical fitness, as well as including more diverse preschool populations, will provide a deeper understanding of developmental trends.

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Conflict of Interest
The authors declare that there is no conflict of interest.

Ethics
This study was approved in advance by the directors of the kindergartens in Osijek - Baranja County (Croatia). The parents or legal guardians of each participant voluntarily signed an informed consent form prior to participation. The study was aprroved by the Ethical Board Faculty of the Kinesiology University of Osijek (Ref. no. KLASA: 029-01/24-01/05; URBROJ: 2158-110-01-24-85, date of approval: 30 October 2024).

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