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RESEARCH NOTE

Motor Competence Prevalence in School-Aged Czech Children: A Cross-Sectional Study

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This study aimed to understand the motor competence (MC) level of Czech school-age children determined using the product-oriented Bruininks–Oseretsky Test of Motor Proficiency (second edition) and to analyze the gender and age differences. The MC level in $n = 637$ children aged 6.0–11.0 years (46.6% girls) was evaluated using total motor composite and subcategories of fine and gross motor skills: fine manual control, manual coordination, body coordination, and strength and agility. Seventy-one percent of children had at least a satisfactory level of MC. The distribution of the total motor composite score of the Czech sample was uneven, with only 11.0% scoring above average and 29.4% scoring below average. However, we found low-level of MC in almost one third of children. The prevalence of well-below average results was found at 7%. Significant differences were found depending on age ($p < .001$), where we observed decreased MC with increasing age. Gender differences were reflected in the poorer level of fine motor skills in boys ($p < .001$). Given the high prevalence of low MC, these findings suggest the need for effective intervention in Czech children as an important prerequisite for comprehensive development in physical, psychosocial, and cognitive aspects.

Keywords: psychomotor development, gross motor skills, fine motor skills, Bruininks–Oseretsky test

The term motor competence (MC) reflects an individual's degree of proficiency in a wide range of motor skills as well as the underlying mechanisms, including quality of movement, motor coordination, and motor control

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(Robinson et al., 2015; Utesch et al., 2019). The understanding and use of the term MC is inconsistent. Different perspectives on the construct of MC as an assessment of motor coordination, (fundamental) movement skills, motor (skill) proficiency/competence, gross motor coordination, psychomotor development, the concept of gross with/without fine motor skills, and so forth complicate the possibility of assessing the level of MC alone and then cross-culturally comparing results obtained by different methods.

Despite the inconsistent approach to the construct of MC, its role in health promotion is clear. The relevance of MC in the context of health promotion is assessed through several studies on the causal relationship of MC with physical activity (PA; e.g., Lima et al., 2017), physical fitness (e.g., Cattuzzo et al., 2016), perceived MC (e.g., De Meester et al., 2020), and body composition (e.g., Webster et al., 2021). Based on the results of the individual studies, significant overviews and conceptual models have been developed (Barnett et al., 2022; Robinson et al., 2015; Stodden et al., 2008).

With secular declines in PA (Eberhardt et al., 2020) and health-related fitness levels (Conger et al., 2022), low levels of MC (Bardid et al., 2015; Bolger et al., 2019; Šeflová, 2022) or selected categories of fundamental movement skills in children have been reported in many countries.

Low MC can have adverse effects on children's physical, cognitive, social, and emotional development, and health, and reduce overall quality of life (Libertus & Hauf, 2017). It may be associated with poorer academic performance (Macdonald et al., 2018), speech and language difficulties (Gonzalez et al., 2019), limited career opportunities, and an increased risk of mental health problems in adulthood (Gu et al., 2019). Children with low MC are less able to participate fully in many sports and recreational activities typically enjoyed by their well-coordinated peers (Hands, 2008). They may consequently prefer a less active lifestyle without PA to avoid the risk of failure. The worrying spiral from physically inactive children to physically inactive adults (Sallis et al., 2000) continues with the tendency to subsequently raise physically inactive children of one's own (Keyes & Wilson, 2021).

With these negative trends as correlates of exercise-deficit disorder (Stracciolini et al., 2013), there is a growing need to promote effective preventive measures. For an effective targeted intervention to improve the situation in health promotion prevention, the starting point is to determine the current state of MC. The choice of a particular method for measuring MC should be guided by the purpose of the measurement and the strengths and limitations of each method (Bardid et al., 2019). Specific tools from systematic reviews can be drawn from objective, standardized methods suitable for comprehensive field screening for MC in a European context (Bardid et al., 2019; Scheuer et al., 2019). In the early phase of the project, we assessed the possibilities of using the available tools in the context of national specificities (Šeflová et al., 2022). Despite the lower feasibility related to the practical aspects of the 53 test tasks, we opted for the German complete form of the Bruininks–Oseretsky Test of Motor Proficiency Second Edition (BOT 2; Blank et al., 2014).

The present study aimed to understand the level of MC in school-aged children aged 6.0–11.0 years in the Czech Republic to analyze the distribution of results in different age and gender categories. These results can provide a valuable basis for individual intervention approaches for children's specific learning needs. National

MC status surveys are a basis for developing local health promotion interventions and strategies and contributing to the reporting of MC status from different parts of the world with different sociocultural contexts. However, to date, such information has been missing for Czech children. The present study sought to address this issue.

Materials and Methods

Participants and Study Settings

This study was conducted in the Czech Republic from 2020–2022. Participants were selected by quota sampling. In our selection process, we accounted for quotas based on the characteristics of age, gender, and school size as expressed by the number of students, urban and rural location, associated estimated ethnicity and minority representation, and related socioeconomic status (lower in small schools outside larger cities). The study involved pupils from six mainstream primary schools in three regions. The study did not include schools specializing in sports and schools for students with special educational needs.

The initial requirement for the total sample size was a minimum of 40 children in each normative age group of a given gender. This number takes into account the condition of the variability of the data (sample > 30 when assessing relative frequency), the required width of the confidence interval (precision of the estimate in the total motor composite [TMC] and subcategories), and the estimate of the effect size under investigation (differences due to age and gender; Maxwell et al., 2008).

Data were obtained from 637 children (297girls, 46.6%) aged 6.0–11.0 years. Age groups were distributed with mean age $M = 8.42$ years ($SD = 1.30$), body mass $M = 35.84$ kg ($SD = 10.66$), and height $M = 139.66$ cm ($SD = 8.67$). Data were collected annually over two consecutive years by 36 methodically trained researchers during physical education classes. Testing that was temporally affected by the SARS-CoV-2 pandemic was always carried out in compliance with current hygiene regulations. It took place in the school premises during periods when wearing protective masks was not mandated in the classroom.

Assessments

MC was measured using the complete form of the BOT 2, German version (Blank et al., 2014). Validity and reliability for measuring motor proficiency were tested in a German standardization study with $n = 1{,}177$ German, Austrian, and Swiss children (Blank et al., 2014). Given the sociocultural affinity of the countries of origin of the normative criteria in Europe (Germany, Austria, and Switzerland) and based on a pilot study (Šeflová, 2022), we considered the normative criteria valid also for the Czech environment.

BOT 2 assesses the TMC score, and fine and gross motor skills level in four motor area composites 1–4 with eight subtests I–VIII: (1) *Fine manual control* (I. Fine motor precision—seven items and II. Fine motor integration—eight items), (2) *Manual coordination* (III. Manual dexterity—five items and VII. Upper-limb coordination—seven items), (3) *Body coordination* (IV. Bilateral coordination—seven items and V. Balance—nine items), and (4) *Strength and agility* (VI. Running speed and agility—five items and VIII. Strength—five items).

From the 53 test items, we obtained raw scores in the form of values in metric units, the number of errors, or the number of successful attempts. By tabulating the total point scores into scale scores I–VIII, intercomparability within age and gender is possible (subtest score profile $M = 15$, $SD = 5$). We obtained the standard scores 1–4 by tabulating the sum of the scaled scores of those pairs of subtest categories ($M = 50$, $SD = 10$).

Body mass was measured using the body composition analyzer InBody 770 (InBody Co., Ltd.), and height was measured using portable measuring equipment (InBody Co., Ltd.) that is suitable for use in the child population (Brewer et al., 2021).

Data Analysis

Lilliefors test was used to test the normality of the data. To evaluate the agreement of the means of the two samples (gender differences), we used a two-sample *t* test for the normality of the data. When data normality was not met, we used the Mann–Whitney test. We used a one-factor analysis of variance (ANOVA) when the data were normal to assess the agreement of the means of more than two samples (age differences). When the data normality condition was unmet, we used the Kruskal–Wallis test. Two-factor ANOVA was used to compare the agreement between two samples (gender differences), where the effect of age was expected.

Hypothesis tests were conducted at the 5% significance level. For ANOVA, Kruskal–Wallis test, and two-factor ANOVA, post hoc analyses of intercomparisons were performed if the H0 hypothesis of agreement of means/medians was rejected.

The effect size was ascertained for the difference in means using Cohen's *d* for two samples or Hedges *g* for more than two samples. Fisher eta was used to assess the variance η. Cohen's *d* classified effect sizes as small ($d = 0.2$), medium ($d = 0.5$), and large ($d \geq 0.8$) (Sullivan & Feinn, 2012).

Statistical data processing was performed using MATLAB software (The MathWorks).

Results

The TMC and Composite and Subtest Score Profiles

In line with the study's first objective, we analyze the results based on the BOT 2 classification of the TMCs and composite score profiles 1–4 and subtest score profiles I–VIII in the Czech sample ($n = 637$ children; Table 1).

The percentage distribution in performance categories is well-above average (0.31%), above average (10.68%), average (59.65%), below average (22.61%), and well-below average (6.75%). To test the symmetry of the data using a two-sample Kolmogorov–Smirnov test, the hypothesis H0 (data symmetrically distributed around the mean) was tested against H1 (data not symmetrically distributed around the mean) at the 5% significance level. H0 of symmetric distribution is rejected ($p = .034$, maximum difference of distribution functions is 0.072).

Table 1 Results of the BOT 2

	Results			BOT 2 Classification
Evaluated categories	***M***	***SD***	**Descriptive categories**	**Scale score, score profiles**
1. Fine manual control	38.51	10.70	Below average	Standard score 31–40
I. Fine motor precision	8.90	5.82	Below average	Scale score 6–9
II. Fine motor integration	12.04	5.17	Average	Scale score 10–19
2. Manual coordination	49.96	11.79	Average	Standard score 41–59
III. Manual dexterity	16.95	6.20	Average	Scale score 10–19
VII. Upper-limb coordination	13.04	5.35	Average	Scale score 10–19
3. Body coordination	50.23	10.30	Average	Standard score 41–59
IV. Bilateral coordination	18.11	3.74	Average	Scale score 10–19
V. Balance	12.13	6.25	Average	Scale score 10–19
4. Strength and agility	50.52	9.83	Average	Standard score 41–59
VI. Running speed and agility	15.66	4.72	Average	Scale score 10–19
VIII. Strength	14.73	4.81	Average	Scale score 10–19
TMC	46.37	10.49	Average	Standard score 41–59

Note. BOT 2 results are presented as scale scores ($M = 15$, $SD = 5$) for subtests I–VIII, and as TMC and standard scores 1–4 ($M = 50$, $SD = 10$). BOT 2 = Bruininks–Oseretsky Test of Motor Proficiency Second Edition; TMC = total motor composite.

Age and Gender Differences

Table 2 shows the TMC and the subcategories for each age group. Differences are discussed in accordance with this study's Aim 2. We analyzed the effect of age on BOT 2 results. At the 5% significance level, hypothesis H0 was tested using ANOVA (mean TMC is the same for all age categories). We reject H0, $F(4.632) = 11.14$, $p < .01$, Hedges' $g = .73$. Post hoc analysis revealed that the TMC value decreased significantly when comparing the older age groups of 10 and 9 years with younger age groups of 8, 7, and 6 years ($p < .001$). The older age groups of 10 and 9 years scored significantly lower on the TMC test than the younger age groups of 8, 7, and 6 years ($p < .001$).

The same methodology as TMC was used to assess the concordance of means by age for composite score profiles 1–4 and subtest score profiles I–VIII. Post hoc analysis revealed significantly lower scores with increasing age for: *1. Fine manual control, 2. Manual coordination, 3. Body coordination, and 4. Strength and agility* ($p < .01$, Hedges' $g = 0.55$–0.77). At the subtest score profiles level, decreasing score level with age was observed in *I. Fine motor integration, III. Manual dexterity, IV. Bilateral coordination, V. Balance, VI. Running speed and agility, and VIII. Strength* ($p < .001$, Hedges' $g = 0.51$–0.80). In *I. Fine motor precision* ($p = .52$, Hedges' $g = 0.20$), we do not confirm an *VII. Upper-limb coordination* ($p = .25$, Hedges' $g = 0.24$).

The effect of age and gender on BOT 2 performance was examined using a two-factor ANOVA ($p = .05$). We found identical mean TMC values for girls and boys of all age categories, $t(635) = 1.77$, $p = .08$, Cohen's $d = 0.15$.

Table 2 Descriptive Results of the BOT 2 by Age

	Age categories (years)				
	6.0–6.9	7.0–7.9	8.0–8.9	9.0–9.9	10.0–10.9
	n = 97	*n* = 185	*n* = 129	*n* = 125	*n* = 101
Evaluated categories	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
1. Fine manual control	41.46 (10.47)	39.37 (9.27)	39.74 (10.80)	35.74 (10.67)	35.99 (11.92)
I. Fine motor precision	9.00 (5.97)	8.41 (5.43)	9.53 (5.76)	9.29 (6.01)	8.40 (6.08)
II. Fine motor integration	13.99 (4.75)	12.70 (5.04)	12.59 (4.99)	9.98 (4.97)	10.83 (5.16)
2. Manual coordination	51.58 (10.70)	50.99 (11.77)	51.05 (11.33)	47.20 (13.19)	48.52 (10.76)
III. Manual dexterity	17.47 (6.03)	17.42 (6.06)	18.48 (5.56)	15.39 (6.74)	15.57 (6.03)
VII. Upper-limb coordination	13.73 (5.44)	13.32 (5.72)	12.49 (5.38)	12.67 (5.15)	13.03 (4.62)
3. Body coordination	54.65 (10.92)	50.65 (9.31)	50.44 (10.24)	48.62 (10.31)	46.92 (9.84)
IV. Bilateral coordination	20.03 (3.63)	18.04 (3.87)	17.90 (3.37)	17.70 (3.64)	17.20 (3.57)
V. Balance	13.97 (6.49)	12.71 (5.46)	12.22 (6.65)	10.98 (6.46)	10.61 (5.94)
4. Strength and agility	52.93 (9.63)	53.01 (8.49)	49.84 (7.95)	48.29 (10.27)	47.31 (11.95)
VI. Running speed and agility	16.73 (4.74)	16.67 (4.13)	15.33 (3.98)	14.70 (4.59)	14.38 (5.96)
VIII. Strength	15.91 (5.25)	16.01 (4.65)	14.46 (4.03)	13.80 (4.57)	12.75 (4.88)
TMC	50.27 (10.44)	48.01 (9.70)	46.97 (9.76)	43.16 (10.77)	42.82 (10.30)

Note. BOT 2 results are presented as scale scores ($M = 15$, $SD = 5$) for subtests I–VIII, and as TMC and standard scores 1–4 (M = 50, SD = 10). BOT 2 = Bruininks–Oseretsky Test of Motor Proficiency Second Edition; TMC = total motor composite.

Girls of all age categories achieved significantly better results in the fine motor categories:

1. *Fine manual control,* $t(635) = 2.39$, $p = .02$, Cohen's $d = 0.19$. Here, the girls are better in the subcategory *I. Fine motor precision,* $t(635) = 2.75$, $p = .006$, Cohen's $d = 0.22$. There is no difference in *II. Fine motor integration,* $t(635) = 0.43$, $p = .67$, Cohen's $d = 0.04$.
2. *Manual coordination,* $t(635) = 3.46$, $p = .06$, Cohen's $d = 0.19$. Here, the girls are better in the subcategory *VII. Upper-limb coordination,* $t(635) = 4.41$, $p < .001$, Cohen's $d = 0.35$. There is no difference in *III. Manual dexterity,* $t(635) = 1.30$, $p = .20$, Cohen's $d = 0.10$.

Boys had better results in the gross motor subcategory *VI. Running speed and agility,* $t(635) = -3.74$, $p < .001$, Cohen's $d = 0.45$. Overall, the gross motor categories did not show a significant difference:

3. *Body coordination,* $t(635) = .66$, $p = .51$. No differences were observed in the subcategories *IV. Bilateral coordination,* $t(635) = -0.59$, $p = .55$), and *V. Balance,* ($t(635) = 1.49$, $p = .14$.
4. *Strength and agility,* $t(635) = 1.30$, $p = .19$. No differences were observed in the subcategory *VIII. Strength,* $t(635) = 1.54$, $p = .12$.

If we focus on the evaluation of differences already at the level of raw scores of 53 test tasks, we observe significantly better results of girls in tasks of *I. Fine manual precision* ($p < .001$) and *VII. Upper-limb coordination* ($p < .001$). Boys had better results in tasks of gross motor category *VIII. Strength* ($p < .001$).

Discussion

The present study identified the overall level of MC in children aged 6.0–11.0 years from the Czech Republic and analyzed the effect of age and gender on performance in BOT 2. This is the first study to report national MC prevalence and specifically presents unique insight for children in the Czech Republic.

The TMC and Composite and Subtest Score Profiles

TMC, composite score profiles 1–4 and subtest score profiles I–VIII, which are standardized scores based on age and gender and are a valuable measure of MC, as they allow skill levels to be directly compared across children. According to the BOT 2 descriptive categories (ranging from well-below to well-above average), the results of the arithmetic means of TMC for all age groups are classified as "average" (TMC score: 41–59). The overall percentage of children with at least a satisfactory level of TMC (TMC score > 40) without the need for intervention is 70.64%. Almost three-quarters of children can use the benefits of sufficient gross and fine motor skills level.

The highest scoring motor skills area was from the gross motor skill *4. Strength and agility*, where 85.39% of children scored at least average, and *3. Body coordination*, with 81.48% of children. In comparison, in the weakest category, *1. Fine manual control*, only 43.10% of the children achieved at least average. These findings can confirm the assumptions of a developmental sequence of motor skills (Ghassabian et al., 2016; Smith & Thelen, 2003). Gross motor skills serve a supporting role for fine motor skills. These fine motor skills are important because they support the production of skills that are necessary for independence, such as activities of daily living and academic skills. Children with strong fine motor skills have been found to demonstrate higher academic and mathematical achievements and earlier development of reading (Gaul & Issartel, 2016).

These above findings provide support for the inclusion of fine motor skills as an important component in the overall assessment of MC using the BOT 2, if we are to account for the potential impact of MC conceptualized on activities of daily living and selected academic skills. Children's fine motor skills did not increase at the expected rate given by the normative data in our study, as also reported consistently by Gaul and Issartel (2016) in their study using BOT 2.

After discussing above-average and average TMC results, we focused on the area of low MC. We observed 6.75% of children with a prevalence of well-below average MC proficiency (standard score TMC < 30) and 22.1% of children in the below-average category of TMC (standard score 31–40). These high numbers can support the opinion about the epidemic of poor motor skills (Tamplain & Cairney, 2024). The lack of movement experience and practice in movement skills associated with a general movement deficit and low perceived MC, self-efficacy, and low motivation for activity, posing a likely risk of failure, help complete the vicious circle of implications of inadequate MC.

Comparison of the prevalence of low MC reported in other studies (e.g., Duncan et al., 2022; Ferreira et al., 2018) is difficult in relation to our BOT 2 results. Screening studies with the complete form of BOT 2 are nonexistent. Comparisons with the results of MC assessment using gross motor tools, such as the frequent Test of Gross Motor Development-2, could be made by excluding fine motor tasks included in the fine manual control task, which best fits Gallahue et al. (2020) definition of fine motor skills as the use of small muscles involved in movements that require the functioning of the extremities to manipulate objects. After we also excluded task *1. Fine manual control* from BOT 2, only 4% of Czech children were in the low MC. After excluding tasks *2. Manual coordination*, which the BOT 2 classification places in fine motor skills, we find 6% of children with low MC.

When assessing the distribution of TMC scores using data symmetry, we observed a shift toward the lower end of the spectrum for Czech children, suggesting that a larger proportion of Czech children scored below than above average. Our findings indicate that the BOT 2 category at the high end of the TMC spectrum may not be sufficiently discriminatory for the Czech sample. The assessment of above-average performance on the BOT 2 test itself appears problematic because some items suffered from a ceiling effect. A similar trend was observed by Brahler et al. (2012), which stated that numerous test items in the BOT 2 do not contribute substantially to motor performance assessments in typically developing children. The low specificity of the BOT 2 for detecting above-average results is defended by the primary purpose of the BOT 2, the complete form for identifying low MC (Blank et al., 2014).

Age and Gender Differences

We found statistically significant differences in MC as a function of age. We observed a significant decrease in the TMC score with increasing age when comparing age groups 10 and 9 years and groups 8, 7, and 6 years in both girls and boys compared with developmental norms. The most significant decrease with respect to age occurred in standard score categories *1. Fine manual control* and *3. Body coordination*.

Gender differences are reflected in boys' poorer fine motor skills. As gender differences are explained more by the type of activities in which children participate than by biological differences in prepubertal age (Jürimäe & Jürimäe, 2019), our results are consistent with girls' preference for writing and drawing and their better levels in early writing and reading (Reilly et al., 2019).

Boys in our sample scored better only in gross motor skills *VI. Running speed and agility*. This is consistent with findings that boys have more freedom to display aggressive behavior and engage in more intense physical activities, and are more required to perform gross motor tasks (Jürimäe & Jürimäe, 2019).

As a result of previous findings of the high prevalence of low MC assessed by BOT 2 with fine motor skills components, it would be beneficial if these results were used in ongoing revisions of national physical education curriculum documents in the Czech Republic. However, the responsibility for the adequate development of MC with a positive impact on health in children cannot lie solely with school physical education, even though it is identified as one of the most influential factors (Vlček et al., 2021). Extracurricular options and PA offerings, as well as proactive physical and social environments in both the close family and school are essential for forming PA habits from an early age (Romero-Blanco et al., 2020). In our opinion, it would also be appropriate to focus on the inclusion of activities for MC development in recommendations for regular PA built on the health-related fitness components included in the consensus statement by Bouchard et al. (1994). At the same time, the development of fundamental movement skills in the MC concept should not be neglected as a necessary foundation for sport-specific technical skills.

Conclusions

The MC of school-age children in the Czech Republic evaluated using the standard score of the TMC of product-oriented BOT 2 is average. However, an alarmingly high proportion of children had below to well-below average levels of the TMC, which for BOT 2 includes an assessment of both gross and fine motor skills. Fine motor skills were the weakest area for Czech school children and reduced the impact of satisfactory gross motor skills on the overall MC score.

Boys have significantly worse results in fine motor skills. This is despite considering age- and gender-different assumptions about developmental sequences of motor skills in the BOT 2 assessment criteria. This may result from the general preference for gross motor activities in boys and the expected preference for fine motor activities such as writing and drawing in girls. Surprisingly, a significant decrease in MC is observed with increasing age, both in the TMC and in the subcategories of fine and gross motor skills. The possible association between these findings and the decline in overall motor activity of Czech children from childhood to adolescence is the subject of further investigation.

Our data suggest that nearly one third of children aged 6–11 years in the Czech Republic do not have a sufficient base of MC, which is considered an important factor in the child's overall development in physical, social-emotional, and cognitive aspects. School and family policy should reflect these findings in national recommendations for PA, emphasizing stabilization and further development of fundamental movement skills later in life.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request. **Ethics Statement**: The studies involving human participants were reviewed and approved by the ethics commission of the Technical University of Liberec, Czech Republic, on October 23, 2019. The procedures involved in the study were in accordance with the ethical standards of the responsible Czech National Committee on Human Experimentation and the Declaration of Helsinki, of 2000. The data were anonymized. Parents and legal guardians provided written informed consent to the anonymized data collection. **Funding Support**: This work was supported by the Technology Agency of the Czech Republic under Grant TA ČR Éta 3 TL03000221.

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