DR ARTO LAUKKANEN (Orcid ID : 0000-0002-9722-0258)

DR FARID BARDID (Orcid ID : 0000-0001-8591-0596)

PROFESSOR VITOR P LOPES (Orcid ID : 0000-0003-1599-2180)

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Comparison of motor competence in children aged 6 to 9 years across northern, central, and southern European regions

Laukkanen, Arto[1]*, Bardid, Farid[23], Lenoir, Matthieu[3], Lopes, Vitor P.[4], Vasankari, Tommi[5], Husu, Pauliina[5] and Sääkslahti, Arja[1]

[1]Faculty of Sport and Health Sciences, University of Jyväskylä, Finland
[2]School of Education, University of Strathclyde, Glasgow, UK
[3]Department of Movement and Sports Sciences, University of Ghent, Belgium
[4]Instituto Politécnico de Bragança, Campus de Santa Apolónia, 5300-223 Bragança, Portugal. Research Centre of Sports, Health and Human Development (CIDESD), Portugal
[5]UKK Institute for Health Promotion Research, Tampere, Finland

*Corresponding author's contact information:
Arto Laukkanen
Faculty of Sport and Health Sciences
P.O. Box 35 (L366), 40014
University of Jyväskylä FINLAND
Phone +358440758578
Email arto.i.laukkanen@jyu.fi
Fax: +358 014 617 422

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Abstract

The present study aimed at examining differences in motor competence (MC) in children aged 6 to 9 years old in northern, central, and southern European regions using the Körperkoordinationstest für Kinder (KTK). The secondary aim of the study was to examine interactions between region and children's age, sex and weight status (determined as healthy weight or overweight/obese). Data was pooled from independent studies conducted in Finland (mean age 7.81 ± 1.19 years, n = 690), Belgium (mean age 8.25 ± 1.09 years, n = 1,896) and Portugal (mean age 8.31 ± 1.02 years, n = 758) between 2008 and 2016. Cross-cultural differences in MC and interaction effects were tested using ANOVAs and ANCOVAs. Age, sex and BMI percentile were used as covariates. Geographical region significantly explained 19% of the variance in MC, while BMI (5%), sex (3%) and age (0.3%) were significant covariates. The interaction effect of region and age (5%), region and sex (0.6%) and region and BMI (0.2%) on MC was also significant. Cross-cultural differences in children's MC seem to increase substantially across 6 to 9 years, independent of the prevalence of overweight or obesity. Girls slightly underperformed in MC compared to boys in regions where the overall level of MC was lower. On the other hand, the association between body weight status and MC seems relatively consistent across the cultures. Future cross-cultural studies should further explore the influence of individual (e.g. physical activity) and environmental (e.g. physical activity and sport policy) factors on MC development.

Key words: childhood, cultural comparison, motor assessment, motor skills, movement skills

The prevalence of children classified as having poor gross motor competence (MC) has increased in recent decades.[1–3] A study from a central European region showed that around 20 per cent of children are 'at-risk' of delays in motor development,[3] whilst another study stated that the proportion of such children is more than 70 per cent in the United States.[4] MC is used as an umbrella term reflecting different terminologies (e.g. motor ability, fundamental movement/motor skills) that describe goal-directed human movement.[5] An adequate level of MC enables one to take part in physical activities that are typical to one's age and developmental level. This is demonstrated by above-average physical activity levels,[6] achieving the daily recommended level of physical activity (PA)[4] and a higher likelihood of achieving a physically active lifestyle.[7] These are globally topical issues, as the prevalence of children's inactivity is high[8] and inactivity is associated with the increased prevalence of being overweight and obesity, as well as the accumulation of related health risks in children.[9] Thus, there are social and public health needs for exploring reasons leading to population-level motor delay.

There is a dearth of international comparison studies on children's MC, even though cross-cultural studies might give insight into the cultural-environmental determinants of motor developmental differences. Existing inter-continental comparison studies have shown that children's MC differs significantly across the geographical regions. For instance, 6- to 8-year-old Belgian children outperform their Australian peers in motor coordination,[1] 4- to 5-year-old Belgian children outperform children in the United States in object control and locomotor skills[2] and 4- to 6-year-old Chinese children outperform their peers in the Unites States in manual dexterity and balance (although the children in the United States outperform their Chinese peers in throwing and catching).[10] Differences have also been found in MC in 7- to 8-year-old children in Europe: northern European children (Norway) outperform southern European children (Greek and Italian) in fine and gross motor skills.[11] It is speculated that cross-cultural differences are due to differing enrolment rates in organized childcare[1,2] and differences in policies governing physical education.[2] The popularity of certain individual and group sports and games across nations may also influence the cross-cultural differences. For instance, Thomas et al. (2010) showed that proficiency in a basic motor skill (throwing) is highly dependent on the prevailing sports culture.[12]

However, reasons for cross-cultural differences in children's MC have remained speculative, in part because these studies used samples representing relatively narrow age ranges. From the perspective of motor development, it is essential to evaluate MC in a sample representing a large age range and to investigate if interactions between MC and factors such as weight status change with age. For instance, being overweight has been found to predict a poor rate of MC development during primary school years.[13] Secondly, previous studies have majorly compared childhood MC levels between countries from different continents, but it remains unclear if and to what extent motor competence levels differ among children from different parts of the same geographical region.

Therefore, to gain a better understanding of cross-cultural differences in MC among children in Europe, we pooled a considerable amount of data on northern, central, and southern European children aged 6 to 9 years (N = 3,460) living in Finland, Belgium and Portugal. The first aim of the study was to investigate differences in MC between northern, central and southern European cultures. The second and third aims were to examine interactions between geographical region and children's age and sex. We hypothesized that there are differences in children's MC across cultures[11] and that these differences accumulate with age, as MC is shown to develop in childhood.[14] Additionally, cultural influences may affect differences in MC between sexes.[12] The fourth aim was to test whether body weight status, i.e. being a healthy weight or overweight, influences MC differently across the geographical regions. There is substantial evidence showing an inverse association between body weight status and MC,[5,15] and we hypothesized that this association might vary across the cultures, and thus, explain cross-cultural differences in MC. As a measure of MC we used the *Körperkoordinationstest fur Kinder* (KTK),[16,17] which is known to be a highly valid, reliable and non-sport specific tool for assessing children's MC.[18]

Materials and methods

Subjects

This study pools data from four independent studies conducted between 2008 and 2016, all of which examined the levels of gross motor competence (MC) of children living in Finland, Belgium and Portugal. The level of MC was assessed in each study using the KTK (Kiphard & Schilling, 1974, 2007). These countries are culturally distinct and reflect different parts within Europe. Subjects from Finland (mean age 7.75 ± 1.19, range 4 years, n = 636) were from two independent studies: the Skilled Kids study (years 2015–2016, mean age 6.64 ± 0.36 years, range 1.8 years, n = 278) and the Naantali Schools on the Move study (year 2013, mean age 8.60 ± 0.85 years, range 3.3 years, n = 412). In the Skilled Kids study, children were enrolled at 37 childcare centres, which were geographically cluster-randomized around the whole country. In the Naantali study, children were enrolled at all 9 primary schools located in the city of Naantali and the principality of Masku in southwest Finland. Subjects were also drawn from 29 primary schools in the northern region of Belgium (i.e. Flanders; year 2007; mean age 8.25 ± 1.09, range 4 years, n = 1,896) and from eight primary schools in Portugal (year 2008; mean age 8.31 ± 1.02, range 3.9 years, n = 758) located in the central mainland region. Ethical approval was obtained from the Ethics Committees of the University of Jyväskylä and the Tampere Region (Finland), Ghent University Hospital (Belgium) and the University of Porto (Portugal). For each participant, written informed consent form was obtained from his or her parent or legal guardian.

Anthropometry

Height and weight were measured in the childcare centres and schools to an accuracy of 0.1 cm/kg by using professional-level scales (Finland: Charder HM 200P and Seca 877/Inbody 720; Belgium: Harpenden Portable Stadiometer, Holtain, UK and ANITA BC-420SM, Japan; Portugal: Seca 217 and Seca 877). Body mass index (BMI) was calculated as weight/height^2 (kg/m^2). For each child, an age adjusted $BMI_{percentile}$ score was calculated using a Children's BMI Group Calculator–Metric Version, provided by the Centers for Disease Control and Prevention (CDC).[19] According to the CDC norms, being overweight was defined as a BMI ≥ 85 percentile and obesity as BMI ≥ 95 percentile.

Motor competence

MC was tested by teams of trained observers using the KTK.[16,17] This is a product-oriented assessment tool appropriate for use with 5- to 14-year-old children who are typically developing as well as those with brain damage, behavioural problems, or learning difficulties. The KTK assesses gross motor coordination and body control, mainly the dynamic balance instead of single motor skills. The KTK has been used widely for research purposes in Europe over the last four decades,[18] and it has been used in criterion validity studies of other assessment tools, such as Movement Assessment Battery for Children (M-ABC).[20,21]

As part of the KTK test battery, the children performed the following four tasks:

1. Walking backwards (WB) on balance beams (length 3 m, height 5 cm) with different widths of 6.0 cm, 4.5 cm and 3.0 cm, starting with the widest one. The maximum test score possible was 72 steps, based on 3 trials per each beam and a maximum of 8 successful steps for each trial.
2. Hopping for height (HH), one foot at a time, over an increasing pile of soft mattresses (width 60 cm; depth 20 cm; height 5 cm each). The first, second or third trial of each height was awarded by three, two or one point(s), respectively. The maximum test score was 39 points (ground level + 12 mattresses) for each leg, resulting in a maximum of 78 points with both legs.
3. Jumping sideways (JS) from side to side over a thin wooden lath (60 cm × 4 cm × 2 cm) on a jumping base (100 cm × 60 cm). Two trials of 15 seconds were performed and the total of successful jumps was calculated.
4. Moving sideways (MS). The children had two identical wooden plates (size 25 cm × 25 cm, height 5.7 cm) and after stepping to one, they had to transfer another one sideways for the next transition. The total of transitions was summed over two 20-second trials. Transitions were performed in the same direction on both trials.

The psychometric properties of the KTK have been well-documented; content and construct validity have been established[16,17] Additionally, the KTK has been shown to moderately correlate with other widely used assessment tools such as the M-ABC (r = 0.62–0.65)[20] and the Bruininks-Oseretsky Test of Motor Proficiency (BOT-2) Short Form (r = 0.61–0.64).[21,22] The KTK protocol has shown moderate to high

reliability based on test-retest correlation (r = 0.60–0.99)[23–26] and high reliability based on inter-rater correlation (r = .90–.99).[24] In addition, the Cronbach's alphas for the four items showed a high internal consistency (0.95).[24] The raw test scores of the KTK test items were transformed into sex- and age-standardized values and into a measure indicating overall gross MC according to the renewed norms.[27] MC scores were classified as follows: 'not possible' (values under 56), 'impaired' (values 56–70), 'poor' (values 71–85), 'typical' (values 86–115), 'good' (values 116–130) and 'very good' (values 131–145).

Statistical analyses

Statistical analyses were performed using the statistical software package IBM SPSS version 24.0. Children with one or more missing MC items (Belgium, n = 209) and children without birth date information (Portugal, n = 127) were excluded from the analyses. Means and standard deviations of sample characteristics (age, height, weight, BMI, $BMI_{percentile}$, being overweight %, obesity % and MC) were obtained and the differences between sexes tested using independent sample t-tests (age, height, weight, and $BMI_{percentile}$) and chi-square (χ^2) tests ($BMI_{healthy/overweight\ or\ obese}$). Differences between the regions in terms of age and anthropometric descriptives were tested using one-way analyses of variance (ANOVA) and one-way analyses of covariance (ANCOVA) when adjusted for age. Internal consistency of the norm-based KTK test item values was examined by calculating Cronbach alphas and item-total correlations separately for the three regions. A 2 (sex) × 4 (age group, age rounded down to the nearest integer) ANOVA was used to examine the age and sex differences in the standardized KTK values and MC within the regions. MC scores were plotted with age separately for healthy weight, overweight, and obese children in each region. Linear regression lines were calculated and drawn to illustrate the linear relationships. Furthermore, Pearson correlations were calculated between the MC scores and age in each of these sub-groups.
A χ^2 test was used to compare the distributions of children from the three regions across the KTK performance categories (impaired, poor, typical, good, very good). ANCOVAs were performed to examine regional differences in MC. Firstly, the effect of geographical region (Finland, Belgium, Portugal) on MC was examined with age and $BMI_{percentile}$ as covariates using a one-way ANCOVA (Model 1). Two-way ANCOVAs were performed where interaction effects were examined: region × age group (Model 2), region × sex (Model 3) and lastly region × BMI status group (Model 4). The covariates used were $BMI_{percentile}$ and sex (Model 2), age and $BMI_{percentile}$ (Model 3) and age and sex (Model 4). Covariates were chosen on the basis of previous evidence indicating their effect on MC in children.[3] $BMI_{percentile}$ was chosen as a covariate instead of weight or height because it had the strongest correlation with MC when adjusted for age. Significant interaction and main effects were further investigated with Bonferroni post-hoc tests or pairwise comparisons. The level of significance was set as $P < .05$ in all analyses.

Results

Sample characteristics

Age and anthropometric statistics showed that boys overall were significantly taller than girls in Finland ($t = 2.09$, $P < .05$) and Belgium ($t = 2.79$, $P < .01$) (Table 1). There were significant differences between the regions in age ($F = 56.12$, $P < .001$, FI<BE/PT), height ($F = 13.89$, $P < .001$, FI < BE < PT), weight ($F = 39.08$, $P < .001$, FI < BE < PT), BMI ($F = 38.59$, $P < .001$, FI/BE < PT), $BMI_{percentile}$ ($F = 33.07$, $P < .001$, BE < FI/PT), prevalence of being overweight (Pearson $\chi^2 = 71.11$, df = 2, $P < .001$, BE < FI < PT) and obesity prevalence (Pearson $\chi^2 = 33.72$, df = 2, $P < .001$, BE < FI < PT). Differences in anthropometric variables between regions were mainly due to differences in the sample mean ages. After adjustment for age, an ANCOVA revealed that the region significantly explained no more than 1% to 3% of the variation in anthropometry.

[Table 1 around here.]

Cronbach alphas of the KTK-test items were .828, .804 and .777 in samples from Finland, Belgium and Portugal, respectively. The corrected item-total correlations for the norm-based values of test items of the walking backwards, hopping for height, jumping sideways, and moving sideways, respectively, were as follows: .571, .710., .695., .655 (Finland); .549, .656, .687, .588 (Belgium); .648, .578, .680, .616 (Portugal). Performance in the KTK norm-based values was significantly higher in older age groups in Finland, remained the same in Belgium and was significantly lower in Portugal (Table 2, Figure 1). Age group affected 15.9%, 0.3% and 16.0% of the variation in MC in Finland, Belgium and Portugal, respectively. Overall, boys outperformed girls in MC in all three regions. However, sex explained 11.7% of the variation in MC in the Portuguese group but only 2.0% and 0.9% in the Belgian and Finnish groups, respectively. For the hopping for height task, the age × sex interaction effect was significant in the Belgian and Portuguese sample and borderline significant in the Finnish sample. For the moving sideways task the age × sex interaction effect was significant in the Belgian group.

[Table 2 around here]

[Figure 1 around here]

$BMI_{percentile}$ was negatively associated with MC in all three regions: Finland ($r = -0.131$), Belgium ($r = -0.228$) and Portugal ($r = -0.316$) (Figure 2). Healthy-weight children had positive associations between age and MC in Finland and Belgium but not in Portugal. Interestingly, all the subgroups of healthy, overweight and obese children showed an increasing trend of MC according to age in Finland, whereas only healthy

weight children showed an increasing trend of MC with age in Belgium, and all the subgroups showed a decreasing trend of MC according to age in Portugal.

[Figure 2 around here]

Differences in motor competence between geographical regions

A χ^2 test showed a significant difference in the distribution of children in the three regions across the KTK performance categories ($\chi^2 = 459.984$; $P < .001$) (Figure 3). The majority of children in each of the regions were rated as typically developing. However, those in Portugal who were not rated as being typically developing were rated mostly as having poor MC (29.3%) or impaired MC (10.3%); only 0.9% scored above the typical range. In comparison, a remarkable proportion of Finnish and Belgian children were categorized as being above the typical range (33.8% and 18.4%) and minority of the children as being below the typical range (8.7% and 10.8%), respectively.

[Figure 3 around here]

The one-way ANCOVA analysis showed a significant main effect of region on MC, explaining approximately 19% of the variance (Table 3, model 1). The results also showed significant main effects for the covariates age, $BMI_{percentile}$ and sex, which explained 0.03 %, 4.8 % and 2.9 % of the variance in MC, respectively. Pairwise comparisons between regions revealed that Portuguese children scored 21.46% and 16.63% lower in MC compared to Finnish (adjusted mean difference -18.93, $P < .001$) and Belgian children (adjusted mean difference -13.60, $P < .001$), respectively. Finnish children scored 5.11% higher in MC compared to Belgian children (adjusted mean difference 5.76, $P < .001$).

Model 2 indicated that there was a statistically significant region × age group interaction effect for MC, explaining around 5% of the variance overall. Pairwise comparisons showed that the region × age group interaction explained 10.6%, 2.5%, and 2.4% of the variability in MC between Finland and Portugal, between Finland and Belgium, and between Belgium and Portugal, respectively (all $P < .001$). Finnish children outperformed Belgian and Portuguese children at ages 7, 8 and 9, while Belgian children outperformed Portuguese children at ages 6 to 9 and Finnish children at age 6.

The region × sex interaction was found to be statistically significant although very weak, explaining only approximately 1% of the variation in MC. Pairwise comparisons showed that region × sex interaction was significant between Finland and Portugal and between Belgium and Portugal (both $P < .001$), although these explained only 1% of the variation in MC in both comparisons. Adjusted means of MC were 2.36%, 3.69% and 9.03% lower in girls compared to boys in Finland, Belgium and Portugal, respectively.

Region × $BMI_{healthy/overweight\ or\ obese}$ showed a statistically significant interaction effect on MC; however, this only explained 0.2% of the variance (Table 3, model 4). Pairwise comparisons showed that the region × $BMI_{healthy/overweight\ or\ obese}$ interaction was statistically significant between Finland and Belgium ($P < .05$) and between Finland and Portugal ($P < .05$), although they only explained 0.2% and 0.4% of the variation in MC, respectively. Adjusted means of MC were 5.92%, 10.2% and 12.07% lower for overweight or obese children compared to the healthy-weight peers in Finland, Belgium and Portugal, respectively.

[Table 3 around here.]

Discussion

The results of this study reveal considerable differences in 6- to 9-year-old children's MC across northern-, central- and southern European regions, suggesting that cross-cultural differences are due essentially to differences in the developmental rate of MC throughout childhood. Additionally, the study suggests that these differences may weakly relate to girls', and on the other hand, overweight children's greater underperformance in MC compared to boys' and healthy weight children's in regions where the overall level of MC is lower. Overall, the results suggest that motor development in childhood is influenced by individual and environmental factors, although only a small part of that variation is explained in the present study.

The cross-cultural differences found in the present study confirm the findings of a previous cross-cultural comparison, which used the same MC assessment. The study conducted by Bardid and colleagues[1] indicated significantly greater MC in Belgian children compared to Australian children, while the children's BMI and age were identified as significant covariates of MC. Bardid et al.[1] also found that cross-cultural differences in MC accumulated significantly between the ages of 6 and 8 years, yet their explained variability was smaller than that of the present study (2% vs 5%). This difference is probably due to greater cross-cultural differences in MC and the broader age range examined in the present study. In contrast to previous cross-cultural comparisons[1,2,10], the present study showed that boys' and girls' differing MC's significantly, although rather weakly, explain cross-cultural differences in MC. Specifically, the sex difference in MC was greater in cultures where the overall level of MC is lower. A unique finding of the present study showing statistically significant interaction between geographical region and BMI category should be interpreted practically trivial because of a very low effect size.

From Newell's constraints-based perspective, there are constraints relating to individual, environmental or task factors which inhibit motor development.[28] These factors influence motor development through their mutual interaction, although some of the factors may be more important than others at a given time. Body weight status is known to act as an individual-level constraint to motor development[13,15], and the negative association found between $BMI_{percentile}$ and MC in all the three regions of the present study confirms this

assumption. We hypothesized that the association between BMI and MC may vary across the cultures, which may explain cross-cultural differences in MC. This hypothesis was partly supported as the correlation between $BMI_{percentile}$ and MC varied across the cultures but the geographical region × BMI interaction effect on MC was found very weak in magnitude. In practice, overweight or obese children are more likely having a low absolute level of MC in cultures where the overall level of MC is lower but the difference between healthy weight and overweight or obese children's MC seem to differ only marginally across the cultures. The findings overall support an assumption that the association between being overweight or obese and having a poor MC is relatively consistent across the cultures. Other individual level factors which might explain MC differences, in addition to being overweight, could be PA and fitness levels. Previously, children's cardiorespiratory fitness has been shown to differ across countries, similar to the differences in MC found in the present study.[29] Poor fitness levels may act as an individual constraint for motor development in childhood, for instance, through lower perceived sports competence[30] and therefore less participation in PA typical of a subject's age and developmental level.

Based on the Global Matrix 2.0 on PA[31], Finland and Belgium are considered to outperform Portugal in some major indicators, namely active play, active transportation, community and built environment, and government strategies and investments for PA. Active play, especially if performed outdoors, is associated with greater moderate-to-vigorous PA and lower sedentary levels,[32] thus contributing to motor development.[6] The total amount of active play also influences the amount of very short-term and high-intensive PA impacts which are known to contribute to the differences in MC.[33] Secondly, active transportation in children goes hand-in-hand with children's independent mobility, an issue in which Finland is the world's leading country and Portugal at the end of the list.[34] Furthermore, children's independent mobility and active transportation are both largely dependent on community and built environment, an issue which separates Finland's and Portugal's PA indicators the most.[31] The results of the present study showed that sex differences in MC are larger when the overall level of MC in the culture is lower, an issue which may reflect cultural differences in attitudes toward the importance of PA for boys and girls. It is well known that boys tend to be more physically active compared to girls[35] and that boys naturally participate in a wider variety of PA games compared to girls.[36] Gender equality has strong historical roots in northern European countries[37], and the more equal levels of MC in girls and boys especially in Finland may be a reflection of national emphasis on gender equality. Interestingly, this hypothesis is supported by the fact that, internationally, poor gender equality is associated with lower grades in PA indicators.[31] Finland's greater effort with regard to government strategies and investments compared to Portugal and Belgium may further explain cross-cultural differences in children's MC, although this needs further investigation. In contrast, Portugal is considered to outperform both Finland and Belgium in organized sport participation[31] and this can be seen, for instance, in systematic and organized school sport competitions at local and national levels in Portugal.[38] Additionally, time allocated to physical

education in primary schools is officially higher in Portugal compared to Finland and Belgium. Nonetheless, it should be noted that generalist classroom teachers teach physical education lessons in primary schools in years 1-4 in Portugal. Physical education lessons in primary schools are generally taught by specialist physical education teachers in Belgium and partly by generalist teachers and specialists physical education teachers in Finland, a fact which may enhance quality of physical education and development of children's MC.[38,39] Finally, remarkable climate differences across Europe may affect cross-cultural differences in KTK performance. Seasonal variation in temperature is associated with children's PA and motor development,[14] and it may be that Finnish children in particular benefit from the long winter season with snow (e.g. cross country skiing) and ice (e.g. ice skating) when it comes to the KTK test, which strongly emphasizes performance in tasks relating to gross motor coordination and dynamic balance. Overall, multiple individual (e.g. PA, physical fitness) and environmental (e.g. organized physical activity and sport, physical education) factors may explain the cross-cultural differences in children's MC and should be explored in future studies.

Strengths and limitations

The strengths of this study are the substantial sample size gathered for each geographical region evaluated and the use of a non-sport-specific, reliable and valid MC assessment. Although in each of the sub-studies great care was taken to collect data from a representative sample, it cannot be excluded that representativeness was equal and optimal in all subsamples. In addition, cross-sectional study design represents a substantial limitation for the interpretation of the study results. Observing children of varying ages at one time point creates a risk of misinterpretation, because we cannot really know how children will develop over time. Furthermore, the data collections are up to nine years apart. Culture-specific phenomena may have taken place, such as physical activity campaigns, which may have affected levels of MC among some groups evaluated in this study. On the other hand, KTK does not assess object control skills nor fine motor skills. Nonetheless, KTK can be considered as a good measure of MC as it has shown to correlate moderately with test batteries including gross and fine motor skills as well as manipulative skills.[20–22] Another limitation is the low number of background variables used in the study. There are several variables which may explain cross-cultural differences in MC, such as parental support[14] and peer support for PA,[40] as well as, children's physical activity level and participation in organized PA and sports.[6] On the other hand, this is one of the first studies that brings cross-cultural differences of MC to the attention, and thus opens the gateway for further research. Lastly, the data has a multi-level structure (subjects in classes, classes in schools, schools in countries) but statistical modelling was done by using single-level structure (subjects), a fact that may blur associations between the factors.

Perspective

This present study suggests that the developmental rate of MC substantially differs among children aged 6 to 9 years between northern, central- and southern European regions. Alarmingly, around 40% of children from southern Europe might have poor or impaired motor competence, compared to around 10% of children from northern and central Europe. The results also indicate that these differences are independent of the remarkable cross-cultural differences in body weight status. Other key findings suggest that girls are slightly more likely to underperform in MC compared to boys when the overall level of MC in the region is lower. However, the inverse association between body weight status and MC seems relatively consistent across the cultures. Overall, only a small part of the cross-cultural variation in children's MC was successfully explained in the present study. The substantial cross-cultural differences in children's MC may be due to several individual and environmental factors, such as active play in childhood, gender equality and government strategies for and investments in PA. These cultural factors should be further explored in future research.

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Table 1. Descriptive statistics (means ± standard deviations) of age and anthropometric measurements stratified by region, age group and sex.

Age group	Variable	Finland		Belgium		Portugal	
		Girls	Boys	Girls	Boys	Girls	Boys
6	N	113	124	172	142	44	34
	Age	6.57 ± 0.3	6.52 ± 0.28	6.59 ± 0.28	6.56 ± 0.31	6.5 ± 0.27	6.59 ± 0.27
	Height	120.74 ± 5.35###	121.92 ± 5.39	119.86 ± 5.73	119.98 ± 5.38	123.98 ± 7.11	125.56 ± 5.85
	Weight	24.19 ± 4.59###	24.16 ± 3.69	22.83 ± 4.0	22.81 ± 3.41	24.91 ± 6.36	25.87 ± 4.62
	BMI(kg/m2)	16.49 ± 2.23##	16.18 ± 1.6	15.80 ± 1.79	15.78 ± 1.52	16.07 ± 3	16.4 ± 2.64
	BMI percentile	62.12 ± 27.2##	59.93 ± 28.52	52.41 ± 27.79	52.32 ± 29.06	49.89 ± 35.73	59.59 ± 36.95
	Overweight (%)	27.4##	24.2	16.9	16.2	27.3	41.2
	Obese (%)	12.4##	6.5	4.7	3.5	13.6	14.7
7	N	75	77	205	250	104	119
	Age	7.52 ± 0.31	7.44 ± 0.27	7.48 ± 0.28	7.53 ± 0.29	7.51 ± 0.26	7.51 ± 0.26
	Height	130.2 ± 6.07###	129.66 ± 6.6	125.77 ± 5.92**	127.32 ± 5.47	126.87 ± 6.96	127.04 ± 7.05
	Weight	28.31 ± 5.19###	27.7 ± 4.57	26.02 ± 4.57	26.41 ± 4.64	28.18 ± 6.03	27.33 ± 5.01
	BMI(kg/m2)	16.63 ± 2.33###	16.4 ± 1.85	16.38 ± 2.17	16.22 ± 2.14	17.37 ± 2.68	16.84 ± 2.1
	BMI percentile	57.06 ± 31.05###	57.99 ± 27.99	56.17 ± 26.76	53.06 ± 27.68	65.51 ± 27.53	64.69 ± 28.33
	Overweight (%)	26.7###	16.9	17.6	14.4	34.6	31.1
	Obese (%)	10.7#	2.6	4.4	6.0	15.4	7.6
8	N	55	53	247	261	122	116
	Age	8.44 ± 0.26	8.54 ± 0.28	8.50 ± 0.29	8.50 ± 0.29	8.53 ± 0.3	8.49 ± 0.3
	Height	134.71 ± 5.24**###	137.96 ± 5.49	132.12 ± 5.68	132.88 ± 5.58	134.79 ± 8.35	134.42 ± 7.87
	Weight	31.35 ± 5.81###	32.34 ± 4.94	29.76 ± 6.08	29.36 ± 5.59	32.09 ± 7.73	32.22 ± 8.1
	BMI(kg/m2)	17.21 ± 2.68###	16.92 ± 1.8	16.96 ± 2.72	16.54 ± 2.34	17.54 ± 3.21	17.63 ± 3.16
	BMI percentile	58.58 ± 30.59##	60.72 ± 27.69	54.67 ± 27.78	51.16 ± 29.0	59.23 ± 32.82	61.92 ± 29.36
	Overweight (%)	30.9###	28.3	19.8	16.5	31.1	29.3
	Obese (%)	5.5##	3.8	8.9	6.1	13.1	14.7
9	N	61	78	299	306	113	106
	Age	9.49 ± 0.29#	9.52 ± 0.26	9.45 ± 0.27	9.56 ± 0.37	9.57 ± 0.29	9.5 ± 0.29
	Height	140.39 ± 6.8*###	142.87 ± 6.47	136.74 ± 6.22	137.92 ± 6.25	138.13 ± 8.72	138.2 ± 6.46
	Weight	34.88 ± 7###	35.83 ± 6.64	32.11 ± 6.44	32.45 ± 6.44	35.3 ± 9.07	35.05 ± 7.72
	BMI(kg/m2)	17.57 ± 2.53###	17.47 ± 2.41	17.07 ± 2.60	16.96 ± 2.52	18.34 ± 3.65	18.25 ± 3.23
	BMI percentile	56.88 ± 26.31###	58.46 ± 26.48	39.96 ± 29.10	50.41 ± 28.94	59.76 ± 30.56	63.68 ± 27.86
	Overweight (%)	18.0###	16.7	16.1	15.9	27.4	33
	Obese (%)	6.6#	7.7	5.7	6.4	13.3	10.4
Total	N	304	332	923	948	383	375
	Age	7.73 ± 1.14###	7.76 ± 1.23	8.22 ± 1.10	8.26 ± 1.07	8.33 ± 1.06	8.29 ± 0.98
	Height	129.55 ± 9.55*###	131.2 ± 10.37	129.92 ± 8.60*	130.90 ± 8.25	132.38 ± 9.55	132.34 ± 8.58
	Weight	28.65 ± 6.83###	29.03 ± 6.77	28.40 ± 6.55	28.46 ± 6.18	31.15 ± 8.35	30.89 ± 7.65
	BMI(kg/m2)	16.87 ± 2.43###	16.65 ± 1.96	16.65 ± 2.46	16.46 ± 2.25	17.56 ± 3.25	17.44 ± 2.9
	BMI percentile	59.18 ± 28.6###	59.26 ± 27.69	53.06 ± 28.06	51.63 ± 28.68	60.02 ± 31.36	63.08 ± 29.31
	Overweight (%)	26.0###	21.4	17.6	15.7	30.5	32.0
	Obese (%)	9.5###	5.4	6.1	5.8	13.8	11.2

*Significant difference between sexes at the level $p < .05$; **Significant difference between sexes at the level $p < .01$; #Significant difference between regions at the level $p < .05$; ##Significant difference between regions at the level $p < .01$; ###Significant difference between regions at the level $p < .001$.

Table 2. Standardized values (mean ± standard deviation) of the four items of the KTK and the total test battery of the Finnish. Belgian and Portuguese boys and girls for all the age groups.

		Age group							
WB		6	7	8	9	Total	Age	Sex	Age × Sex
Finland	Girls	90.03 ± 14.03	97.48 ± 19.53	101.95 ± 12.17	104.84 ± 14.15	96.99 ± 16.34	F = 30.388	F = 0.00	F = 2.078
	Boys	89.46 ± 14.75	101.16 ± 15.48	103.75 ± 14.59	99.96 ± 15.31	96.92 ± 16.08	P < .001	P =.993	P = .102
	Mean	89.73 ± 14.38	99.34 ± 17.64	102.83 ± 13.38	102.1 ± 14.96	96.96 ± 16.19			
Belgium	Girls	94.16 ± 13.04	94.05 ± 13.02	95.34 ± 13.63	96.52 ± 14.74	94.97 ± 13.82	F = .904	F = 4.308	F = 1.008
	Boys	96.62 ± 14.09	96.55 ± 13.75	96.77 ± 15.33	96.44 ± 14.42	96.18 ± 14.54	P = .439	P < .05	P = 0.388
	Mean	95.27 ± 13.56	95.41 ± 13.46	96.08 ± 14.54	96.48 ± 14.57	95.59 ± 14.20			
Portugal	Girls	128.61 ± 14.77	125.6 ± 11.8	123.65 ± 10.46	119.95 ± 10.29	123.66 ± 11.65	F = 17.484	F = 39.604	F = 2.386
	Boys	129.59 ± 13.88	133.95 ± 9.5	130.04 ± 8.21	125.72 ± 9.53	130.02 ± 10.09	P < .001	P < .001	P = .068
	Mean	129.04 ± 14.31	130.05 ± 11.4	126.76 ± 9.94	122.74 ± 10.32	126.8 ± 11.36			
HH		6	7	8	9	Total	Age	Sex	Age × Sex
Finland	Girls	93 ± 13.06	104.05 ± 15.37	105.24 ± 11.95	104.64 ± 10.94	100.28 ± 14.2	F = 22.936	F = 21.450	F = 2.554
	Boys	102.06 ± 13.9	106.29 ± 14.86	111.15 ± 12.3	107.77 ± 11.75	105.83 ± 13.76	P < .001	P < .001	P = .055
	Mean	97.74 ± 14.22	105.18 ± 15.11	108.14 ± 12.43	106.4 ± 11.47	103.18 ± 14.23			
Belgium	Girls	99 ± 12.08	102.23 ± 13.23	103.36 ± 13.16	100.06 ± 13.07	100.85 ± 13.10	F = 1.766	F = 218.843	F = 9.480
	Boys	113.63 ± 11.11	110.75 ± 12.61	108.08 ± 13.64	108.93 ± 12.24	109.32 ± 12.74	P = .152	P < .001	P < .001
	Mean	105.59 ± 13.73	106.86 ± 13.56	105.82 ± 13.61	104.49 ± 13.41	105.14 ± 13.59			
Portugal	Girls	74.16 ± 6.24	72.99 ± 7.17	67.58 ± 8.01	63.33 ± 7.29	68.55 ± 8.46	F = 94.605	F = 191.162	F = 8.831
	Boys	89.32 ± 7.08	81.15 ± 7.65	72.06 ± 8.21	71.64 ± 10.52	76.39 ± 10.45	P < .001	P < .001	P < .001
	Mean	80.77 ± 10.03	77.35 ± 8.46	69.76 ± 8.4	67.35 ± 9.9	72.43 ± 10.27			
JS		6	7	8	9	Total	Age	Sex	Age × Sex
Finland	Girls	107.74 ± 12.56	114.2 ± 16.3	119.78 ± 14.99	118.95 ± 12.33	113.76 ± 14.8	F = 26.680	F = 0.791	F = 1.776
	Boys	109.59 ± 11.03	116.35 ± 13.32	121.6 ± 13.63	117.01 ± 12.74	114.82 ± 13.12	P < .001	P = .374	P = .508
	Mean	108.71 ± 11.8	115.29 ± 14.86	120.68 ± 14.3	117.86 ± 12.55	114.31 ± 13.95			
Belgium	Girls	104.62 ± 12.65	110.81 ± 15.17	111.54 ± 13.78	108.17 ± 13.27	108.46 ± 13.95	F = 15.211	F = 13.563	F = 1.950
	Boys	107.11 ± 10.67	113.76 ± 13.68	111.99 ± 14.63	111.59 ± 12.66	111.10 ± 13.41	P < .001	P < .001	P = .120
	Mean	105.74 ± 11.85	112.42 ± 14.44	111.77 ± 14.22	109.88 ± 13.07	109.80 ± 13.74			
Portugal	Girls	103.61 ± 12.55	108.06 ± 16.63	105.57 ± 16.84	98.16 ± 14.38	103.83 ± 16.06	F = 15.284	F = 44.325	F = .080
	Boys	112.53 ± 18.85	115.51 ± 15.24	114.28 ± 14.47	106.56 ± 15.23	112.33 ± 15.75	P < .001	P < .001	P = .971
	Mean	107.5 ± 16.13	112.04 ± 16.3	109.82 ± 16.29	102.22 ± 15.35	108.04 ± 16.46			
MS		6	7	8	9	Total	Age	Sex	Age × Sex
Finland	Girls	103.12 ± 14.4	110.04 ± 16.57	113.4 ± 15.64	111.92 ± 15.33	108.45 ± 15.87	F = 20.766	F = 4.747	F = 0.648
	Boys	104.54 ± 15.51	113.23 ± 14.01	118.92 ± 17.5	112.64 ± 12.02	110.76 ± 15.61	P < .001	P < .05	P = .584
	Mean	103.86 ± 14.98	111.66 ± 15.36	116.11 ± 16.73	112.32 ± 13.52	109.66 ± 15.77			
Belgium	Girls	100.88 ± 13.63	99.28 ± 12.05	101.83 ± 13.07	100.16 ± 14.07	100.02 ± 13.36	F = 0.393	F = 0.004	F = 3.110
	Boys	99.51 ± 12.72	101.99 ± 12.98	100.66 ± 14.95	100.54 ± 14.53	100.21 ± 13.99	P = .758	P = .948	P = .025
	Mean	100.27 ± 13.23	100.75 ± 12.63	101.22 ± 14.08	100.35 ± 14.29	100.12 ± 13.68			
Portugal	Girls	63.18 ± 5.35	58.41 ± 5.93	55.26 ± 4.79	53.66 ± 5.35	56.56 ± 6.12	F = 85.068	F = 30.597	F = 1.308
	Boys	67.03 ± 7.67	61.46 ± 6.36	57.07 ± 6.1	55.16 ± 4.77	58.83 ± 6.99	P < .001	P < .001	P = .271
	Mean	64.86 ± 6.7	60.04 ± 6.34	56.14 ± 5.53	54.39 ± 5.12	57.68 ± 6.66			
MC		6	7	8	9	Total	Age	Sex	Age × Sex
Finland	Girls	97.85 ± 13.73	108.17 ± 18.19	112.93 ± 13.78	112.82 ± 13.5	106.13 ± 16.26	F = 39.698	F = 5.616	F = 1.050

	Boys	101.68 ± 14.19	111.82 ± 14.96	117.7 ± 14.51	111.92 ± 12.46	108.99 ± 15.22	P < .001	P < .05	P = .370
	Mean	99.85 ± 14.07	110.02 ± 16.68	115.27 ± 14.28	112.32 ± 12.88	107.62 ± 15.78			
Belgium	Girls	99.41 ± 12.8	101.92 ± 13.42	103.74 ± 13.72	101.41 ± 14.7	101.23 ± 13.96	F = 2.137	F = 38.195	F = 2.463
	Boys	105.29 ± 11.86	107.27 ± 13.64	105.2 ± 15.21	105.49 ± 13.86	105.27 ± 14.07	P = .094	P < .001	P = .061
	Mean	102.06 ± 12.71	104.83 ± 13.78	104.5 ± 14.52	103.45 ± 14.42	103.28 ± 14.13			
Portugal	Girls	90 ± 10.32	88.57 ± 10.69	84.37 ± 10.98	78.91 ± 9.97	84.55 ± 11.29	F = 47.619	F = 99.420	F = 0.457
	Boys	99.35 ± 13.5	97.32 ± 9.57	91.28 ± 8.52	86.61 ± 9.51	92.61 ± 10.71	P < .001	P < .001	P = .712
	Mean	94.08 ± 12.62	93.24 ± 10.99	87.74 ± 10.43	82.64 ± 10.46	88.54 ± 11.71			

KTK. KörperkoordinationsTest für Kinder; WB, walking backwards; MS, moving sideways; HH, hopping for height; JS, jumping sideways; MC, motor competence.

Table 3. Main and interaction effects on motor competence according to geographical region, age, body mass index and sex.

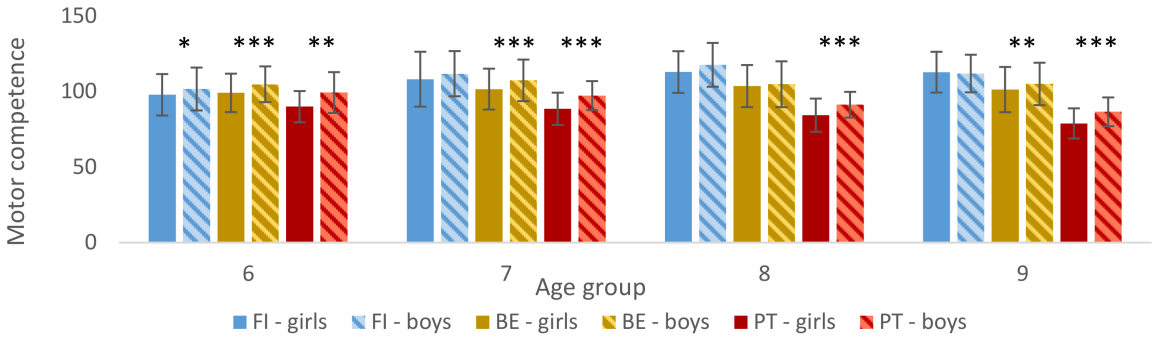
	Type III Sum of squares	*df*	Mean square	*F*	Sig	η_p^2
Model 1 (ANCOVA)						
Region	142635,633	2	71317,816	392,119	.000	.194
Age (covariate)	1686,581	1	1686,581	9,273	.002	.003
$BMI_{percentile}$ (covariate)	30189,825	1	30189,825	165,990	.000	.048
Sex (covariate)	17811,403	1	17811,403	97,931	.000	.029
Model 2 (2-way ANCOVA)						
Region	122441,798	2	61220,899	360,060	.000	.181
$Age_{6\text{-}9\text{-}years}$	7226,833	3	2408,944	14,168	.000	.013
$BMI_{percentile}$ (covariate)	30137,419	1	30137,419	177,248	.000	.052
Sex (covariate)	17111,363	1	17111,363	100,638	.000	.030
Region × $Age_{6\text{-}9\text{-}years}$	29386,325	6	4897,721	28,805	.000	.050
Model 3 (2-way ANCOVA)						
Region	142696,093	2	71348,047	394,484	.000	.195
Age (covariate)	1757,145	1	1757,145	9,715	.002	.003
$BMI_{percentile}$ (covariate)	30721,824	1	30721,824	169,861	.000	.050
Sex	16112,949	1	16112,949	89,089	.000	.027
Region × Sex	3665,137	2	1832,569	10,132	.000	.006
Model 4 (2-way ANCOVA)						
Region	115957,686	2	57978,843	326,444	.000	.167
Age (covariate)	1923,222	1	1923,222	10,829	.001	.003
$BMI_{healthy/overweight\ or\ obese}$	35084,598	1	35084,598	197,540	.000	.057
Sex (covariate)	16932,491	1	16932,491	95,337	.000	.028
Region × $BMI_{healthy/overweight\ or\ obese}$	1225,683	2	612,842	3,451	.032	.002

Region = Geographical region; ANCOVA = Analysis of covariance; BMI = Body mass index

Figure 1. The comparison of motor competence between the sexes in Finland, Belgium and Portugal.
* Significant sex difference at the level of $P < 0.05$; ** Significant sex difference at the level of $P < 0.01$;
*** Significant sex difference at the level of $P < 0.001$. FI = Finland; BE = Belgium; PT = Portugal.

Figure 2. Scatter plot of the association between age and motor competence for healthy weight, overweight and obese Finnish, Belgian and Portuguese children. Pearson correlation coefficients are presented for each body weight category.

Figure 3. Proportion of children across KTK performance ratings for the three geographical regions.



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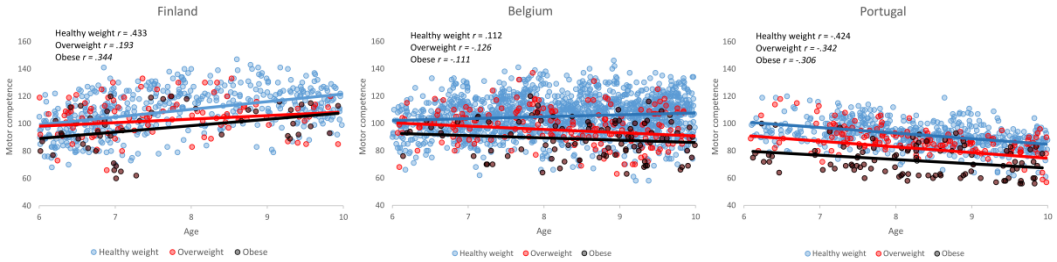

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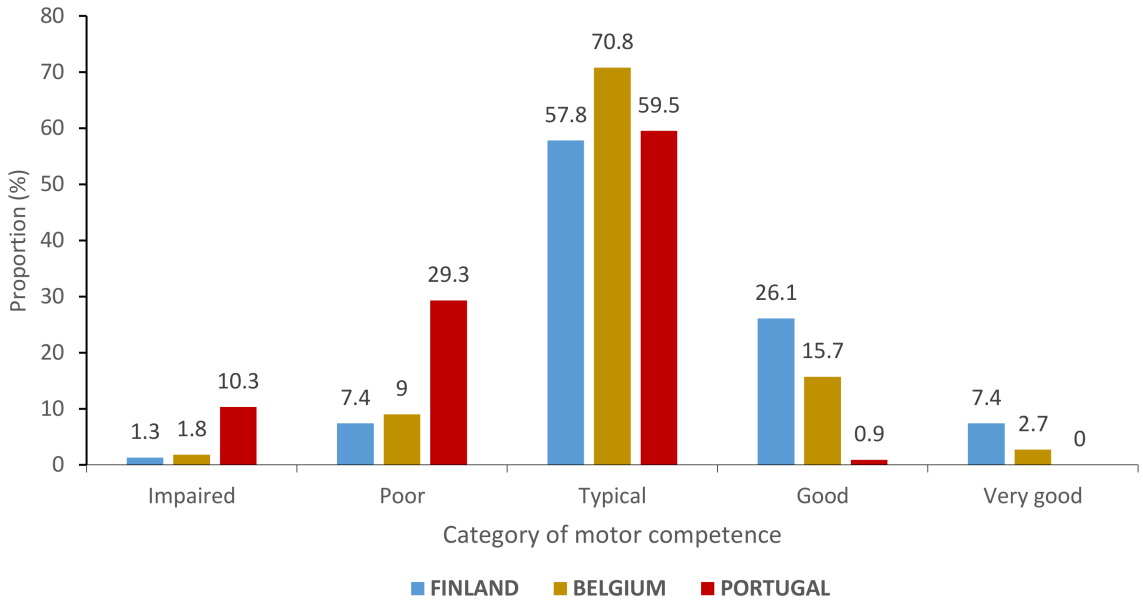

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