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The Influence of Weight Status on Motor Abilities of Prepubertal Children

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Abstract

The aim of this study was to examine the influence of weight status on motor abilities in 9- and 10-year-old children from the city of Šabac, Serbia. The sample consisted of 184 primary school students (107 boys and 77 girls) from the third and fourth grades who participated in the "Sport in Schools – Grow Healthy" project during the 2022/2023 school year. Body mass index (BMI) values were used to categorize children according to the Centers for Disease Control and Prevention (CDC). Motor abilities were assessed using the following tests: standing long jump, 4×10 m shuttle run, sit-ups for 30 seconds, sit-and-reach, and handgrip strength dynamometry. The results indicated that the majority of participants were classified as having normal weight (66.3%), while 20.7% were overweight and 13.0% obese. In boys, significant differences among BMI categories were observed in the standing long jump (F=16.92, p=0.00), 4×10 m shuttle run (F=19.92, p=0.00), sit-ups (F=4.91, p=0.01), and relative handgrip strength (F=23.19, p=0.00). Post-hoc analysis showed that boys with normal weight achieved significantly better results compared to overweight and obese peers, while no significant differences were observed in the sit-and-reach test (F=1.42, p=0.25).In girls, statistically significant differences were found in the standing long jump (F=6.79, p=0.00), 4×10 m shuttle run (F=4.95, p=0.01), sit-ups (F=3.67, p=0.03), and relative handgrip strength (F=8.30, p=0.00). Post-hoc analysis indicated that girls classified as obese generally performed worse compared to girls with normal body weight, particularly in tests assessing explosive strength, speed, and relative muscular strength. Similar to boys, no significant differences were observed in the sit-and-reach test (F=0.08, p=0.93).These findings confirm the inverse relationship between increased body mass index and motor abilities in early school-aged children.

Keywords: *obesity, body mass index, prepubertal age*

Introduction

Findings from previous research indicate an increasing trend of overweight and obesity among children aged 5–19 years between 1990 and 2022 (NCD Risk Factor Collaboration, 2024). In the period from 2022 to 2024, it was estimated that 25% of children aged 7–9 years were overweight (including obesity), while 10% of children in this age group were classified as obese. In most countries included in this study, obesity prevalence was higher among boys than girls (World Health Organization, 2024). Previous studies in Serbia have also indicated high prevalence rates of overweight and obesity, reaching up to 39% (Ostojić et al., 2011). Similarly, prevalence rates were reported at 33.83% in an Iranian study (Keykhaei et al., 2016), approximately 27% in an Italian study (Ceschia et al., 2015), and 40.1% in a Spanish study (Fernández-Vázquez et al., 2025). The upward trend in overweight among preschool-aged children has been observed consistently across most regions of the world over the past two decades (Muyulema, 2025). High prevalence was also reported in Iranian preschool children (17.30%) according to CDC criteria (Agha-Alinejad et al., 2015), as well as in Serbian preschool children from the city of Vranje (Nikolić et al., 2024).

Childhood obesity can significantly affect physical health, social and emotional well-being, and self-esteem (Sahoo et al., 2015). Overweight children tend to report lower self-perception of physical competence compared to their normal-weight peers (Jones et al., 2010; Poulsen et al., 2011). Childhood obesity has been associated with the development of depression (González-Toche et al., 2017) and chronic conditions such as hypertension, diabetes, atherosclerosis, coro-

nary heart disease, and liver disease (Barton, 2012).

Compared to children from earlier generations, current cohorts show a clear upward trend in body mass index (Monacis et al., 2023). Overweight and obesity rates remain high across Europe (Spinelli et al., 2021), with a growing trend also reported in Serbia (Djordjic et al., 2016; Marković et al., 2021), neighboring countries (Ljuboljević et al., 2024), Montenegro (Martinović et al., 2015), Algeria (Zerguine et al., 2025), and Kuwait (Al-Taiar et al., 2021).

As a practical and relevant indicator of childhood obesity, body mass index (BMI) is considered a useful tool, especially when interpreted against national and international reference values (Christoforidis et al., 2011). Previous studies suggest that obesity is a significant factor contributing to reduced motor efficiency in school-aged children (Parfeneva & Sonkin, 2023).

There is evidence supporting an inverse association between body mass and motor competence: children with higher body weight are at greater risk of insufficient motor development (Möller et al., 2021), while normal-weight children demonstrate superior motor competence and coordination (Batez et al., 2019; Graf et al., 2004) compared to their overweight and obese peers (Casonatto et al., 2016; Cruz et al., 2014; D'Hondt et al., 2009; Dumith et al., 2010; Gjonbalaj et al., 2022; Marmeleira et al., 2017; Mijalković et al., 2024; Monacis et al., 2024; Šekeljić et al., 2019). Nevertheless, obese children have been shown to achieve better upper-body strength (Fiori et al., 2020) and, in some cases, better performance in strength-related tests such as handgrip strength (Gulías-González et al., 2014).

Previous research studies have predominantly used IOTF and WHO normative tables for BMI classification (Đokić & Međedović, 2013; Milanović et al., 2019; Šekeljić et al., 2018). Although the use of CDC standards has been observed in studies involving preschool children in Serbia (Nikolić et al., 2024; Pelemiš et al., 2020), as far we know, no previous study applied these normative standards to children attending primary school grades. This indicates a certain methodological gap in national research and, at the same time, highlights the potential of the present study to contribute to better international comparability of results with studies that use the same or similar reference values.In line with this evidence, the aim of the present study was to examine the relationship between body mass index (BMI), as an indicator of weight status, and motor abilities in prepubertal children.

Methods

Participants and procedure

A cross-sectional study was conducted on a sample of 184 primary school students from the third and fourth grades (9- and 10-year-old children) in the City of Šabac, who participated in the "Sport in Schools – Grow Healthy" project during the 2022/2023 school year. All participants had obtained informed consent for participation in the anthropometric and motor testing procedures. All measurements and treatments were performed in accordance with the ethical standards laid down in the Declaration of Helsinki.

Participants were categorized according to weight status into one of three groups based on percentile charts from the Centers for Disease Control and Prevention (CDC, 2000). According to percentile values, participants were classified into three groups: normal weight (5th≤BMI<85th percentile), overweight (85th≤BMI<95th percentile), and obesity (BMI≥95th percentile).

The number of participants with BMI values below the 5th percentile was very small and therefore excluded from further statistical analysis, meaning the impact of underweight on motor abilities cannot be reliably assessed in this sample. Due to the small number of participants classified in the severe obesity category (BMI ≥ 120th percentile), these children were combined with the obesity category (BMI ≥ 95th percentile). Therefore, all participants with BMI values above the 95th percentile were grouped into a single obesity category and analyzed as such in the subsequent statistical analyses.

Measurements

Testing was performed by trained evaluators, physical education and sport teachers. The following tests were conducted: body height measurement, body mass measurement, standing long jump, 4×10 m shuttle run, handgrip dynamometry, sit-ups for 30 seconds, and sit-and-reach. A detailed description of the testing procedures and protocols is provided in the National Battery manual (Milanović et al., 2016).

Body height - Height was measured using a SECA 213 stadiometer (SECA, Hamburg, Germany). During measurement, the participant stood barefoot on the base of the stadiometer. The evaluator stood on the left side of the participant and ensured the stadiometer was positioned vertically along the spine, then lowered the sliding headpiece to the top of the participant's head. The result was recorded with an accuracy of 0.1 cm.

Body mass- Body mass was measured using a digital body composition scale OMRON BF511 (OMRON, Kyoto, Japan). The participant was minimally clothed, stood on the scale on a flat surface in an upright position until the body completely stabilized on the scale. The result was recorded with an accuracy of 0.1 kg.

Standing long jump -The participant's task is to perform a standing long jump using a two-foot take-off and jump as far as possible. The result, expressed in centimeters, is recorded as the distance from the take-off line to the point where the heels first contact the surface, or to any other mark closest to the take-off line.

4x10m shuttle - This test was used to evaluate participants' agility and speed of change of direction. The equipment required for the test included two sponges, a stopwatch, and a marked 10-meter running course. From a standing start position, the participant, upon a signal, runs as fast as possible between two parallel lines set 10 meters apart while transferring two sponges, one at a time, from the far line to the starting line. The test is completed after four 10-meter shuttle runs have been performed, covering a total distance of 40 meters.

Handgrip dynamometry - The participant's task is to squeeze the handgrip dynamometer with maximal force. During testing, the arm and hand holding the dynamometer

must not touch the body, and the device should be held in line with the forearm alongside the body. The best result from two trials (recorded separately for the right and left hand) was used for evaluation. The score was expressed in kilograms, with an accuracy of 0.1 kg (Gajević, 2009). Hand grip strength was assessed using a digital hand dynamometer (KERN MAP 80K1S, KERN & Sohn GmbH, Germany).

Sit-ups - was used to assess the repetitive strength and endurance of the trunk muscles. From a supine position, with the hands placed behind the head and the knees flexed at 90°, while the feet were stabilized by the examiner, participants performed the maximum number of sit-ups possible within 30 seconds. The test was administered once, and the score was recorded as the total number of correctly completed repetitions during the specified time period.

Sit and reach - was used to assess the flexibility of the lower back and hamstring muscles. The equipment required for this test consisted of a wooden box (45 × 35 × 32 cm) fitted with a sliding ruler mounted on a measuring scale, which the participant pushed forward with the hands. The participant assumed a seated position in front of the box, with the legs fully extended and the feet placed against the front side of the box. The examiner knelt beside the participant and applied pressure to the knees to prevent them from bending during the test. The participant's task was to reach forward as far as possible with the arms fully extended, without bending the knees, while smoothly pushing the sliding ruler forward. The result was recorded as the farthest position reached with the fingertips without any bouncing movement. Each participant was allowed two attempts, and the better result, expressed in centimeters, was recorded.

Statistics

For all motor tests, basic descriptive statistics were presented – mean and standard deviation. Normality was assessed using the Shapiro–Wilk test. Differences in motor abilities among groups of different weight status were analyzed using one-way analysis of variance (ANOVA) with Bonferroni post-hoc test. The significance level was set at $p \leq 0.05$. Data were processed using SPSS software (v19.0, SPSS Inc., Chicago, IL, USA).

Results

Table 1 presents the distribution of participants by sex andweight status. The largest proportion of participants belonged to the normal weight category (66.3%), with a slightly higher percentage among girls (71.4%) compared to boys (62.6%). Overweight was identified in 20.7% of the participants, with no significant difference observed between boys (20.6%) and girls (20.8%). Obesity was present in 13.0% of the sample, with a higher prevalence among boys (16.8%) compared to girls (7.8%). The number of participants with values below the 5th percentile was very small; therefore, due to insufficient representation, this category was not included in the subsequent statistical analysis.

Table 1. Weight status categories by gender in children aged 9 and 10 years

Group	Male (N=107)	Female (N=77)	Total (N=184)
Normal weight	67 (62.6%)	55 (71.4%)	122 (66.3%)
Overweight	22 (20.6%)	16 (20.8%)	38 (20.7%)
Obesity	18 (16.8%)	6 (7.8%)	24 (13.0%)

Observing the results of the one-way analysis of variance (Table 2), it is noticeable that for most analyzed variables, there are significant differences between participants belonging to different weightstatus categories. Statistically significant differences were observed in most of the assessed motor abilities among third- and fourth-grade boys according to BMI categories. Boys with BMI between the 5th and 85th percentile achieved significantly better results in the standing long jump (F=16.92; p=0.00), 4 × 10 m shuttle run (F=19.92; p=0.00), sit-ups (F=4.91; p=0.01), and relative handgrip strength (F=23.19; p=0.00) compared to boys classified as overweight or obese. Bonferroni post-hoc analysis indicated that the differences were primarily observed between the normal-weight group and the other two groups, whereas no statistically significant differences were found between overweight and obese boys in most tests. In contrast, no significant differences were identified in the sit-and-reach test (F=1.42; p=0.25). These findings suggest that elevated BMI in early school-aged boys is associated with poorer performance in tests of explosive strength, speed, agility, and relative muscular strength, while flexibility does not appear to be significantly related to weight status.

Table 2. Descriptive statistics and differences between groups of male students according to weight status in motor abilities

Test	5th≤BMI<85th (A)	85th≤BMI<95th (B)	BMI≥95th (C)	F	p	A/B	A/C	B/C
Standing long jump (cm)	144.10±17.40	126.59±20.09	120.11±17.04	16.92	0.00*	0.00*	0.00*	0.77
Sit-and-reach (cm)	15.43±6.06	12.86±6.14	15.22±7.19	1.42	0.25	0.29	1.00	0.72

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Table 2. Descriptive statistics and differences between groups of male students according to weight status in motor abilities

Test	5th≤BMI<85th (A)	85th≤BMI<95th (B)	BMI≥95th (C)	F	p	A/B	A/C	B/C
Shuttle run 4×10 m (s)	12.48±0.90	13.72±1.45	13.89±0.97	19.92	0.00*	0.00*	0.00*	1.00
Sit-ups (n)	20.64±4.10	17.73±5.34	18.22±3.75	4.91	0.01*	0.02*	0.11	1.00
Relative handgrip strength total (kg)	0.95±0.19	0.78±0.15	0.66±0.11	23.19	0.00*	0.00*	0.00*	0.09
Relative handgrip strength right hand (kg)	0.48±0.10	0.41±0.08	0.34±0.06	18.09	0.00*	0.01*	0.00*	0.08
Relative handgrip strength left hand (kg)	0.46±0.10	0.37±0.08	0.33±0.08	16.79	0.00*	0.00*	0.00*	0.75

Legend: F-value for the F test, p – value for the level of significance, * – p<0.05 (statistically significant).

For girls of the same age (third- and fourth-grade), the results show a slightly different pattern in relation to BMI categories. Statistically significant differences were observed in several motor ability tests, particularly those assessing strength, speed, and agility. Girls with BMI between the 5th and 85th percentile generally performed better in the standing long jump (p=0.01), 4 × 10 m shuttle run (p=0.01), and relative handgrip strength (p=0.00) compared to girls classified as obese (BMI ≥95th percentile). In post hoc analyses, significant differences were primarily found between the normal-weight and obese groups, while differences between normal-weight and overweight girls (85th≤BMI<95th) were generally not statistically significant. No significant differences were detected in the sit-and-reach test (F=0.08; p=0.93), indicating that flexibility was not influenced by BMI category. Similarly to boys, these results suggest that elevated BMI in early school-aged girls is associated with poorer performance in tests of explosive strength, speed, and relative muscular strength, whereas flexibility appears unaffected by weight status.

Table 3. Descriptive statistics and differences between different groups of female students according to weight status in motor skills

Test	5th≤BMI<85th (A)	85th≤BMI<95th (B)	BMI≥95th (C)	F	p	A/B	A/C	B/C
Standing long jump (cm)	133.87±19.43	133.25±21.10	103.00±16.91	6.79	0.00*	1.00	0.00*	0.01*
Sit-and-reach (cm)	19.51±6.84	20.19±7.02	20.17±4.75	0.08	0.93	1.00	1.00	1.00
Shuttle run 4×10 m (s)	13.21±1.23	13.09±0.87	14.73±1.16	4.95	0.01*	1.00	0.01*	0.01*
Sit-ups (n)	19.30±4.57	20.88±3.61	15.33±2.58	3.67	0.03*	0.59	0.10	0.03*
Relative handgrip strength total (kg)	0.89±0.16	0.81±0.12	0.65±0.05	8.30	0.00*	0.16	0.00*	0.08
Relative handgrip strength right hand (kg)	0.45±0.09	0.43±0.06	0.33±0.05	5.10	0.01*	0.97	0.01*	0.08
Relative handgrip strength left hand (kg)	0.43±0.09	0.39±0.08	0.32±0.04	4.93	0.01*	0.56	0.01*	0.12

Legend: F-value for the F test, p – value for the level of significance, * – p<0.05 (statistically significant).

Discussion

Documenting the findings of this study, it is evident that the highest percentage of tested participants belongs to the normal-weight category, which is encouraging compared to previous research in Serbia indicating higher rates of overweight and obesity. Participants with normal weight status achieved better results in most of the analyzed motor tests, whereas obese children, regardless of sex, demonstrated poorer performance, particularly in tasks assessing agility, speed, and explosive strength. Overall, the obtained results unequivocally indicate a proportional association between excess body weight and motor performance, highlighting the necessity of maintaining a healthy weight status for optimal motor development in prepubertal children.

Children with higher BMI values performed worse in tests requiring agility, speed, andexplosive strength, particularly in tests such as the 4×10 m shuttle run and standing long jump. These findings are consistent with studies by Graf et al. (2004) and D'Hondt et al. (2009), which indicate impaired movement and reduced coordination in obese children. This may be explained by the fact that excess body fat represents

additional non-functional mass that must be moved during locomotor tasks, increasing energy expenditure and reducing movement efficiency. Moreover, lower relative strength (strength in relation to body mass) may negatively affect performance in activities requiring rapid acceleration and force production. It is noteworthy that children with normal body weight achieved the best results in most motor tests, in line with previous research (Cruz et al., 2014; Marmeleira et al., 2017; Mijalković et al., 2024).

Boys achieved better results in most tests compared to girls, who performed better in the flexibility test (De Miguel-Etayo et al., 2014; Dobosza et al., 2015). Conversely, flexibility (sit-and-reach test) did not show consistent statistically significant differences between groups, suggesting that flexibility may not be influenced by increased BMI as other motor abilities are. In girls, flexibility was not significantly correlated with BMI, consistent with other studies (Ceschia et al., 2016; Tokmakidis et al., 2006). This indicates that, unlike strength and speed, flexibility is less dependent on body weight and more influenced by biological and environmental factors, including sex and participation in specific types of physical activities. Previous evidence has consistently shown that girls exhibit greater flexibility than boys throughout childhood and adolescence (Nuzzo, 2026), while participation in activities such as rhythmic gymnastics and dance is associated with superior flexibility and coordination performance (Popović et al., 2017). Sex-related differences in flexibility may be partially explained by anatomical and hormonal factors. Greater joint laxity, differences in connective tissue properties, and earlier maturation in girls may contribute to superior flexibility performance compared with boys.

Agility test results confirm the negative impact of obesity on motor efficiency. Our findings align with other studies, highlighting that obese children experience greater difficulties in tasks involving speed and coordination (D'Hondt et al., 2009; Parfeneva & Sonkin, 2023). Excess body mass increases inertia and mechanical load during changes of direction, making agile movements more demanding and less efficient. Boys performed better than girls in this test, indicating higher motor efficiency in favor of boys (Dobosz et al., 2015; Ortega et al., 2008).

The results of the sit-up test indicate that children with higher BMI, particularly those classified as obese, performed worse compared to their normal-weight peers, reflecting reduced functional strength and endurance of the abdominal muscles (Marmeleira et al., 2017; Mijalković et al., 2024). Among girls, obese participants achieved significantly lower scores than their normal-weight counterparts ($p=0.03$), while in boys, poorer performance was observed in those with both overweight and obesity. These findings confirm the negative impact of excess body weight on abdominal strength and highlight the role of individual factors such as muscle mass and coordination.

The standing long jump test, measuring explosive lower limb strength, showed the most pronounced differences between groups. Children with obesity achieved the lowest results. This aligns with previous studies indicating that excess body weight imposes a burden during motor tasks (Batez et al., 2019; Monacis et al., 2023). Excess adipose tissue increases the mass that must be propelled forward during the jump without contributing to force production. Consequently, children with obesity may exhibit lower relative power output and reduced movement efficiency, resulting in shorter jump distances.

In contrast, in handgrip strength tests, students with higher body mass showed greater absolute strength, but when expressed relative to body weight (relative handgrip strength), the advantage shifted to normal-weight children. This is consistent with literature reporting that obese children have higher absolute but lower relative strength in relation to body mass (Fiori et al., 2020; Gulías-González et al., 2014).

Several limitations should be acknowledged. The sample was geographically limited to one region of Serbia, which may reduce the generalizability of the findings. Furthermore, factors that may substantially influence both body composition and motor performance, such as physical activity levels outside school, dietary habits, socioeconomic status, and family environment, were not assessed. Another limitation relates to the use of BMI as the sole indicator of weight status. Although BMI is widely used in epidemiological studies, it does not distinguish between fat mass and lean mass and may therefore provide an incomplete representation of body composition. Future studies should incorporate direct measures of body composition and examine the independent contributions of fat mass and muscle mass to motor performance. Longitudinal designs are also recommended to better understand causal relationships between changes in body composition and motor development throughout childhood and adolescence.

Conclusion

The present study demonstrated that weight status is associated with motor test performance in prepubertal children. Children with normal body weight generally achieved better results in tests assessing explosive strength, agility, speed, and relative muscular strength, whereas overweight and obese children showed lower performance, particularly in weight-bearing motor tasks. No significant differences according to BMI categories were observed in flexibility.

The findings have both practical and theoretical implications. From a practical perspective, the observed association between excess body weight and lower motor abilities highlights the importance of regular monitoring of weight status and motor development in school-aged children. Schools may serve as an important setting for promoting healthy lifestyle habits and encouraging participation in physical activity. Regular monitoring of body weight and motor development in younger school-aged children, with active involvement of parents, teachers, and healthcare professionals, is also recommended, with particular attention given to children with overweight and obesity, who demonstrated lower performance in several motor tests. From a theoretical perspective, the results support previous evidence indicating that weight status is associated with motor abilities during childhood and further emphasize the relationship between body composition and motor development.

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Conflicts of Interest
The authors declare no conflict of interest.

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