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BIOCULTURAL PREDICTORS OF MOTOR COORDINATION AMONG PRE-PUBERTAL SCHOOL CHILDREN

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Abstract:	This study aimed to predict motor coordination from a matrix of biocultural factors. The sample included 173 children (89 boys, 84 girls) aged 7-9 years assessed on the Körperkoordinationtest für Kinder test battery. Socioeconomic variables included built environment, area of residence, educational level and physical activity of the mothers [using the International Physical Activity Questionnaire (IPAQ; short version)]. The behavioural domain was marked by participation in organized sports and habitual physical activity measured by accelerometry (ActiGraph GT1M accelerometers). Indicators of biological development included somatic maturation and body mass index (BMI). Among males, the best logistic regression model to explain motor coordination (Nagelkerke R^2=50.8; χ^2=41.166; $p<0.001$) emerged from age group [odds ratio (OR): 0.007-0.065], late maturation (OR=0.174), normal body weight status (OR=0.116), educational level of the mother (OR=0.129) and urban area of residence (OR=0.236). It was also possible to obtain a logistic regression model for girls (Nagelkerke R^2=40.8; χ^2=29.933; $p<0.01$) derived from age (OR: 0.091-0.384), normal BMI (OR=0.142), participation in organized sport (OR=0.121) and physical activity level of the mother (OR=0.183). This sex-specific approach to proficiency level in motor coordination may be relevant for the ecological promotion of physical activity during pre-pubertal years and recommends a focus on family, in parallel to inter-individual variability in developmental biology.

Original Manuscript

BIOCULTURAL PREDICTORS OF MOTOR COORDINATION AMONG PRE-PUBERTAL SCHOOL CHILDREN

ABSTRACT

This study aimed to predict motor coordination from a matrix of biocultural factors. The sample included 173 children (89 boys, 84 girls) aged 7-9 years assessed on the *Körperkoordinationtest für Kinder* test battery. Socioeconomic variables included built environment, area of residence, educational level and physical activity of the mothers [using the International Physical Activity Questionnaire (IPAQ; short version)]. The behavioural domain was marked by participation in organized sports and habitual physical activity measured by accelerometry (*ActiGraph GT1M* accelerometers). Indicators of biological development included somatic maturation and body mass index (BMI). Among males, the best logistic regression model to explain motor coordination (Nagelkerke R^2=50.8; χ^2=41.166; p<0.001) emerged from age group [odds ratio (OR): 0.007-0.065], late maturation (OR=0.174), normal body weight status (OR=0.116), educational level of the mother (OR=0.129) and urban area of residence (OR=0.236). It was also possible to obtain a logistic regression model for girls (Nagelkerke R^2=40.8; χ^2=29.933; p<0.01) derived from age (OR: 0.091-0.384), normal BMI (OR=0.142), participation in organized sport (OR=0.121) and physical activity level of the mother (OR=0.183). This sex-specific approach to proficiency level in motor coordination may be relevant for the ecological promotion of physical activity during pre-pubertal years and recommends a focus on family, in parallel to inter-individual variability in developmental biology.

KEYWORDS:

Built environment, Socioeconomic status, Familial determinants, Accelerometry, Physical activity

INTRODUCTION

Motor competence is considered an important predictor of activity and fitness in children (Stodden et al., 2008). A systematic review evidenced positive associations among fundamental motor skill, coordination, physical activity, and fitness in young people (Lubans, Morgan, Cliff, Barnett, & Okely, 2010). While there are several tools to assess movement skills (Cools, Martelaer, Samaey, & Andries, 2009), the *Körperkoordinationtest für Kinder* (KTK; Kiphard & Schilling, 1974) has emerged as popular battery in the assessment of motor coordination for both research and practical purposes (Freitas et al., 2015; Henrique et al., 2017; Lopes, Santos, Pereira & Lopes, 2013). The KTK battery involves measurements of gross body control and coordination, and its current version corresponds to a shortened adaptation of a 6-item protocol (Cools et al., 2009).

The development of motor coordination has received considerable attention (Freitas et al., 2015; Henrique et al., 2017; Kerr, 1975; Lopes et al., 2013; Seils, 1951). That said, specific aspects of motor development have traditionally been considered in isolation. Freitas et al. (2015) examined the relationship among skeletal maturation and gross motor coordination in children aged 7-10 years (213 boys, 216 girls) using hierarchical multiple regression. Skeletal maturation explained 7% of the variance in motor coordination beyond that attributed to body size, leading these researchers to conclude that maturation alone, or even in interaction with body size, has a negligible influence on motor performance. By inference, Freitas et al. (2015) suggested that inter-individual differences in neuromuscular maturation, interacting with environmental conditions, would be the primary factors influencing fundamental motor skills and motor coordination.

The impact of sex, rearing style and age on motor competence might vary across socio-geographic contexts characterized by distinct degrees of active transportation and social autonomy (Barnett et al., 2016), among other determinants. Physical activity, motor performance and motor coordination occur in cultural and social contexts, including free play, Physical Education, recess, and competitive sport (Malina, Cumming, & Coelho, 2016). The purpose of the current study was to investigate variance in motor coordination in relation to a broad spectrum of correlates, including built environment, familial characteristics such as maternal education and maternal physical activity, physical growth of the children, sex, and biological maturation. In accordance with two recent papers advancing a biocultural approach to the study of physical activity and movement proficiency (Barnett et al., 2016; Malina et al., 2016), the current study hypothesized that this broad framework would provide gender-specific comprehensive hierarchical models to explain inter-individual variability in the development of motor coordination among primary school children.

METHODS

Procedures and participants

The Scientific Committee of the Faculty of Sports Sciences and Physical Education of the University of Coimbra approved this research, and the proposal was then registered at the *Portuguese Commission for Data Protection* [process: 1014/2015]. The research project was approved by the Ethics Committee of the *University of Coimbra* (CE/FCDEF-UC/00092014). The participants were randomly recruited from private and public primary schools in Mondego Valley (Portuguese Midlands) taking into account institutional agreements of cooperation with the University of Coimbra. Mondego Valley is an administrative geographic unit comprising 332.306 inhabitants and 2.062 km^2 and has eight councils. Parents or legal guardians of 300 children were contacted to sign an informed consent and children were informed about the goals of the study and that their participation was voluntary. From the initial sample, 90 children failed the return of signed informed consent. Afterwards, the following inclusion criteria were considered: (i) not being injured or physically restricted for efforts, such as suffering from asthma; (ii) being present in the three Physical Education classes used to carry out the assessments; (iii) completed information about midparental stature obtained by questionnaire; (iv) completeness of the International Physical Activity Questionnaire (IPAQ) by mothers; (v) compliance to registered time as detailed for accelerometry. The final sample comprised 173 children (89 boys, 84 girls) aged 7.00-9.90 years. Data were collected in the schools during visits to school by an unique research team. The data collection emerged from 10 classes (usually 20-25 participants). Each class requested three visits within 15 days. The first visit included the completion of a built environment questionnaire in parallel to questions regarding family and personal data. A second session was used for anthropometry and accelerometry. The final session was used to assess motor coordination using the *Körperkoordinationtest für Kinder* (KTK) and completion of the questionnaires, anthropometry and accelerometry.

Measurements

Anthropometry and body mass index: Stature was measured with a stadiometer (Harpenden model 98.603, Holtain Ltd, Crosswell, UK) to the nearest 0.1 centimeter (cm). Body mass was recorded using a portable scale (Seca model 770, Hanover, MD, USA) to the nearest 0.1 kilogram (kg). Waist circumference measurement was performed using a non-elastic tape following standardized procedures (Lohman, Roche, & Martorell, 1988). Waist-to-stature ratio was calculated as a percentage. Replicated assessments were taken from 19 students 1-week apart with technical errors as follow: stature = 0.6 cm, body mass = 0.6 kg, waist circumference = 1.6 cm; this process yielded respective reliability coefficients of 0.98; 0.99; 0.93. Body mass index (BMI) was calculated using the standard formula: BMI = [body mass (kg) × (stature (m)^2)]. Overweight and obesity were defined according to the BMI cut-off points established by the International Obesity Task Force (Cole, Bellizzi, Flegal, & Dietz, 2000).

Skinfolds and body composition: Triceps and subscapular skinfold measurements were made with Lange skinfold callipers (Beta Technology, Santa Cruz, California, USA) following standardized procedures (Lohman et al., 1988). Fat mass (in percentage and in kg) was derived from skinfold thickness using an equation for young people (Slaughter et al., 1988). Technical errors of measurement and reliability coefficients for skinfolds ranged between 1.0–1.4 millimeters (mm) and 0.94–0.98, respectively.

Biological maturation: The Khamis-Roche method was used to estimate mature stature (Khamis & Roche, 1994). The method requires current stature and body mass from each children and respective midparental stature. Data about the stature of biological parents were obtained as part of the familial questionnaire. Parent statures were extracted from national identification cards, which included stature that was measured to the nearest centimeter. After calculating predicted mature stature (PMS), current stature was expressed as a percentage of PMS (that is, %PMS). The method assumes that among children of the same chronological age, individuals closer to predicted mature stature are advanced in biological maturation compared with individuals who are further from predicted mature stature. Subsequently, for each individual, z-scores of %PMS was calculated from sex-and age-specific means and standard deviations obtained from the Berkeley Guidance Study (Bayer & Bayley, 1959). Individuals contrasting in somatic maturation were grouped into two groups using specific median of z-scores derived from %PMS: group 1 corresponded to half of the sample with lowest z-scores or latest maturing children (scores below the median), and group 2 was composed of the half of the sample with highest z-scores or earliest maturing children (scores above the median).

<u>*Accelerometry*</u>: Physical activity was assessed with *ActiGraph GT1M* accelerometers (ActiGraph™, LLC, Fort Walton Beach, FL, USA) to obtain individual objective information from each child in the study. Participants were instructed to wear the accelerometer on the hip (held by an elastic belt) for five consecutive days: three-week days and two weekend days (Lopes, Santos, Mota, Pereira, & Lopes, 2017). The measurement epoch was set at 15 seconds (Ward, Evenson, Vaughn, Rodgers, & Troiano, 2005). Children were instructed to remove the accelerometer during water activities. Data was downloaded into a computer using the *Actilife Software,* and data was analysed using a specific application (MAHUffe; see www.mrc-epid.cam.ac.uk). Periods with 20 minutes of consecutive zeros were detected and flagged as non-wear time (Andersen et al., 2006). Inclusion criteria for accelerometer data acceptability were: a minimum of three days (two-week days and one weekend day) and a minimum

of 600 minutes valid data per day. A similar procedure was adopted in previous studies (Andersen et al., 2006; Baptista et al., 2012; Lopes et al., 2017). The established accelerometer age-specific cut-points as proposed by Freedson, Pober, and Janz (2005) were adopted to obtain physical activity intensity levels expressing the energy cost METs (multiples of energy expenditure while resting). The present study assumed four METs as the threshold for moderate intensity (Baptista et al., 2012; Trost, Loprinzi, Moore, & Pfeiffer, 2011), and seven METs for vigorous intensity (Baptista et al., 2012). Sedentary time was identified using a cut off value of <100 counts.min^{-1} (Trost et al., 2011). Physical activity levels were expressed as the average number of minutes of physical activity on valid days.

<u>*Motor coordination*</u>: Motor coordination was evaluated using a battery of tests termed KTK - *Körperkoordinationtest für Kinder* (Kiphard & Schilling, 1974). Psychometric characteristics of the KTK revealed test-retest reliability coefficients for each item ranging from 0.80-0.96. The test battery includes four items: walking backward on balance beams (WB), jumping sideways across a wooden slat (JS), moving sideways on boxes (MS), and hopping for height on one leg (HH). The KTK has been used to evaluate children's gross motor performance (Freitas et al., 2015; Lopes et al., 2013). We analysed KTK data with gender-specific composite z-scores from the four KTK items: WB, JS, MS, and HH.

<u>*Built environment*</u>: To assess parent-perceived neighbourhood characteristics in the familial environment, the short version of the Assessing Levels of Physical Activity and Fitness (ALPHA) questionnaire (Spittaels et al., 2010) was used. This instrument was designed to assess the activity-friendly neighbourhood characteristics: access to

destination; connectivity of the street network; infrastructures for walking and cycling; safety of the neighbourhood; social environment; aesthetics; facilities for recreational activities. The definition of neighbourhood corresponded to a 1-km distance from home (Spittaels et al., 2010). The ALPHA included ten binary questions ('Yes'=1; 'No'=0, except for questions about safety: 'No'=1 and 'Yes'=0). The intraclass correlation coefficient of the total sum score of the ALPHA short version was 0.73. For the specific items, agreement rates ranged from 85 to 95% (Spittaels et al., 2010). In the present study, total scores ranged from 3-8, as some questions were not applicable to children. The sample was grouped according to median value as follows: (a) poor neighbourhood perceptions were defined as ≤ 6 total points; and (b) positive neighbourhood perceptions were defined by > 6 total points.

Area of residence: According to criteria by the *Portuguese Institute of Statistics* (Moteiro, 2000), rural communities were defined as having no more than 100 inhabitants/kilometer^2 or a total population < 2000 inhabitants, and we defined all other communities as urban.

Maternal education: The educational background of the mother was obtained from institutional records at the primary schools. Based on the *Portuguese Educational System,* three groups were initially created: (a) low education (< 9 years of formal education, primary or elementary level); (b) middle education (10-12 years of formal education, corresponding to secondary school level); and (c) high education (> 12 years of formal education, university level). In the present study, the variable was dichotomized into high (c) and low (a + b).

Physical activity level of the mother: The physical activity level of the mother was assessed using with the IPAQ (short version) and data was handled according to the IPAQ scoring protocol. The IPAQ demonstrated acceptable properties for monitoring population levels of physical activity among 18-to 65-year-old adults (Craig et al., 2003). The short IPAQ form has been shown to be reliable (Spearman's ρ = 0.76) and valid (Spearman's ρ = 0.30). Subjects were categorized into insufficiently and sufficiently active according to the ACSM/AHA physical activity guidelines (Haskell et al., 2007): (a) insufficiently active was defined as <150 minutes/week^{-1} of at least moderate-intensity physical activity or <20 minutes/week^{-1} of vigorous-intensity physical activity; and (b) sufficiently active was defined as >150 minutes/week^{-1} of at least moderate-intensity physical activity or 20 or more minutes/week^{-1} or more of vigorous-intensity physical activity.

Sport Participation: Children were also requested to identify the sports they engaged in during the previous 12 months. Additional information was obtained by interview and sport participation was defined as engaging in activities that implied a formal registration in a sport organization (mostly clubs and federations) supervised by a certified coach (Mota, Almeida, Santos, Ribeiro, & Santos, 2009).

Data Analysis

Descriptive statistics were calculated for males and females and sex differences were tested using independent t-student tests. The magnitude of the differences was then assessed using standardized mean differences (Cohen's d effect sizes and thresholds of 0.20, 0.60, 1.20, 2.0 and 4.0 for small, moderate, large, very large and extremely large)

(Hopkins, Marshall, Batterham, & Hanin, 2009). Normal distribution was checked using the Kolmogorov-Smirnov test and log-transformed variables were obtained when adequate. Multivariate logistic regression was used to examine the association among biological factors, behavioural attributes, and social and built environmental factors on sex-specific KTK performance level. These variables were entered into the logistical regression analyses following the order: (a) biological factors in model 1; (b) biological factors and behavioural attributes in model 2; (c) biological factors, behavioural attributes, and family characteristics in model 3; and (d) all prior variables plus environmental factors in model 4. Odds ratios (OR) and respective 95% confidence limits (CL) were reported for each model, and statistical significance level was settled at 0.05. Statistical analyses were performed using SPSS 22.0.

RESULTS

Sex-specific descriptive statistics are presented in Table 1. Girls showed higher values than boys for attained mature stature (d=-1.98) and estimated fat mass (d=-0.46). Boys presented higher mean values than girls for estimated fat-free mass (d=0.49). Boys attained higher levels than girls on physical activity (d=0.79) and KTK motor coordination [JS (d=0.31) and HH (d=0.45)]. Descriptives for perceived environments assessment and biological variables for boys and girls are summarized in Table 2. The present data indicated a significant association between sex and poor neighbourhood perceptions [χ^2=4.544, p=0.04]. Data also indicated a significant association between sex and normal BMI [χ^2=11.467, p<0.01].

**** Table 1 near here ****

**** Table 2 near here ****

The association between motor coordination and biological, behavioural, social and built environmental factors in the four models is shown in Figure 1. In both genders, motor coordination was associated with biological factors (Boys: R^2=38.5; p<0.001; Girls: R^2=19.4; p<0.05), and this association increased when behavioural attributes were added to the logistic analysis in model 2 (Boys: R^2=40.2; p<0.001; Girls: R^2=26.2; p<0.01), social factors were added in model 3 (Boys: R^2=44.6; p<0.001; Girls: R^2=40.1; p<0.001), and built environment were included in model 4 (Boys: R^2=50.8; p<0.001; Girls: R^2=40.8; p<0.01).

**** Figure 1 near here ****

As expected, boys classified as latest maturing and with normal body mass were more likely to attain better motor coordination, compared with their earliest maturing (OR=0.174; 95% CL=0.047: 0.639) and overweight (OR=0.116; 95% CL=0.017: 0.772) peers (Table 3). Higher level of maternal education (graduate level completed) was significantly associated with an increased likelihood of having a high level of motor coordination. Boys residing in urban areas were more likely to have high KTK motor coordination performance compared to boys residing in rural areas (OR=0.236; 95% CL=0.063: 0.888). The final regression model (model 4) revealed that girls with normal body mass were more likely to have a high level of motor coordination compared to their overweight peers (OR=0.142; 95% CL=0.033: 0.608). Finally, participants in the organized sport participation group and with higher level of maternal physical activity exhibited significantly better KTK scores than their peers without sports participation

(OR=0.121; 95% CL=0.018: 0.805) and mothers insufficiently active (OR=0.183; 95% CL=0.052: 0.642).

**** Table 3 near here ****

DISCUSSION

Meanings and values attached to physical activity and motor proficiency vary with age and sex among school children. Young people commonly view motor activities in terms of fun and/or play and not necessarily as health-promoting forms of physical activity. A biocultural approach is needed to capture the complex interactions between biological (maturation, growth) and behavioural (meanings, perceptions, values) variables that are associated with motor proficiency (Malina et al., 2016). The results of the present study provide relevant insights with regard to the nature and direction of relations among motor competence, physical growth and biological maturation, family characteristics and built environment.

An important and unique aspect of this study was the consideration of a broad range of biological, psychosocial, behavioural, and environmental correlates of motor proficiency. Previous studies have applied hierarchical multiple regression approaches, using quantitative variables from a single biological perspective (Freitas et al., 2015; Rudd et al., 2016). The results of the present study suggest that the impact of maturation on motor coordination may favour late maturing boys, as previously supported by parameters of running economy among young soccer players. More specifically, late maturing males in soccer have been shown to possess longer relative stride length expressed as percentage of leg length compared to early maturing peers (Segers, De Clercq, Janssens, Bourgois, & Philippaerts, 2008).

The importance of cultural and contextual factors in relation to motor proficiency was also highlighted in the current study. Urban boys, for example, were more likely to attain superior scores in motor coordination. This observation may result from urban boys having more social autonomy in terms of play and/or walking to the metro or bus. This particular aspect may also be linked with rearing style and maternal education, as evidenced in the present study for boys. Accordingly, children growing up in cultures in which participation in organized sport is encouraged and valued, and with mothers who demonstrate higher level of habitual physical activity may be more likely to develop superior motor skills, especially in the case of girls.

Prior research focused predominantly on relationships between KTK motor coordination performance and biological variables and showed, for example, an inverse relationship between KTK performance and BMI in Brazilian children (Luz et al., 2015). The current research confirmed that boys and girls of normal weight (as determined by age and gender specific BMI criteria) had higher KTK scores compared to their overweight or obese peers. As expected for boys, being delayed was associated with the better scores in KTK battery and this is consistent with the literature that relates an early maturing status to an advantage, uniquely for those motor tasks that do not require body displacement (Malina, Bouchard, & Bar-Or, 2004). The influence of skeletal maturation on motor coordination was recently identified as sex-specific and most likely during early ages of the second decade of life (Freitas et al., 2016). Moreover, Freitas et al. (2016) concluded that the percentage of variance in motor coordination skills explained by biological maturation was generally small, but differed between boys and girls (aged 11-14 years).

Several studies have previous investigated the relationship between KTK performance and behavioural (Henrique et al., 2017; Lopes et al., 2013; Opstoel et al., 2015) and environmental variables (Chaves et al., 2015). Henrique et al. (2017) investigated gross motor coordination (using KTK) among 245 boys and girls who were assessed longitudinally from 6 to 9 years of age and concluded that children who consistently demonstrated high levels of motor coordination during the 4 years of follow-up were lighter, had lower BMI and subcutaneous fat, and showed higher scores in physical fitness tests at 6 years of age than those who consistently had low levels in KTK. In addition, Laukkanen, Pesola, Havu, Sääkslahti, and Finni (2014) examined the relationship between gross motor skills also assessed by KTK battery and accelerometer-derived physical activity among 84 Finnish aged 5-8 years (53 pre-schoolers, 28 girls; 31 primary schoolers, 18 girls) and concluded that gross motor skills were associated with mean level of physical activity in primary school girls but not in boys. Although it is not possible to establish causal relation from these studies, it would appear that many of the aforementioned factors are associated with variance in motor proficiency and healthy weight status (Padez, Fernandes, Mourao, Moreira, & Rosado, 2004). The results of the current investigation indicated that girls who participated in organized sports were more likely to attain better KTK scores. In other words, the result emphasizes an important relationship between gross motor skills and type of physical activity programs stressing both metabolic and neuromuscular systems in primary school children (Opstoel et al., 2015). Collectively, these results highlight the importance of encouraging girls to both participate and remain in competitive sports.

Going forward, it will be important to better understand what girls want from sports programmes and how they can be best designed to help girls achieve these objectives.

In the present study, the level of maternal education was used as a proxy marker of the economic status of the family (Lopes et al., 2013), and it was positively related to higher KTK scores in boys. For girls, maternal physical activity levels were the significant familial predictor of higher KTK scores, perhaps because mothers who tended to be physically active served as role models (Moore et al., 1991).

Environmental factors such as the physical and built environment should also be considered when examining inter-individual differences in motor competence and physical activity. Chaves et al. (2015) studied 390 Portuguese children aged 6-10 years and concluded that school having larger surface area for free physical activity presented a small but significant relationship to higher KTK values. In the present study and regarding the influence of the built environment, it was not possible to detect a relationship between with ALPHA questionnaire and KTK values for either boys or girls. It is possible to hypothesize that school at the ages of the current study may provide more experiences and time compared to neighbourhood which may be more prominent during adolescence. There is a need to extend studies of physical activity and movement proficiency to different cultural contexts and impact of social and environmental determinants should not be generalized. Walhain, van Gorp, Lamur, Veeger, and Ledebt (2016) studied 156 children and did not observe differences in the KTK total motor quotient among urban and countryside residents. However, when KTK tests were analysed in isolation, urban children obtained lower scores on walking backward and jumping sideways, and high scores on hopping for height and moving sideways.

The present study is unique in that it simultaneously examined the extent to which biological factors, lifestyle, and social and built environment factors may contribute to variance among children in their performance on KTK motor coordination tasks. However, limitations include a cross-sectional design that does not permit causal inference, sample size somatic indicators of biological maturation. Nevertheless, results appeared generally consistent with other studies that used skeletal age as an indicator of maturational status (Freitas et al., 2016; Freitas et al., 2015) and did not evidenced a substantial estimation of explained variance in motor coordination items.

In summary, the present study reinforced motor coordination as associated with biological factors in parallel to behavioural attributes, familial determinants, and built environment. Of importance, distinct sex-specific models emerged for practical interventions. Ecological models are of interest in framing potential programs to enhance motor development of primary school children.

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DECLARATION OF CONFLICTING INTERESTS

The authors declared no potential conflict of interest with respect to the research, authorship, and/or publication of this article.

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TABLE LEGEND

Table 1. Descriptive statistics for boys and girls and results of independent t-test for sex differences including effect size.

Table 2. Descriptive statistics for qualitative variables in boys and girls and results of the chi-squared test between groups.

Table 3. Logistic regression model estimating the Odds Ratio for beter KTK performance in boys and girls.

FIGURE LEGEND

Figure 1. Logistic regression models using four blocks of variables to study the influence of biological factors, behavioural attributes, social factors and built environmental factors on the KTK performance of boys (n=86) and girls (n=82).

Model 1 - biological factors (chronological age, biological maturation and body mass index); model 2 includes all variables of model 1 and behavioural attributes (organized sport participation and average intensity of physical activity); model 3 includes all variables of model 2 and social factors (maternal education and maternal physical activity); model 4 includes all variables of model 3 and built environmental factors (environment assessment and area of residence).
KTK= *Körperkoordinationtest für Kinder*. *R-squared*= Nagelkerke *R-squared*.
$^{*}p<0.001$; $^{**}p<0.01$; $^{***}p<0.05$ (Omnibus test).

Table 1. Descriptive statistics for boys and girls and results of independent t-test for sex differences including effect size.

Variables	Units	Descriptive statistics				Comparisons					
		Boys (n = 89)		Girls (n = 84)		Mean differences		t-test		Effect size	
		Mean	SD	Mean	SD	Value	(95% CL)	*t*	p	*d*	(qualitative)
Biological variables											
Chronological age	years	8.62	0.65	8.52	0.55	0.10	(-0.08; 0.29)	1.153	0.25	0.16	(Trivial)
Predicted mature stature (PMS)	cm	178.1	6.2	165.7	5.0	12.4	(10.8; 14.1)	14.518	<0.01	2.18	(Very large)
Attained PMS	%	74.0	2.2	79.0	2.8	-5.0	(-5.8; -4.3)	-13.137	<0.01	-1.98	(Large)
Stature	cm	131.8	6.0	130.9	6.0	0.9	(-0.9; 2.7)	0.975	0.33	0.15	(Trivial)
Body mass[a]	kg	29.7	4.5	30.0	5.5	-0.3	(-1.8; 1.2)	-0.233	0.82	-0.06	(Trivial)
Waist circumference[a]	cm	59.0	4.9	59.2	6.2	-0.2	(-1.9; 1.5)	-0.121	0.90	-0.04	(Trivial)
Waist-to-stature ratio[a]	%	44.8	3.8	45.2	4.3	-0.4	(-1.6; 0.8)	-0.670	0.50	-0.10	(Trivial)
Fat mass[a]	kg	7.2	3.2	8.8	3.7	-1.6	(-2.7; -0.6)	-3.337	<0.01	-0.46	(Small)
Fat-free mass[a]	kg	22.5	2.6	21.2	2.7	1.3	(0.5; 2.1)	3.288	<0.01	0.49	(Small)
Accelerometry[b]											
Average physical activity	$counts.min^{-1}$	649	154	532	141	117	(73; 162)	5.201	<0.01	0.79	(Moderate)
Registered time	$min.day^{-1}$	803	56	799	45	4	(-11; 20)	0.549	0.58	0.08	(Trivial)
Sedentary time	$min.day^{-1}$	432	68	435	75	-3	(-24; 19)	-0.192	0.85	0.04	(Trivial)
Activity time	$min.day^{-1}$	371	67	365	80	6	(-16; 29)	0.562	0.58	0.08	(Trivial)
Light physical activity[a]	$min.day^{-1}$	258	47	279	62	-21	(-37; -5)	-2.231	0.03	-0.38	(Small)
Moderate physical activity	$min.day^{-1}$	93	31	74	26	19	(11; 28)	4.445	<0.01	0.66	(Moderate)
Vigorous physical activity[a]	$min.day^{-1}$	20	11	12	7	8	(5; 11)	5.517	<0.01	0.86	(Moderate)
Motor coordination											
Walking backward	#	40.1	13.6	39.0	14.6	1.1	(-3.2; 5.3)	0.506	0.61	0.08	(Trivial)
Jumping sideways	#	49.4	13.7	45.7	9.7	3.7	(0.2; 7.3)	2.077	0.03	0.31	(Small)
Moving sideways[a]	#	32.0	6.2	30.7	5.0	1.3	(-0.4; 3.0)	1.188	0.24	0.23	(Small)
Hopping for height	#	47.6	14.5	41.6	2.0	6.0	(2.0; 10.0)	2.968	0.03	0.45	(Small)

PMS = predicted mature stature; SD = Standard deviation; 95% CL = 95% Confidence limits; *d* = Cohens'd effect size.
[a] Log-transformed values were used in the analysis; [b] Mean value from valid measured days.

Table 2. Descriptive statistics for qualitative variables in boys and girls and results of the chi-squared test between groups.

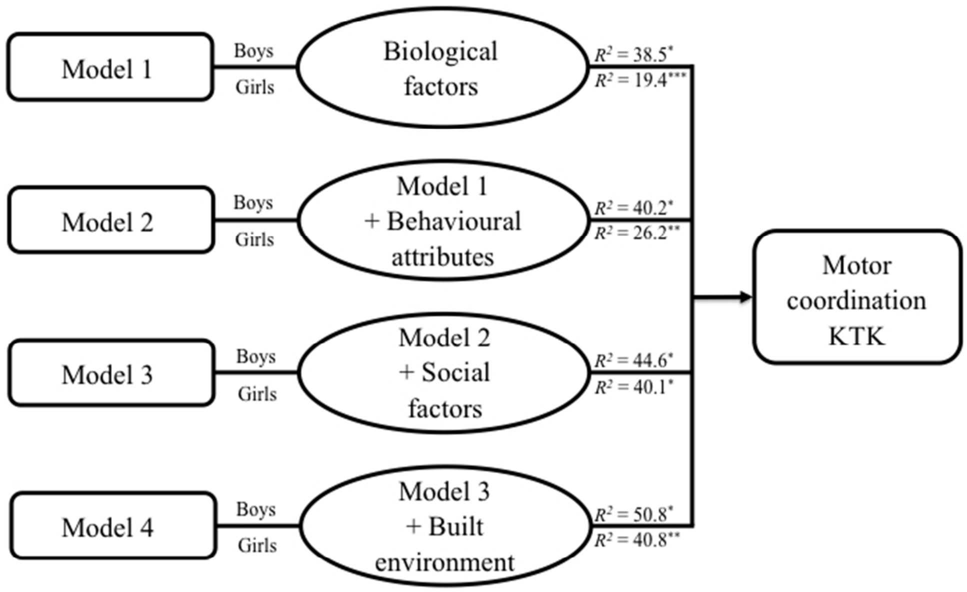
Domain	Variable	Descriptive statistics				Chi-squared	
		Boys (n=86)		Girls (n=82)		$\chi 2$	*p*
		n	%	n	%		
Built environment	Environmental Assessment					4.544	0.04
	Higher score	40	46.5	25	30.5		
	Lower score	46	53.5	57	69.5		
	Area of residence (urban)					0.007	0.93
	Yes	54	62.8	52	63.4		
	No	32	37.2	30	36.6		
Social factors	Maternal education					0.295	0.59
	High	71	82.6	65	79.3		
	Low	15	17.4	17	20.7		
	Maternal physical activity					1.948	0.16
	Sufficiently active	66	76.7	55	67.1		
	Insufficiently active	20	23.3	27	32.9		
Behavioural attributes	Organized sport					0.123	0.73
	Yes	76	88.4	71	86.6		
	No	10	11.6	11	13.4		
Biological factors	Chronological age					4.706	0.09
	7.00-7.99 years	11	12.7	15	18.3		
	8.00-8.99 years	47	54.7	52	63.4		
	9.00-9.90 years	28	32.6	15	18.3		
	BMI					11.467	<0.01
	Overweigh/Obesity	12	14.0	30	36.6		
	Normal	74	86.0	52	63.4		

BMI = Body Mass Index.

Table 3. Logistic regression model* estimating the Odds-Ratio for better KTK performance in boys and girls.

Domain	X_i: Independent variables	Y_i: Motor coordination (KTK)			
		Boys (n=86)		Girls (n=82)	
		Odds ratio	95% CL	Odds ratio	95% CL
Built environment	Environmental assessment				
	Higher score[a]	1		1	
	Lower score	0.412	(0.120; 1.419)	0.629	(0.186; 2.130)
	Area of residence (urban)				
	Yes[a]	1		1	
	No	0.236	(0.063; 0.888)	1.038	(0.329; 3.276)
	Maternal education				
	High[a]	1		1	
	Low	0.129	(0.019; 0.889)	0.299	(0.075; 1.196)
	Maternal physical activity				
	Sufficiently active[a]	1		1	
	Insufficiently active	1.566	(0.424; 5.783)	0.183	(0.052; 0.642)
Behavioural attributes	Organized sport				
	Yes[a]	1		1	
	No	1.567	(0.216; 11.389)	0.121	(0.018; 0.805)
Physical activity	Counts/minute	1.003	(0.999; 1.007)	1.004	(1.000; 1.009)
Biological factors	Age group				
	9.00-9.90 years[a]	1		1	
	8.00-8.99 years	0.065	(0.013; 0.321)	0.384	(0.087; 1.694)
	7.00-7.99 years	0.007	(0.000; 0.141)	0.091	(0.012; 0.690)
	Somatic maturation (z-score)				
	Lower[a]	1		1	
	Higher	0.174	(0.047; 0.639)	0.824	(0.218; 3.115)
	BMI				
	Normal[a]	1		1	
	Overweigh/Obesity	0.116	(0.017; 0.772)	0.142	(0.033; 0.608)

* The logistic regression model explained 50.8% (Nagelkerke R^2) of the variance in the performance in boys (Omnibus test: $\chi 2 = 41.166$; $p<0.001$) and 40.8% in girls (Omnibus test: $\chi 2 = 29.933$; $p<0.01$); KTK= *Korperkoordinationstest fur Kinder*; 95% CL= 95% confidence limits; [a]Reference category.



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KTK= Korperkoordinationstest fur Kinder. R2= Nagelkerke R2.
*p<0.001; **p<0.01; ***p<0.05 (Omnibus test).

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