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A Longitudinal Analysis of Motor Performance Development in School-Aged Youth: A Composite Index Approach

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Abstract

Understanding the developmental dynamics of motor performance during adolescence is essential for evidence-based physical education and youth sport practice. The aim of this longitudinal study was to examine the development and determinants of motor performance across school-aged years. Fifty-one pupils underwent anthropometric assessment and completed five motor tests (sit-ups, standing broad jump, medicine ball throw, 50 m sprint, and Cooper test) in the 5th, 7th, and 9th grades. Exploratory factor analysis suggesting a predominantly unidimensional structure of motor performance, with all five tests loading strongly on a single factor (loadings ranging from |0.572| to |0.897|), which justified the creation of a composite motor performance index. In the developmental model without BMI, significant main effects of grade, gender, and sport participation were observed (all $p<0.001$), along with significant interaction effects, indicating differences in motor performance across school years and between subgroups. After including BMI as a covariate, most grade and group effects were attenuated, while BMI remained the only consistent predictor of motor performance ($p=0.024$). Model comparison demonstrated improved explanatory relevance when BMI was included. Motor performance develops across adolescence and differs according to gender and sport participation; however, BMI plays a central role in explaining these differences. Weight status should therefore be considered when interpreting developmental trajectories of motor performance in school-aged youth.

Keywords: *school-aged youth, physical development, fitness testing, performance index, factor, mixed-effects modeling*

Introduction

Motor performance is a key indicator of physical development, health, and functional capacity during childhood and adolescence (Barnett et al., 2022; Burton et al., 2023). Its development is influenced by biological maturation, weight status, physical activity, sport participation, and school-based movement experiences (Brusseau et al., 2018; Telford et al., 2016). During adolescence, rapid physical and psychosocial changes may contribute to substantial inter-individual variability in performance outcomes, which makes this developmental period particularly important for monitoring motor abilities in school settings (Barnett et al., 2022; Lima et al., 2019).

Previous research has shown that motor competence, physical fitness, physical activity, and weight status are closely interrelated in youth. Longitudinal evidence indicates that motor competence is associated with health-related fitness and weight status across childhood and adolescence, with reciprocal relationships observed between motor competence, body fatness, and aerobic fitness (Barnett et al., 2022; Lima et al., 2019). In addition, participation in organized sport has been associated with higher physical activity, better fitness, and healthier weight status during childhood and adolescence (Telford et al., 2016). These findings suggest that motor performance should be interpreted as a developmental outcome shaped by both biological and behavioral factors.

In school practice and research, motor performance is commonly assessed using field-based test batteries. These batteries often include tests of muscular endurance, explosive strength, throwing ability, sprint speed, and aerobic endurance. Such tests are practical for school environments and have been widely used in youth fitness assessment (Ruiz et al., 2011). However, individual tests are usually expressed in different units, such as repetitions, distance, time, or running performance. Moreover, higher values indicate better performance in some tests, whereas lower values indicate better performance in others. This makes direct comparison or simple summation of raw scores inappropriate. One possible solution is to standardize individual test scores using z-scores and, when supported by the structure of the data, combine them into a composite index (Andrade, 2021; Curtis, 2016).

A composite index may provide a more integrated representation of motor performance than separate test outcomes. This approach is particularly useful when several tests reflect a common underlying construct. Exploratory factor analysis (EFA) is commonly applied to examine whether multiple observed variables can be reduced to one or more latent dimensions (Fabrigar et al., 1999). In sport and physical fitness research, factor-analytic approaches have been used to identify the structure of performance-related variables and to support the interpretation of complex test batteries (Perroni et al., 2023; Smits-Engelsman et al., 2020). Therefore, when motor tests load on a common factor, the creation of a composite motor performance index may be justified.

Another important aspect in the interpretation of youth motor performance is body mass index (BMI), which is widely used as a simple indicator of weight status and has been associated with motor competence, physical fitness, and physical activity in children and adolescents (Lima et al., 2019; Morrison et al., 2018). Higher BMI has been linked to lower motor coordination and poorer performance in tasks requiring relative strength, speed, and endurance (Lopes et al., 2012). Recent studies have also shown that BMI and sport participation are related to physical fitness in school-aged children (Aniśko et al., 2025; Coe et al., 2024). Nevertheless, the extent to which BMI explains developmental and group-related differences in motor performance remains insufficiently explored in longitudinal school-based samples.

Longitudinal designs are particularly useful for understanding how motor performance changes across school years. Repeated measurements allow researchers to examine developmental trajectories rather than isolated differences between age groups. Previous youth fitness studies have successfully applied multilevel and mixed-model approaches to examine changes in physical fitness, motor competence, physical activity, and body composition over time (Brusseau et al., 2018; Lima et al., 2019; Telford et al., 2016; Wang et al., 2013). Such approaches are especially relevant when individual development is expected to vary between pupils.

Although previous studies have examined associations between motor performance, sport participation, and BMI, longitudinal evidence describing overall motor performance development during school-age using a composite index remains limited. This study was conducted to address this gap and provide a more comprehensive understanding of motor performance development.

The purpose of this study was to investigate the development of motor performance during school-age through a composite index approach and to examine the effects of gender, sports participation, and body mass index (BMI) on developmental trajectories. Particular attention was given to determining whether motor performance could be meaningfully represented by a composite index and whether differences across school grades, gender, and sports participation remained evident after accounting for BMI. It was hypothesized that motor performance would improve across school grades and differ according to gender and sports participation, with BMI partially explaining these differences.

Methods

Study design

This study was designed as a longitudinal investigation focusing on the development of motor performance in school-aged youth. Participants were selected using a purposive sampling approach to enable repeated assessment within a natural school setting. The study was conducted over a four-year period, from 2022 to 2026, in Trebišov, Slovakia, with repeated measurements performed in March 2022, February 2024, and February 2026. The sample included both boys and girls with varying levels of sport participation, allowing comparison between sport-participating and non-sport-participating individuals. All measurements were conducted during regular physical education classes under standardized conditions, with appropriate familiarization and warm-up procedures applied prior to testing.

Participants

A total of 67 pupils were initially enrolled in the study. During the four-year follow-up, 16 participants were excluded due to incomplete participation in one or more measurement sessions. Consequently, the final sample consisted of 51 pupils participated in the study, including 17 girls (7 sport-participating and 10 non-sport-participating) and 34 boys (17 sport-participating and 17 non-sport-participating). The same participants were assessed repeatedly in the 5th, 7th, and 9th grades, constituting a longitudinal study design. Participants' age ranged from approximately 11.5 years at baseline (5th grade), 13.5 years at the second assessment (7th grade), to 15.5 years at the final assessment (9th grade). Participants were categorized according to their level of organized sport participation. The study involved pupils recruited from three primary schools and three sports clubs (two football clubs and one volleyball club). Participants were classified as sport-participating if they were actively involved in organized sports training and regularly attended at least three training sessions per week throughout the study period. Sport participation status was verified in cooperation with the respective coaches at each assessment. Participants who did not participate in any organized sports training and attended only the two compulsory physical education lessons per week, delivered according to the national curriculum, were classified as non-sport-participating.

Table 1. Descriptive characteristics M (SD) of participants by grade, gender, and sport participation

Parameter	Grade			Gender		Sport participation	
	5	7	9	Female	Male	Yes	No
BW	42.03 (6.06)	47.82 (4.90)	57.80 (5.60)	48.69 (8.28)	49.49 (8.70)	47.59 (7.79)	50.67 (8.97)
BH	148.82 (6.50)	155.46 (6.70)	167.21 (5.91)	157.59 (9.16)	156.94 (10.31)	157.77 (10.36)	156.62 (9.54)
BMI	19.00 (2.63)	19.78 (1.50)	20.66 (1.48)	19.51 (2.39)	19.96 (1.85)	19.04 (1.92)	20.50 (1.92)

Note. BW = body weight, BH = body height, BMI = body mass index values are presented as mean (M) and standard deviation (SD).

All participants were healthy and free from acute musculoskeletal injuries at the time of testing. The measurements were originally conducted between 2022 and 2026 as part of the regular physical fitness assessment programme implemented during physical education classes in the participating schools. The study procedures and objectives related to the scientific analysis and publication of the anonymized dataset were subsequently explained to the participants' parents or legal guardians, and written informed consent was obtained prior to participation in accordance with the ethical principles of the Declaration of Helsinki and approved by the Ethics Committee of the Catholic University in Ružomberok (Approval Code: 01313/2026 RE, Approval Date: 05.05.2026).

Procedures

Anthropometric measurements were performed to assess the participants' basic body characteristics, including body height (cm) and body mass (kg). Body height was measured to the nearest 0.1 cm using a portable stadiometer (Seca 213, Seca GmbH & Co. KG, Hamburg, Germany), while body mass was measured to the nearest 0.1 kg using a calibrated digital scale (Seca 813, Seca GmbH & Co. KG, Hamburg, Germany). All measurements were conducted according to the standardized procedures of the International Society for the Advancement of Kinanthropometry (ISAK). Participants were measured barefoot and wearing light sports clothing, with body height recorded in an upright standing position (Frankfurt plane) and body mass assessed before the motor performance testing. Body mass index (BMI; $kg \cdot m^{-2}$) was subsequently calculated as body mass divided by the square of body height ($kg \cdot m^{-2}$) and used as an indicator of weight status in subsequent analyses (Stewart et al., 2011).

Motor performance was assessed using five standardized field-based tests commonly used in youth physical fitness evaluation. To minimize the effects of fatigue, testing was conducted over two consecutive days. On the first day, participants completed the standing broad jump, medicine ball throw, and sit-up tests. On the second day, they performed the 50 m sprint, followed by the Cooper 12-minute run, which was administered last due to its high physiological demands. Standardized recovery intervals (3–5 min between tests and 10–15 min before the Cooper test) were provided to minimize fatigue and ensure comparable testing conditions. All motor performance tests were managed according to standardized field-testing protocols commonly used in physical education and youth sports research. The testing took place in the school gymnasium and athletic field under standardized environmental and organizational conditions. Participants received verbal instructions and one familiarization trial before each test to ensure proper technique and reliability of measurement.

Standing broad jump: Lower-body power was assessed using the standing broad jump test. Participants stood with their feet shoulder-width apart behind a take-off line and were instructed to jump forward as far as possible using a two-foot take-off. Arm swing and countermovement were allowed. The distance from the take-off line to the nearest heel on landing was measured in centimeters. Two attempts were allowed, and the better result was recorded (Castro-Piñero et al., 2010).

Medicine ball throw (upper-body power): Upper body power was assessed using the 2 kg overhead medicine ball throw from a standing position. Participants stood upright with their feet placed shoulder-width apart behind a marked starting line. After receiving standardized instructions and performing a brief familiarization, each participant held the medicine ball with both hands in front of the chest. On the signal, they performed an explosive throw forward using an overhead motion, without taking a step. The throw was required to be executed with both feet remaining in contact with the ground throughout the movement (Van den Tillaar & Marques, 2013).

Sit-ups: Abdominal muscle endurance was assessed using the 60-second sit-up test. Participants lay in a supine position with knees bent at approximately 90°, feet flat on the floor, and hands crossed over the chest. A partner held the feet in place. On the signal, participants performed as many correct sit-ups as possible within 30?? seconds, touching their knees with their elbows on each repetition and returning the shoulders to the mat. The final score represented the total number of correctly executed repetitions (Bös, 2003).

50 m sprint: Running speed was assessed with a 50-meter sprint performed on a synthetic track. Participants started from a standing position behind the start line. Timing began at the starting signal and ended when the participant crossed the finish line. The sprint time was recorded in seconds using

handheld stopwatches, with one timer. The faster time of two trials was recorded (Kraemer & Fleck, 2005).

Cooper test: Cardiorespiratory endurance was measured using the 12-minute Cooper run test. Participants were instructed to cover as much distance as possible within 12 minutes by running or jogging on a standard 400 m track. The total distance covered was measured in meters and used as the final result. Pacing was self-selected. Standardized verbal encouragement was given during the test to motivate maximal effort (Cooper, 1968).

Data analysis

Descriptive statistics are reported as mean (standard deviation), minimum–maximum. The Shapiro–Wilk test was used to assess normality of the data. Anthropometric measurements were used to calculate body mass index (BMI) as body mass (kg) divided by height squared (m^2). Exploratory factor analysis (EFA) was applied to examine the underlying structure of motor performance across the five tests. Based on the factor structure, standardized z-scores were calculated for each test using the formula $z = (x - M) / SD$. These standardized scores were subsequently averaged to create a composite motor performance index, allowing comparison across variables measured in different units. To analyse developmental changes and the effects of grade, gender, sport participation, and BMI, linear mixed effects models with random intercepts for participants were applied. This approach accounted for the repeated-measures structure of the data and enabled the assessment of both within- and between-subject variability. The significance level was set at $p<0.05$. Statistical analyses were performed using MS Excel 2016 and JASP 0.16.4.0.

Results

Table 2 presents descriptive statistics M (SD) of motor performance tests across grade, gender, and sport participation. A clear developmental trend is evident, with performance improving from 5th to 9th grade in all tests, while sprint time (50 m) decreases. Boys tend to achieve higher scores than girls, particularly in strength- and power-related tests (SBJ, MBT, CT). In addition, sport-participating pupils consistently outperform their non-sport-participating peers across all tests.

Table 2. Descriptive statistics M (SD) of motor performance tests by grade, gender, and sport participation

Parameter	Grade			Gender		Sport participation	
	5	7	9	Female	Male	Yes	No
S-U	28.57 (5.28)	32.65 (6.87)	34.69 (8.33)	27.94 (4.13)	33.98 (7.78)	37.04 (6.63)	27.46 (4.45)
SBJ	143.61 (15.68)	161.82 (17.98)	172.88 (21.08)	154.57 (18.19)	161.87 (23.25)	171.71 (19.02)	148.53 (18.31)
MBT	375.39 (72.06)	466.37 (81.33)	586.96 (100.92)	437.26 (111.11)	495.74 (122.47)	483.89 (134.69)	469.44 (109.12)
50 m	9.85 (0.78)	8.87 (0.93)	8.28 (1.07)	9.14 (0.84)	8.93 (1.25)	8.25 (1.01)	9.66 (0.76)
CT	1640.75 (201.44)	2032.35 (413.50)	2226.47 (431.32)	1869.22 (343.15)	2015.18 (470.39)	2269.83 (429.89)	1696.91 (203.92)

Note. S-U = sit-ups; SBJ = standing broad jump; MBT = medicine ball throw; CT = Cooper test; values are presented as mean (M) and standard deviation (SD).

The figure 1 presents the results of the exploratory factor analysis, indicating a predominantly unidimensional structure of motor performance represented by a single latent factor. All motor tests show moderate to high loadings on this factor, suggesting that they capture a shared underlying construct of physical performance. The Cooper test (CT) and the 50 m sprint demonstrate the highest loadings, reflecting a strong contribution to the common factor. The remaining tests—standing broad jump (SBJ), medicine ball throw (MBT), and sit-ups (S-U)—also contribute meaningfully, although they may reflect more task-specific components such as technique and coordination. The values presented alongside each variable represent residual variances, indicating the proportion of variance not explained by the common factor. Overall, the results support the use of a single-factor solution; however, model fit indices should be interpreted with caution.

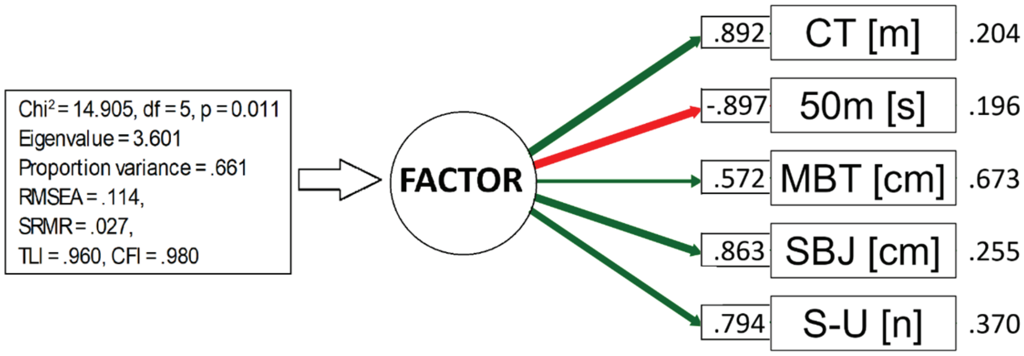

Figure 1. Exploratory factor analyses of observed parameters

Table 3 presents descriptive statistics of standardized motor performance (z-scores) across grade levels, gender, and sport participation. A clear developmental trend is evident, with motor performance improving across grades. This is accompanied by increased variability, indicating greater inter-individual differences with age. Boys tend to achieve higher performance levels than girls, particularly in strength- and power-related tests. Similarly, sport-participating pupils show consistently higher scores compared to their non-sport-participating peers. Overall, the distribution of scores suggests increasing differentiation in motor performance across adolescence.

Table 3. Descriptive statistics of standardized motor performance (z-scores) across grade, gender, and sport participation

Z-score	Grade			Gender		Sport participation	
	5	7	9	Female	Male	Yes	No
S-U	-0.463	0.092	0.370	-0.548	0.274	0.690	-0.614
SBJ	-0.723	0.109	0.614	-0.222	0.111	0.560	-0.498
MBT	-0.829	-0.081	0.910	-0.321	0.160	0.063	-0.056
50 m	-0.652	0.104	0.551	-0.104	0.054	0.577	-0.511
CT	-0.746	0.151	0.596	-0.223	0.111	0.695	-0.618
Composit index	-0.682	0.075	0.608	-0.284	0.142	0.517	-0.459

Note. Values represent standardized scores (z-scores). Positive values indicate above-average performance, and negative values indicate below-average performance relative to the overall sample. The “average” row represents the composite motor performance index. S-U = sit-ups; SBJ = standing broad jump; MBT = medicine ball throw; CT = Cooper test. For the 50 m sprint, scores were inverted prior to standardization so that higher values consistently represent better performance.

Table 4 summarizes the fixed effects estimates from the linear mixed-effects models. In the unadjusted model, grade and sport participation were significant predictors of motor performance. After including BMI, the effect of grade remained significant but was attenuated, whereas sport participation was no longer significant. BMI emerged as a significant negative predictor in the adjusted model.

Table 4. Fixed effects estimates from linear mixed-effects models with and without BMI

Effect	Model	B	SE	95% CI	p
Grade	without BMI	−0.637/0.077	0.023	[−0.68, −0.59]	<0.001
	with BMI	−0.673/0.143	0.325	[−1.31, −0.04]	0.040
Gender	without BMI	−0.188	0.032	[−0.25, −0.13]	<0.001
	with BMI	−0.366	0.295	[−0.94, 0.21]	0.216
Sport participation	without BMI	0.425	0.032	[0.36, 0.49]	<0.001
	with BMI	0.251	0.295	[−0.33, 0.83]	0.396
BMI	with BMI	−0.034	0.015	[−0.06, −0.01]	0.023

Note. B = unstandardized regression coefficient; SE = standard error; CI = confidence interval. Grade represents school grade level; sport participation distinguishes pupils engaged in organized sport activities from those not participating. BMI was included only in the adjusted model.

The figure 2 illustrates the differences in the significance of fixed effects between linear mixed-effects models before and after the inclusion of BMI. Bars represent chi-square (χ^2) values for individual fixed effects tested using likelihood ratio tests. Light bars indicate the model without BMI, and dark bars represent the model including BMI as a covariate. Significance levels are denoted as p<0.05, while n.s. indicates non-significant effects. The inclusion of BMI substantially reduced the significance of most predictors and interaction terms, with BMI emerging as the only significant effect in the adjusted model.

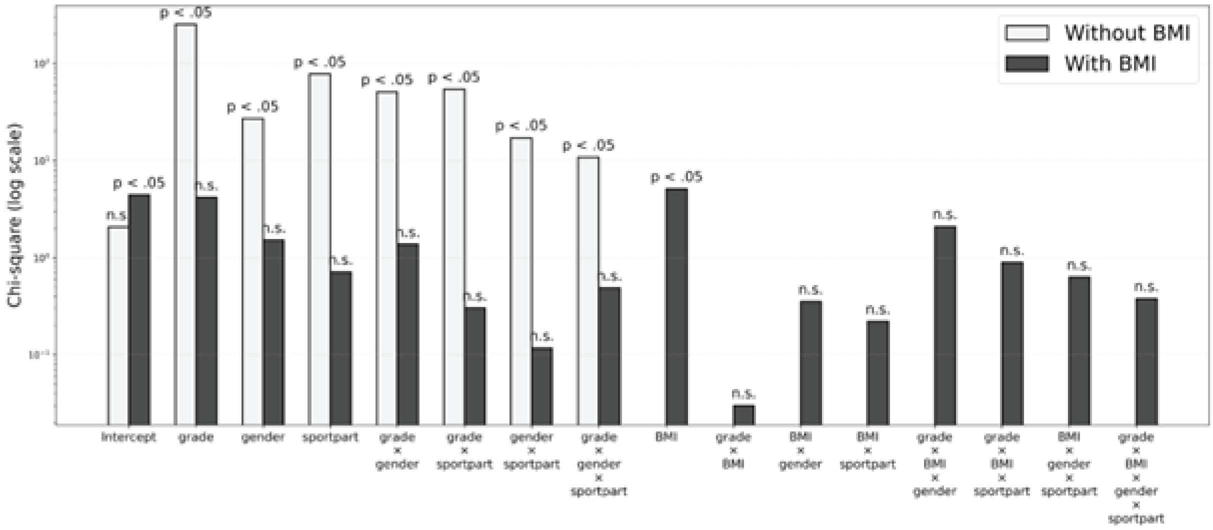

Figure 2. Comparison of fixed effects in linear mixed models without and with BMI

Discussion

The aim of this study was to examine the development and determinants of motor performance during adolescence, with particular emphasis on the role of gender, sport participation, and body mass index. The results revealed a clear developmental trend, with motor performance improving across grades, which is consistent with previous longitudinal findings documenting age-related increases in physical fitness and motor competence during adolescence (Brusseau et al., 2018; Wang et al., 2013). This improvement likely reflects both biological maturation and increased exposure to physical activity stimuli over time.

Building on this developmental perspective, the exploratory factor analysis supported a predominantly unidimensional structure of motor performance, indicating that the selected tests reflect a shared underlying construct. This finding aligns with previous research suggesting that different components of physical fitness may cluster into broader domains representing general motor competence (Perroni et al., 2023). At the same time, the presence of residual variances highlights that individual tests still capture task-specific abilities, which corresponds with methodological recommendations emphasizing careful interpretation of factor solutions (Fabrigar et al., 1999).

In order to capture this common dimension while preserving comparability across heterogeneous test measures, standardized z-scores were used to construct a composite motor performance index. This approach is supported by Andrade (2021), who emphasizes that standardization allows meaningful aggregation of outcomes measured in different units and scales. Importantly, similar approaches have been applied in previous research, where composite indices based on standardized scores were used to represent overall motor performance or fitness (Larsen et al., 2015). Likewise, the use of composite indices has been shown to strengthen the interpretation of relationships between motor competence and broader health-related fitness constructs, even when individual test correlations are modest (Stodden et al., 2013). However, existing evidence also indicates considerable heterogeneity in how motor competence is operationalized, with multiple assessment approaches and composite structures reported in the literature (Burton et al., 2023). This variability underscores both the utility and the methodological challenges associated with composite indices.

Consistent with existing literature, boys generally achieved higher performance levels than girls, particularly in strength- and power-oriented tests. These differences are commonly attributed to biological and hormonal factors, as well as differences in physical activity engagement (Morrison et al., 2018). Similarly, pupils participating in organized sports consistently outperformed their non-participating peers, supporting evidence that regular sport participation is associated with higher levels of physical activity, fitness, and motor competence (Aniśko et al., 2025; Telford et al., 2016). These findings are in line with broader models suggesting that motor competence, physical activity, and fitness are closely interrelated and tend to reinforce each other over time (den Uil et al., 2023).

However, extending beyond these descriptive patterns, a key finding of this study is the substantial role of weight status. After including BMI in the linear mixed-effects model, most previously significant effects of grade, gender, and sport participation were attenuated and no longer statistically significant. BMI emerged as the only significant predictor, suggesting that weight status may largely explain differences in motor performance between groups. This result is consistent with studies demonstrating negative associations between BMI and motor competence (Lopes et al., 2012) and highlighting the reciprocal relationship between motor competence, body fatness, and fitness over time (Barnett et al., 2022; Lima et al., 2019).

The importance of BMI is further supported by evidence showing that higher body mass is associated with lower physical activity and fitness levels (Coe et al., 2024), while interventions targeting physical activity can simultaneously improve motor skills and reduce BMI (Li et al., 2025). Although some studies report modest or inconsistent associations between physical activity and motor performance (Čech & Ružbarský, 2020), the present findings suggest that weight status may act as a mediating or confounding factor in these relationships. This interpretation is further supported by meta-analytic evidence indicating inverse associations between motor competence and weight status during adolescence (Burton et al., 2023).

Interestingly, while sport participation was associated with higher performance in descriptive analyses, its independent effect diminished after controlling for BMI. This suggests that the benefits of sport participation may be partly mediated through its influence on body composition and fitness rather than acting as a direct determinant. Similar patterns have been observed in longitudinal studies, where the relationship between motor performance and physical activity is influenced by underlying fitness characteristics (Larsen et al., 2015), as well as in conceptual models highlighting the dynamic and reciprocal nature of these relationships (Barnett et al., 2022; Coe et al., 2024).

These findings should, however, be interpreted with caution in light of the study sample characteristics. Although the longitudinal design with repeated measurements strengthened the ability to monitor developmental trajectories, the overall sample size was relatively modest for subgroup analyses. In particular, the unequal distribution of participants by sex and the small number of sport-participating girls may have reduced the statistical power to detect interaction effects and increased the likelihood of Type II error. Consequently, some non-significant findings, particularly in the mixed-effects models, may reflect limited statistical power rather than the true absence of group differences. Similar concerns regarding subgroup imbalance and statistical power have been highlighted in longitudinal pediatric studies, where repeated-measures designs partially compensate for smaller samples but do not eliminate the limitations associated with unequal group sizes (Fitzmaurice et al., 2011; Twisk, 2013). Therefore, the present findings should be considered exploratory and interpreted cautiously until confirmed in larger and more balanced cohorts.

Overall, the findings highlight that motor performance in adolescence is a multidimensional phenomenon influenced by developmental, behavioral, and biological factors. While age, gender, and sport participation contribute to performance differences, body composition appears to play a central role in shaping these relationships. At the same time, the use of a composite motor performance index provides a useful integrative perspective, although it may partially obscure task-specific variability. Taken together, these results suggest that interventions aimed at improving motor performance should not focus solely on increasing physical activity, but also consider strategies targeting healthy body composition and the broader interaction between motor competence, fitness, and growth-related factors.

Limitations of the study

This study has several limitations that should be considered. First, the sample size was relatively small and participants were selected from a single school using purposive sampling, which limits the generalizability of the findings. Although the longitudinal design strengthens the interpretation of developmental trends, the results may not fully reflect broader populations.

Another limitation concerns the classification of participants according to sport participation. Although participants were categorized based on their involvement in organized sports training throughout the study period, this classification may not have fully captured all forms of extracurricular physical activity. Consequently, some participants classified as non-sport-participating may still have engaged in informal or recreational physical activities that were not systematically monitored.

Second, biological maturation was not directly assessed. Given the dynamic changes during adolescence, differences in pubertal status may have influenced motor performance and contributed to inter-individual variability.

Third, weight status was assessed using BMI, which, although practical, does not distinguish between fat mass and fat-free mass. This may partly affect the interpretation of the strong effect of BMI observed in the models.

Another limitation relates to the use of a composite motor performance index based on standardized z-scores. While this approach allows integration of tests measured in different units and is supported by previous studies (e.g., Larsen et al., 2015; Stodden et al., 2013), there is no clear consensus on its construction. As highlighted in the literature (Burton et al., 2023), such aggregation may simplify the multidimensional nature of motor performance and partially obscure task-specific differences.

Finally, the use of linear mixed-effects models based on the composite index may introduce a degree of interpretational bias, as relationships between predictors and individual motor abilities cannot be examined separately.

Conclusions

Motor performance increases across adolescence and differs according to gender and sport participation. However, these differences are largely explained by weight status, as BMI emerged as the only significant predictor after adjustment. These findings indicate that BMI should be considered a key factor when evaluating and interpreting motor performance in youth populations.

At the same time, the results highlight that motor performance represents a complex and multifactorial construct influenced by developmental, behavioral, and biological factors. The use of a composite motor performance index proved to be a practical approach for capturing overall performance trends across heterogeneous tests, although it may partly mask task-specific differences.

From a practical perspective, these findings suggest that interventions aimed at improving motor performance in youth should not focus solely on increasing physical activity or sport participation, but should also consider strategies targeting healthy weight status. Future research should expand the sample size, include direct measures of biological maturation and body composition, and further explore both composite and individual performance indicators to better understand developmental trajectories.

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Conflicts of Interest
The authors declare no conflict of interest.

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