ORIGINAL SCIENTIFIC PAPER
ORIGINALNI ZNANSTVENI RAD

Hrvat. Športskomed. Vjesn. 2025; 40:177-185

WEIGHT-RELATED DIFFERENCES IN MOTOR COMPETENCE OF PRESCHOOL CHILDREN

RAZLIKE U MOTORIČKIM KOMPETENCIJAMA DJECE PREDŠKOLSKE DOBI RAZLIČITOG STATUSA UHRANJENOSTI

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Cite as: Šalaj S, Cobal S, Vlašić D. Weight-related differences in motor competence of preschool children. Croat Sports Med J. 2025; 40(2):177-85.

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DOI: 10.69589/hsv.40.2.8

ABSTRACT

Purpose of this study was to determine differences in motor skills and abilities in 3–7-year-old children across different weight categories, ranging from thin to obese. A total of 732 preschoolers (384 boys and 348 girls) attending public kindergartens in Croatia participated. They were divided into two age groups: under five years and over five years and categorized according to body mass index (BMI) following WHO classifications. Measurements included anthropometric assessments and motor evaluations using the Test of Gross Motor Development – Second Edition (TGMD-2) and the Bruininks-Oseretsky Test of Motor Proficiency – Second Edition (BOT-2). Data were analyzed with Statistica v.13. The prevalence of obesity was 1.2% among children under five and 5.25% among those over five, lower than rates reported in other European countries and globally. Analysis of variance showed no significant differences in TGMD-2 scores across weight categories in either age group. However, significant differences emerged in BOT-2 results: in both younger ($F = 4.24$; $p < 0.01$) and older children ($F = 5.72$; $p < 0.01$), obese children achieved the lowest scores, with post-hoc tests confirming significant differences between obese and normal-weight peers. These findings suggest that while fundamental motor patterns remain preserved in overweight and obese preschoolers, difficulties arise in more physically demanding tasks requiring strength and endurance. The results underscore the importance of early and targeted interventions in

SAŽETAK

Svrha ovog istraživanja bila je utvrditi razlike u motoričkim vještinama i sposobnostima djece u dobi od 3 do 7 godina različitog statusa uhranjenosti, od pothranjenih do pretilih. U istraživanju je sudjelovalo ukupno 732 djece predškolske dobi (384 dječaka i 348 djevojčica) koja pohađaju javne vrtiće u Hrvatskoj. Djeca su bila podijeljena u dvije dobne skupine: mlađu od pet godina i stariju od pet godina, te razvrstana prema indeksu tjelesne mase (BMI) u skladu s klasifikacijom Svjetske zdravstvene organizacije (WHO). Mjerenja su uključivala antropometrijska ispitivanja i procjenu motoričkih vještina i sposobnosti pomoću Test of Gross Motor Development – Second Edition (TGMD-2) i Bruininks-Oseretsky Test of Motor Proficiency – Second Edition (BOT-2). Podaci su analizirani programskim paketom Statistica v.13. Prevalencija pretilosti iznosila je 1,2% među djecom mlađom od pet godina i 5,25% među djecom starijom od pet godina, što je niže u odnosu na druge europske zemlje i u odnosu na svjetsku razinu. Analiza varijance pokazala je da nema značajnih razlika u rezultatima TGMD-2 među različitim kategorijama statusa uhranjenosti u obje dobne skupine. Međutim, značajne razlike uočene su u rezultatima BOT-2: i kod mlađe djece ($F = 4,24$; $p < 0,01$) i kod starije djece ($F = 5,72$; $p < 0,01$) pretila djeca postigla su najniže rezultate. Ovi nalazi upućuju na to da su temeljni obrasci kretanja očuvani kod djece s prekomjernom tjelesnom masom i pretilošću, dok se poteškoće javljaju u zahtjevnijim zadacima koji traže

preschool and sports settings to promote motor competence and physical fitness in children of all weight categories.

Keywords: motor skills, physical activity, obesity

jakost i izdržljivost. Rezultati naglašavaju važnost ranih, ciljano usmjerenih intervencija u predškolskim i sportskim programima kako bi se poticala motorička kompetencija i tjelesna spremnost djece svih stupnjeva uhranjenosti.

Ključne riječi: motoričke vještine, tjelesna aktivnost, pretilost

INTRODUCTION

Movement and play are essential components of physical development in early childhood. Through physical activity and play, children develop the motor competence necessary for exploring their environment and participating in daily routines. In turn, motor competence in movements such as running, jumping, and throwing—commonly referred to as fundamental motor skills—enables children to achieve levels of physical activity that support cardiovascular health and long-term well-being.[42, 39, 43] Higher levels of motor competence in early childhood have been linked to better overall health, greater school readiness (including math and reading skills), and continued participation in physical activity during adolescence.[42, 3, 29, 48]

Motor skills can be categorized as locomotor skills (moving the body through space), object control skills (manipulating objects with the arms or legs), or fine motor skills (precise finger movements such as writing). These skills develop progressively from birth throughout childhood, influenced by structured support from professionals and parents, as well as opportunities for free play with peers. Institutional support in early care and education centers—such as motivating educators, informing parents, providing free access to movement spaces, and purchasing sports equipment—can contribute to motor skill development.[5]

Competence in fundamental motor skills contributes not only to children's physical development but also to cognitive, socio-emotional, and overall developmental outcomes.[21] However, children generally demonstrate 'below average' to 'average' levels of these skills compared to normative data, indicating widespread motor competence deficits.[4] At the same time, children's physical activity levels have remained low over the past couple of decades, while sedentary behaviours—such as screen time—continue to rise.[38, 33] Poor dietary habits, including high intake of energy-dense, nutrient-poor foods, further contribute to unhealthy weight gain. Several behavioural factors are closely associated with higher body mass index, including lower motor competence[31], insufficient physical activity[30], screen time exposure[14], and inadequate nutrition[16]. The nature of overweight and obesity is multifactorial[1], and these behavioural determinants, among others, contribute to the continued global rise in childhood obesity.[37] In 2022, a total of 878 million adults and 159.3 million children and adolescents aged 5–19 years were living with obesity worldwide[35]. According to the latest UNICEF/WHO/World Bank Joint Child Malnutrition Estimates (JME), in 2024 approximately 35.5 million children under 5 years of age (5.5% of all children in this age group) were affected by overweight or obesity[45].While the prevalence of overweight and obesity is rising across all age groups, rates in early childhood remain relatively low. According to data from Croatia, the prevalence of overweight among children under the age of 5 is below 2%, and under 5% among children aged 5–8 years, with a visible trend of increasing prevalence with age.[23]

Additional body mass can make everyday movement more challenging, reducing endurance and coordination, and often leading to avoidance of physical activity and play with peers[36]. The literature recommends early intervention from the preschool years for the prevention and treatment of overweight and obesity, as this period is optimal for establishing healthy lifestyle habits[27]. Preventive measures in early childhood, such as providing opportunities for physical activity, enhancing fundamental motor skills, and reducing screen time, offer an important opportunity for the long-term adoption of behavioral patterns that help prevent overweight and obesity.[47] However, there is still limited scientific evidence supporting the effectiveness of various interventions in improving weight status.[18]

Previous research investigating the relationship between weight status and motor skills in children has produced inconsistent findings. Some studies report no significant differences in motor proficiency between healthy-weight and obese children as measured by BMI [25, 20, 30], while others have found that overweight or obese children demonstrate poorer motor skills compared to their normal-weight peers. [28, 17, 24, 49, 26, 12, 34, 40, 50] In particular, heavier children have been reported to experience difficulties in performing locomotor tasks[19], such as jumping and hopping.[7] Notably, the association between motor skills and obesity appears strongest in tasks that involve managing one's own body weight.[20] Published reviews show a predominantly negative relationship between motor skills and weight status in children aged 3–12 years, but they are inconclusive and suggest further research.[41, 31]

There is a clear need for more data on preschool-aged children, particularly in the 2–5 years age group. Few studies use multiple assessment tools for motor proficiency,

and there remains limited understanding of how obesity affects distinct motor domains. This study examines motor skills and abilities in 3–7-year-old children attending public kindergartens, across different weight categories, using two distinct measurement tools (BOT-2 and TGMD-2).

METHODS

Subjects

A total of 732 preschool children (384 boys and 348 girls) from public kindergartens in Croatia participated in this study. The study is part of a national, population-based research project on physical activity and motor skills in preschool children.[46] It was approved by the national Ministry of Education and the principals of early education and care centers. Parents or legal guardians were informed about the research protocol and provided written informed consent for their child's participation. The research was conducted in accordance with the Declaration of Helsinki and was approved by the institutional ethics committee (approval number: 100/2014).

For the purposes of this study, children aged 3 to 7 years were divided into two age groups: under five years (average age 4.1) and over five years (average age 6.09), in accordance with the World Health Organization (WHO) nutritional status classification based on anthropometric measurements.[13] Children were classified according to body mass index (BMI), calculated as weight divided for height^2 (kg/m^2). Since the WHO classification differs for children below and above 60 months (5 years) of age, participants were grouped accordingly, and then further categorized based on their BMI status using WHO age-and sex-specific z-score classification.[13] For children under 5 years of age, the categories were: a) At risk of overweight (BMI > +1 SD to +2 SD), b) Overweight (BMI > +2 SD to +3 SD), c) Obesity (BMI > +3 SD), while all other values were considered normal weight. For children over 5 years of age, the categories were: a) Severely thin (BMI < –3 SD), b) Thin (BMI between –3 SD and –2 SD), c) Overweight (BMI > +1 SD), d) Obesity (BMI > +2 SD), while BMI values between –1.99 SD and +0.99 SD were considered normal weight.

Measurement procedures

The measuring process was organized into two parts: first, anthropometric measurements; and second, assessments of motor skills and abilities using the Test of Gross Motor Development – Second Edition (TGMD-2) and the Bruininks-Oseretsky Test of Motor Proficiency – Second Edition (BOT-2). Data on weight and height of children was obtained by a trained professional in all preschools. The measurements of body weight (kg) and height (cm) were taken in minimal precision of 0.1 kg and 0.1 cm. The height of the children was measured with the head in horizontal Frankfurt plane. Their body weight was measured while wearing light clothes and no shoes in a setting that ensured privacy.

The TGMD-2 was used to evaluate motor abilities in children. It consists of twelve tasks divided into two groups: locomotor skills and object control skills. The first group includes locomotor tasks such as running, galloping, hopping, long jumping, leaping, and sliding. The second group assesses manipulative skills, including striking a ball, dribbling, catching, kicking, overhand throwing, and underhand rolling. Each motor skill is evaluated using three to five criteria, scored as 0 (criterion not met) or 1 (criterion met), in accordance with the user manual.[44] The TGMD-2 has demonstrated high reliability, with a Cronbach's alpha of $\alpha = 0.94$.[44] We used gross motor quotient (TGMD-2), standardized locomotor score (LOK) and standardized object control score (MAN) as variables.

BOT-2[6] is a test battery used to assess gross and fine motor skills in children and young adults in ages 4 to 21. BOT-2 test battery consists of 53 distinctive tests subdivided into eight motor areas: motor precision, motor integration, ambidexterity, hand coordination, balance, bilateral coordination, speed, agility and strength. For research requirements short form of BOT-2 test battery was used, containing 14 tests. The testing was carried out according to official manufacturer instructions.[6] A standard score is composed by the sum of all scores considering subject's age and sex. The reliability of this test battery is high (0.86 do 0.89).[11] We used standardized total score (BOT-2) as the dependent variable.

Data Analysis

Data were analyzed using the software package Statistica v.13 (TIBCO Statistica Inc., OK, USA). Descriptive parameters were calculated for all quantitative variables. A univariate analysis of variance (one-way ANOVA), followed by the Bonferroni post-hoc test, was used to determine differences in motor skills and abilities among children in different BMI categories. Statistical significance was set at $p < 0.05$.

RESULTS

Table 1 presents the distribution of children across two age groups and weight categories. In the under-5 age group, 80.1% of children had a normal body weight, 15.4% were identified as being at risk of overweight, 3.3% were overweight, and 1.2% were obese. Among children older than 5 years, 3% were thin or severely thin, 81% had a normal weight, 10.75% were overweight, and 5.25% were obese. A higher prevalence of obesity was observed in the older age group, with 2.0% of boys and 3.25% of girls classified as obese. In contrast, the prevalence among children under 5 years of age was considerably lower, both for boys and girls at 0.6%.

Table 1. Distribution of children in age, sex and weight status
Tablica 1. Raspodjela djece prema dobi, spolu i statusu uhranjenosti

		Severely thin and Thin	Normal weight	Possible risk of overweight	Overweight	Obesity
<5 years	Total (n=332)	–	266	51	11	4
	%	–	*80.1*	*15.4*	*3.3*	*1.2*
	Boys (n=180)	–	145	25	8	2
	%	–	*80.6*	*13.9*	*4.4*	*1.1*
	Girls (n=152)	–	121	26	3	2
	%	–	*79.6*	*17.1*	*2.0*	*1.3*
>5 years	Total (n=400)	12	324	–	43	21
	%	*3.0*	*81.0*	–	*10.8*	*5.3*
	Boys (n=204)	5	169	–	22	8
	%	*2.5*	*82.8*	–	*10.8*	*3.9*
	Girls (n=196)	7	155	–	21	13
	%	*3.6*	*79.1*	–	*10.7*	*6.6*

Table 2. Average values (±Standard deviation) and ANOVA results in motor skill and proficiency tests in children below 5 years of age in different weight (BMI) categories
Tablica 2. Prosječne vrijednosti (±standardna devijacija) i rezultati analize varijance u testovima motoričkih vještina i sposobnosti djece mlađe od 5 godina različitog statusa uhranjenosti

	LOK	MAN	TGMD-2	BOT-2**
Normal weight	9.88±2.42	8.34±2.18	94.86±11.75	50,91±8,82
Possible risk of overweight	9.31±2.32	7.84±2.18	91.47±11.76	47,47±7,70
Overweight	9.55±2.5	8.55±1.75	94.27±11.18	54,40±5,41
Obesity	9.75±2.99	7.5±3.00	91.75±16.86	40,20±9,23*
F test; p value	F=0.83; p=0.98	F=0.98; p=0.40	F=1.24; p=0.30	F=4.24; p<0.01

** p<0.01 significant difference between groups

* p<0.05 significantly different from overweight group values

Table 3. Average values (±standard deviation) and ANOVA results in motor skill and proficiency tests in children over 5 years of age in different weight (BMI) categories
Tablica 3. Prosječne vrijednosti (±standardna devijacija) i rezultati analize varijance u testovima motoričkih vještina i sposobnosti djece starije od 5 godina različitog statusa uhranjenosti

	LOK	MAN	TGMD-2	BOT-2**
Severely thin and Thin	10.17±1.40	7.33±1.61	92.50±6.83	49.82±8.95
Normal weight	9.77±2.20	7.82±2.26	92.74±11.40	49.11±8.24
Overweight	9.77±2.48	7.84±2.14	92.81±12.00	48.04±9.94
Obesity	10.05±2.18	8.95±1.96	97.00±9.20	42.68±6.88*
F test; p value	F=0.23; p=0.88	F=1.95; p=0.12	F=0,95; p=0.42	F=5.72; p<0.01

** p<0.01 significant difference between groups

* p<0.05 significantly different from normal weight group values

Univariate analysis of variance (ANOVA) showed no significant differences between children below 5 years of age in the four weight status groups in motor quotient values (TGMD-2), standard locomotor score (LOK), and object-control score (MAN) (Table 2). However, significant differences were found in BOT-2 scores between children of different weight categories ($F = 4.24$; $p < 0.01$). Children in the obese category had the lowest BOT-2 motor proficiency scores (40.20 ± 9.23), which were significantly different from those of the overweight group ($p < 0.05$) (Table 2).

In children older than 5 years, no significant differences were found between the mean values of different weight status groups in motor quotient values (TGMD-2), standard locomotor score (LOK), and object-control score (MAN) (Table 3). However, a significant main effect between groups was found in BOT-2 scores ($F = 5.72$; $p < 0.01$). Post-hoc tests showed a significant difference between the normal weight and obese categories ($p < 0.05$).

DISCUSSION

The main results of this study show that overweight and obese preschool children in both age categories (<5 years and >5 years) do not significantly differ from their normal-weight peers in gross motor skill quotient, locomotor and object-control skills, as assessed by the Test of Gross Motor Development. However, significant differences between weight groups in both age categories were observed in tasks measured by the Bruininks–Oseretsky Test of Motor Proficiency. These findings highlight the importance of distinguishing potential motor limitations of obese children across different types of movements. The TGMD-2 is a process-oriented test that focuses on how a movement is performed, evaluating the quality and technique of fundamental motor patterns using specific performance criteria.[44] In contrast, the BOT-2 is a product-oriented assessment that measures the outcome of motor actions and requires higher levels of strength and endurance, such as in tasks like hopping, sit-ups, or push-ups.[6] Although some tasks overlap between the two assessment tools, the difference is particularly evident in the duration of the task, which increases the physical demands in the BOT-2. For example, in the TGMD-2, hopping is performed three times on each leg and evaluated according to several criteria, whereas in the BOT-2, hopping is performed for a longer duration—15 seconds—during which the maximum number of hops is recorded as the final score. Our results suggest that fundamental motor patterns are preserved in obese children, while more physically demanding tasks may reveal early functional limitations associated with excess body weight.

Previous studies have employed a variety of process- and product-oriented tests, including the TGMD-2 and BOT-2, as well as other tools such as the *Move it Groove it* process-oriented checklist or the *Körperkoordinationstest für Kinder* (KTK), in samples of children ranging from preschool to school age (see review by Trecroci and associates[43]). In studies that used the TGMD-2 to assess motor skills in preschool children, inconsistent results have been reported regarding differences between obese and normal-weight children; some studies found poorer performance among obese children[24, 34], while others found no significant differences.[25, 30] In contrast, studies employing product-oriented assessments have shown more consistent results, indicating that obese children demonstrate lower motor proficiency than their normal-weight peers.[9, 28, 2]

Previous research has also employed different statistical approaches, such as ANOVA, correlation, and regression analyses, which may account for inconsistencies in the interpretation of findings. In a recent pooled cross-sectional analysis of data from eight countries, Martins and associates[31] applied regression techniques that enabled the detection of associations at different percentiles of BMI, thereby capturing gradients that may not be visible when comparing group means. They concluded that negative associations exist between locomotor skills, ball skills, and overall motor competence with BMI percentiles, and that these associations become stronger at the higher end of the BMI distribution (97th percentile). In our study, ANOVA was an appropriate choice given the relatively small proportion of overweight and obese children in our sample, and it provided a valid and interpretable method for examining meaningful differences between groups. This distinction in analytical approach may help explain why our results showed no significant differences in TGMD-2 outcomes between weight groups, yet revealed clear disparities in the more physically demanding BOT-2 tasks. Taken together, our findings suggest that the detection of weight-related differences in motor competence depends on the specific demands of the assessment tool and the physical demands of the task performed.

Our study reported an obesity prevalence of 1.2% in children under 5 years of age and 5.25% in children over 5 years. These results are consistent with population-based data from Croatia, where a large-scale study involving 146,857 children aged 24 to 98 months documented an average obesity prevalence of 1.9% among 2- to 5-year-olds, and prevalence rates ranging from 2.74% to 4.77% within the 5- to 8-year age group.[23] Globally, the prevalence of obesity among children aged 5 to 14 years has been estimated at 6.9%, with Europe exhibiting a slightly higher prevalence of 7.6%.[15] Reported prevalence rates of overweight and obesity in children under 5 years vary widely across WHO member countries, ranging from 1% to 28.6%.[22] However, data on children under 5 years remain limited, as only 66% of WHO member states have published literature on this age group. Notably, in recent multi-country research examining the association between motor competence and weight status in 5,545 preschoolers aged 3–5 years, Martins and associates[31] reported substantially higher obesity prevalence (9.1 – 13.9%) than observed in our sample.

When comparing average results in motor skill and proficiency tests of children in our study to normative data, results across all weight categories in locomotor and overall motor skills fall within the average category (locomotor score 8–12; gross motor quotient 90–110), and below average for object-control skills (score 6–7).[44] Although most results across all weight categories fall within the average range for locomotor and gross motor skills, below-average scores in object-control skills may reflect broader challenges in early motor development. Skills such as throwing and catching often require guided instruction, regular practice, and access to appropriate sports equipment. In our sample, this may reflect limited exposure to object-control activities during early childhood, regardless of the child's weight. These findings may be influenced by cultural and regional factors, including the structure of the early childhood education system and the sports values prioritized in our society. Early development of object-control skills appears to be particularly important, potentially even more so than locomotor skills, for its long-term influence on both the type and total amount of physical activity in adolescence.[3] In our study, overweight children obtained numerically higher scores in object control skills compared to other weight categories, although these differences were not statistically significant. Similar findings were reported in a previous study, which suggested a potential preference for, and outperformance of, children with excessive weight in manipulation tasks and activities compared to locomotor tasks that are more weight-dependent.[24]

In motor proficiency (BOT-2), all weight groups scored within the average range, except for obese children under 5 years of age, who were classified in the below-average category.[6] When considered alongside the finding that the incidence of obesity is three times higher in children over 5 years compared to those under 5, this highlights the importance of early identification of potential deficits in strength- and endurance-related skills. Previous research has shown that obese children typically demonstrate lower relative knee extensor strength, reduced explosive leg power, and greater difficulties with weight-bearing movements such as hopping or bending the knees.[10] Our results therefore point to the need for targeted support within early childhood education settings, particularly in activities that develop strength, endurance, and weight-bearing capacity.

This study has some limitations. First, the results are based on a population-based sample in which BMI, calculated from weight and height, was used as the primary indicator of nutritional status. Although BMI is a widely used and robust method, previous research suggests that it may not be the most accurate measure for detecting adiposity, obesity risk, or related movement limitations.[20] In a study by Henrique and associates[20], motor competence in preschool children was not associated with their BMI, but it was related to another measure of central adiposity, the waist-to-height ratio, which the authors suggest is a more sensitive measure than BMI.[20] Moreover, different studies use varying classification systems for defining obesity, such as the CDC growth charts, whereas we applied the WHO criteria. Another limitation is that the incidence of obesity in our sample of children under and over 5 years of age was lower than in other countries and previous studies, as discussed earlier; therefore, analyses by specific age and sex were not conducted.

The strength of this study lies in the use of two different testing protocols, which enabled more specific conclusions about the types of movement limitations obese children may face. Nevertheless, our findings from a national sample may reflect particularities of the early care and education system or sport practices in Croatia, rather than a universal relationship, and may suggest that the movement repertoire of obese children is somewhat restricted. These results underscore the need to design early education and sport programs that support children of all body weights in developing strength, endurance, and overall motor competence.

CONCLUSION

This study indicates that fundamental motor patterns are preserved in overweight and obese preschool children, while potential limitations emerge in more physically demanding strength- and endurance-related tasks. These results highlight the need for early, targeted interventions in educational and sports programs to support motor competence and strength development across all weight groups.

Acknowledgements

This study is part of the research project *Motor Skills in Preschool Children* (UIP-2014-09-5428), funded by the Croatian Science Foundation.

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