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Tracking of gross motor coordination

Tracking of gross motor coordination from childhood into adolescence

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Abstract

Purpose: To analyze tracking and stability of motor coordination in children from age 6 years to ages 9 and 13 years. **Methods:** Data are from the Copenhagen School Child Intervention Study. Motor coordination (MC) was measured using the KTK-test. The crude performance score on every item was converted into a standardized 'score' based on the original German reference study, which was used to generate a total MQ-Score. The MQ-Scores, which represented children's level of gross MC, were classified as low (MQ-Score<85), normal (MQ-Score=85–115) or high (MQ-Score>115). Pearson correlation was used to calculate the tracking coefficients of each KTK element and MQ-Score, and weighted kappa used to analyze maintenance in MC classification groups. Mixed-effects logistic regression analyses were performed to examine the odds of remaining in the low motor coordination group over time based on BMI, weight and height tertiles. **Results:** Tracking coefficients among the MQ-Score and each KTK element at different ages were moderate ($r>0.35$). Children in the highest BMI and weight tertiles had a 5.44 and 5.15 times greater chance to be in lower MC classification group during the seven-year follow-up, respectively, in comparison with children in their lowest tertiles. **Conclusion:** Motor coordination tracked moderately through childhood to early adolescence. Since heavier children had higher chance to be in lower MC group membership at older ages, intervention may be useful at earlier ages for those with lower MC and disadvantageous weight status.

Key-words: Physical activity, longitudinal, motor development, fundamental motor skills

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Fundamental motor skills (FMS) are a group of motor skills individuals begin to learn during early childhood. FMS are comprised of locomotor skills and object control skills. Locomotor skills are those used to move the body through space. Examples of locomotor skills are running, galloping, skipping, hopping, sliding, and leaping (Haywood & Getchell, 2005). Object control skills consist of manipulating and projecting objects (e.g., throwing, catching, dribbling, kicking, striking, and rolling) (Haywood & Getchell, 2005). Locomotor and object control skills can be assessed via process-based or product-based measures. Often, when product-based measures of locomotor skill performance are assessed, the performance outcomes are referred to as motor coordination (Clark & Metcalfe, 2002). FMS are important in child development, since theoretical frameworks support the idea that FMS form the foundation for future physical activity engagement (Clark & Metcalfe, 2002; Stodden et al., 2008).

Tracking is a term used to describe the stability of the development of a characteristic over time and involves the longitudinal stability of the variable of interest (Twisk, Kemper, & Mellenbergh, 1994). Malina (1996) reported the tracking coefficients of FMS from previous studies. However, the test batteries did not exclusively address FMS and included several assessments of physical fitness. In addition, the studies reviewed by Malina (1996) analyzed the tracking components in late adolescence and adulthood (Malina, 1996). Ahnert, Schneider, and Bös (2009) published the first study to follow children with direct measures of motor coordination (using the *körperkoordinationstest für Kinder*–KTK) from childhood (8 years of age) throughout the adolescence and early adulthood (23 years of age). Results of this study showed moderate to high stability over time in motor coordination (Ahnert et al., 2009). Subsequent studies investigated the tracking of FMS (Jenni et al., 2011; Lloyd, Saunders, Bremer, & Tremblay, 2014; McKenzie et al., 2002; Vandorpe et al., 2012), but tracking coefficients were inconsistent, and all of the researchers did not directly measure

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FMS from early childhood into adolescence in a representative sample (Jenni et al., 2011; Lloyd et al., 2014; McKenzie et al., 2002; Vandorpe et al., 2012). Although a few of these studies examined the specific time frame from childhood to early adolescence, the lack of controlling for BMI (Jenni et al., 2011; Lloyd et al., 2014; Vandorpe et al., 2012) and pubertal status (Jenni et al., 2011; Lloyd et al., 2014; McKenzie et al., 2002; Vandorpe et al., 2012) does not permit definitive conclusions regarding tracking of motor coordination during this specific time frame.

It is known that tracking coefficients often vary based on time frame in between measures, with shorter time intervals providing better tracking coefficients (Malina, 1996). Lloyd et al. (2014) followed 204 six-year-old children for 20 years and observed stable and good tracking coefficients ($r=0.77$ from 6 to 16 years; $r=0.85$ from 16 to 26 years) for FMS. However, this study included direct measures of FMS for only 5 years, and all of the subsequent measures were indirect using questionnaire (Lloyd et al., 2014). Another study with a significant period of follow-up (12 years) showed weaker tracking coefficients ($r=0.46$ – $r=0.49$) in 256 six-year-old children at baseline using mainly balance tasks (Jenni et al., 2011). Other studies with shorter follow-up (3 years) had different conclusions. McKenzie et al. (2002) observed low ($r=0.20$ – 0.41) or non-significant tracking coefficients in 207 four-year-old children at baseline, while Vandorpe et al. (2012) observed stronger tracking coefficients ($r=0.66$ from 6 to 8 years; $r=0.87$ from 7 to 9 years) in 371 six-year-old children at baseline (Vandorpe et al., 2012). Studies using direct measures of motor coordination, starting during childhood and having regular measurement intervals, a considerable follow-up period, and large sample size are needed.

Understanding tracking is important in order to judge whether it is possible to improve a particular characteristic with the purpose of preventing later undesirable health

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outcomes (i.e. disease, coordination disorder, physical inactivity). It may not be advisable to design an intervention for a variable which will track too strongly over time (coefficient [$r > 0.9$]) or a variable that will track too weakly over time (coefficient [$r < 0.2$]). Because poor motor coordination may affect health and/or health-related behaviors, it is of interest to analyze how motor coordination tracks through childhood (Lubans et al., 2010). During early childhood (i.e. six years of age), children's motor coordination is still developing (Gallahue, Ozmun, & Goodway, 2012), which could represent an excellent opportunity to intervene in order to avoid later motor coordination disorder and its associated factors: low physical activity level, low cardiorespiratory fitness and higher fat mass (D'Hondt et al., 2014; de Souza et al., 2014; Lopes, Rodrigues, et al., 2011). Therefore, the aim of this study was to analyze tracking of motor coordination in children from age 6 years to ages 9 and 13 years.

Methods

This study is based on a longitudinal analysis of data from the "Copenhagen School Child Intervention Study", which was started in 2001. Participants for the study were all children attending primary school in two communities in the area of Copenhagen (46 classes in 18 schools [grade 1, ages 5-7 years]). Written informed consent was obtained from the parents/guardians of 706 children (69% of the population), and 696 participated in the study at baseline. The intervention consisted of doubling the number of minutes spent in physical education classes per week, aiming to increase the physical activity level of the children. The research group trained the school teachers to provide fun activities with high levels of intensity that incorporated both strength and cardiovascular training (Bugge et al., 2012). Following the intervention, the children were re-tested in 2004/2005 at the age of 9 years and followed-up again in 2008 at the age of 13 years. Almost all of the children were born in

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Denmark (98.1%). At baseline, the annual family income (parents combined) was lower than 200,000 Danish Kroner (DKK) (approximately 30,000 U.S. Dollars) in 5.6% of the families in our study (14.5% between 200,000-400,000 DKK; 44.5% between 400,000-600,000 DKK; 35.5% more than 600,000 DKK). Less than 1% of the children's mothers had less than 7 years of education (0.5%: 7-8 years of education; 98.7%: 9+ years of education). There were no statistical differences in age or other demographic characteristics between those children with complete or incomplete data (Morrison et al., 2012). The study was approved by the ethical committee.

The complete methodology for the study has been previously published, as have the primary and some secondary study outcomes. Bugge et al. (2012) evaluated the short-term and long-term effects of the three-year controlled school-based physical activity intervention on fatness, cardiorespiratory fitness and cardiovascular disease risk factors in this project. Eiberg et al. (2005) analyzed the association between physical activity and cardiorespiratory fitness, and Hasselstrom et al. (2008) evaluated the effect of increasing the amount of time spent in physical education classes on bone mineral accrual and gain in bone size in the same participants. In particular, none of the previous studies have used motor coordination measures in their analysis. The methodology included here presents only those variables of interest for the present investigation.

Only two individuals were responsible for measurement throughout the course of the study. Height was measured without shoes to the nearest 1 mm using a Harpenden stadiometer (West Sussex, UK). Body mass was measured in light clothing to the nearest 0.1 kg using an electronic scale (Seca 882, Brooklyn, NY). BMI was calculated (kg/m^2). Pubertal status was individually assessed by self-report of stages of sexual maturation according to Tanner's criteria using a scale of black and white pictures of breast

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development for girls and genital development for boys (Tanner, 1986). The child self-assessed their pubertal status in a private setting, but there was a researcher nearby to answer any questions.

Gross motor coordination was measured using the “Körperkoordinationstest für Kinder” (KTK), which is a standardized normative German test battery (Kiphard & Schilling, 1974). At baseline, 649 completed the full KTK battery, while 600 were tested in the first follow-up and 495 in the second follow-up. The KTK was designed to be suitable for all participants of this study and has a high test-retest reliability ($r=0.90$ to 0.97) (Cools, Martelaer, Samaey, & Andries, 2009; Kiphard & Schilling, 1974; Vandorpe et al., 2011). The KTK consists of four independent tests: (1) walking backwards on balance beams of decreasing width: 6.0, 4.5, and 3.0 cm (KTK_{BEAM}), (2) moving sideways on wooden boards for 20s (KTK_{BOARD}), (3) hopping on one leg over a foam obstacle with increasing height, in consecutive steps of 5cm (KTK_{HOP}) and (4) jumping (two-legged) from side to side for 15s (KTK_{JUMP}). The KTK test battery was originally developed to evaluate motor disorders in children with brain lesions and behavioral disorders; however, the KTK battery has been used to evaluate gross motor coordination in several studies with ‘typically developing’ children and adolescents (from five up to 14 years and 11 months) (D'Hondt et al., 2013; Graf et al., 2004; Laukkanen, Pesola, Havu, Saakslähti, & Finni, 2014; Morrison et al., 2012). In addition, the KTK has been used in studies on talent identification, which accentuates the wide applicability of the test (Fransen et al., 2012; Pion et al., 2015).

The crude performance score on every item was converted into a standardized ‘score’ (MQ-Score) based on the standardized tables in the original German reference study (all items) and gender-specific (KTK_{HOP} and KTK_{JUMP}) reference values (Kiphard & Schilling, 1974). Because of abovementioned standardization, the MQ-score is comparable across age

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groups, which means that older children need to perform the test better to present the same standardized score as younger children. Therefore, if the child performs the test with the exact same crude scores at the age of 6 and 13, the standardized score at the age of 13 will be lower than at 6 years of age. The sum of the standardized items provides a total MQ-Score, for which children's level of gross motor coordination can be classified as low (MQ-Score < 85; ≤ 15th percentile), medium (MQ-Score = 85–115; 16–84th percentile) or high (MQ-Score > 115; ≥ 85th percentile) (D'Hondt et al., 2013).

Statistical analysis

STATA version 13.0 was used in the analysis. For descriptive purposes, means and standard deviations of age, BMI, KTK score (raw data), MQ-Score, and the standardized score for each of the KTK tests at ages 6, 9 and 13 years were calculated.

The tracking coefficients of each KTK element and the MQ-Score from the ages of 6–9, 9–13, and 6–13 years were calculated adjusting for the school in which the children were enrolled (control, intervention), sex, age, and BMI (kg/m^2) for each follow-up and pubertal status for nine and 13 years of age. Additionally, we ran additional analyses with height and weight measures replacing BMI in order to test whether those components could change the interpretation of the results. Percent agreement and weighted kappa coefficient were used to analyze the maintenance in the motor coordination classification group (low, medium, high) among the follow-ups (6–9; 9–13; and 6–13 years). We used a previous study to classify the strength of the tracking coefficients ($r < 0.3$: low; $r = 0.3–0.6$: moderate; $r > 0.6$: moderately high) (Malina, 1996).

Mixed-effects logistic regression analysis was performed to examine the odds of remaining in the low motor coordination group over time based on BMI tertiles. Two other mixed-effect logistic regression analyses were performed to examine the odds of remaining

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in the low motor coordination group over time based on weight and height tertiles. All of the mixed-effects logistic regression models were adjusted for the school in which the children were enrolled (control, intervention), sex, age for each follow-up and pubertal status for nine and 13 years of age.

Results

The majority of the boys at nine years of age were in the initial stages of genitalia development (95.4% stage 1 and 4.6% stage 2). At 13 years of age, most of the boys characterized themselves in the stage 3 in genitalia development (45.7%), followed by stage 4 (40.3%), stage 2 and 5 (6.3% each), and stage 1 (1.4%). At nine years of age, 54.7% of the girls recognized themselves in the stage 1 regarding their breast development, while 40.4% in the stage 2, and 4.9% in the stage 3. At 13 years of age, most of the girls characterized themselves in the stage 4 (55.3%), 23.3% in the stage 3, 15.2% in the stage 5, 5.7% in the stage 2, and 0.5% in the stage 1.

Insert Table 1

Table 1 presents the physical and motor characteristics of the participants in each age period of monitoring. There were significant sex differences in age at baseline (6 years), MQ-score at all ages and in some of the KTK battery tests at different ages. At baseline (6 years), 19.7% children were classified in the low motor coordination group, and 10.3% were classified in the high group. At the first follow-up (9 years), 21.3% of children were classified in the low motor coordination group and 7.8% in the high group. In the second follow-up (13 years), 23.4% of the participants were classified in the low motor coordination group and 12.7% in the high group (Table 2).

Insert Table 2

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Table 3 presents the tracking coefficients among different age groups for the whole sample and stratified by sex. Independent of BMI and pubertal status, all coefficients were moderate-to-moderately high both in the individual KTK tests and in the MQ-Score. Only the correlation in KTK_{BOARD} test between 6 to 13 years was low for the whole sample and both sexes ($r < 0.30$). Additional analyses (data not presented), replacing the adjustment of BMI for height and weight measures separately, did not change the interpretation of the tracking coefficients shown in Table 3.

Insert Table 3

The overall percent agreement for classification into the motor coordination groups was higher than 85% at all time points, indicating a higher chance to continue in the same motor coordination group in the next follow-up (Table 4). Weighted kappa values ranged from 0.37-0.51. For children in the low motor coordination group, at least 50% of the children continued in the low group in the next follow-up (9 years), and none of them improved to the high motor coordination group at either follow-up (9 and 13 years; Table 4). In addition, 51% of the children in the low motor coordination group at six years of age continued in the low motor coordination group across nine and 13 years of age. From the children in the medium motor coordination group at six years of age, 78% of them continued in the medium motor coordination group at nine and 13 years of age. And, 57% of the children in the high motor coordination group at six years of age continued in the high motor coordination group the next two follow-ups (nine and 13 years of age).

Insert Table 4

Table 5 shows that children in the highest BMI or weight tertile had higher odds of being classified in the low motor coordination group during the seven-year follow-up. Children in the higher BMI tertile had 5.44 greater odds of being in the low motor

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coordination group compared to children in the lowest BMI tertile. Similarly, children in the highest weight tertile presented 5.15 greater odds of being in the low motor coordination group compared to children in the lowest weight tertile. Children in the middle height tertile showed slightly lower chance of being classified in the low motor coordination group compared to children in the lowest height tertile (OR=0.53; 95% CI: 0.30: 0.92).

Insert Table 5

Discussion

Results of this study showed that the tracking coefficients among the MQ-Score and each single KTK element in different ages were moderate or moderately high, with correlation coefficients for the single elements (r) in the range from 0.37 to 0.58 and the coefficient (r) of the MQ-Score ranging from 0.49 to 0.62, with the exception of KTK_{BOARD} from 6 to 13 years ($r=0.20$). We can also conclude that children with higher BMI or weight are more likely to present low motor coordination during childhood and early adolescence.

To the best of our knowledge, this is the first paper to analyze the tracking coefficients from direct measures of motor coordination in a sample of six-year-old children until early adolescence (13 years), adjusting for BMI, weight, height and pubertal status. The coefficients presented in the present paper were slightly lower than the coefficients presented in Belgian children (Vandorpe et al., 2012). Vandorpe et al. (2012) analyzed 371 children from 6 to 11 years-old, but they analyzed the tracking coefficients in a two-year interval which probably explains their higher coefficients (r) 0.66 (6-8 years), 0.87 (7-9 years), 0.85 (8-10 years) and 0.82 (9-11 years). Other tracking studies indicated coefficients similar to the results presented in our study (Jenni et al., 2011; Lloyd et al., 2014). Therefore, motor coordination tracks from early childhood until early adolescence; however, the coefficients observed show that motor coordination may be modifiable from six to 13 years of age

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($r < 0.9$), which in turn could suggest that it is viable to design interventions to address motor coordination in children and adolescents with the hope of increasing physical activity; however, our results do not directly address this notion.

Similarly, intervention studies have shown that fundamental movement skills (FMS) are amenable to change in children. A systematic review conducted by Morgan et al. (2013) analyzed 22 intervention studies which aimed to improve FMS in children. All of the interventions achieved positive, significant effects in FMS for overall gross motor proficiency, with large effect sizes, and in locomotor and object control skills, with medium effect sizes (Morgan et al., 2013). Recently, Cohen, Morgan, Plotnikoff, Callister, and Lubans (2014) conducted a randomized controlled trial in eight-year-old children from low-income schools, and the multi-component physical activity and FMS intervention maintained daily moderate to vigorous physical activity level, improved overall FMS competency, and increased cardiorespiratory fitness (Cohen et al., 2014). These results show that FMS are amenable to change in school-age children, as also indicated by the tracking coefficients presented in this paper.

Interventions devised to improve FMS could be an important tool to address health parameters in children. In the current study, heavier children were more likely to present low motor coordination over time. Similarly, several studies have shown associations between low motor coordination and overweight (D'Hondt et al., 2013; Lopes, Santos, Lopes, & Pereira, 2011). For example, D'Hondt et al. (2013), followed 100 children (50 overweight) for two years, and the evolution of motor coordination was strongly associated with children's weight status. Their results showed that obese children had poorer motor coordination than their normal weight peers. In addition, D'Hondt et al. (2014) showed that children with lower motor coordination levels at baseline had an increase in BMI z-score

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after two years; and a higher BMI at baseline also predicted a decrease in gross motor coordination performance after two years. In addition, several other investigations have shown associations between low motor coordination and low physical activity and low fitness levels (Barnett, van Beurden, Morgan, Brooks, & Beard, 2008; Hardy, Reintgen-Reynolds, Espinel, Zask, & Okely, 2012; Laukkanen et al., 2014; Lopes, Rodrigues, et al., 2011; Lubans et al., 2010; Morrison et al., 2012). In particular, motor coordination predicted overall physical activity, measured by questionnaire. The trend for a decrease in physical activity level across years was attenuated for those who had better motor coordination and was amplified for those who had poorer motor coordination (Lopes, Stodden, & Rodrigues, 2013). In relation to the association between motor coordination and physical fitness, Fransen et al. (2014) observed that children with higher motor coordination scored better on physical fitness tests and participated in sports more often than those with lower motor coordination. In the present study, the high prevalence of children with low motor coordination in all age groups highlight the importance of implementing interventions that aim to improve motor coordination in children.

Interestingly, the tracking coefficients were the same regardless of the adjustment for BMI, weight, height or pubertal status. Nevertheless, over a seven-year period, heavier children (highest tertile in BMI or weight) presented five times higher odds of being in the low motor coordination group. It is known that several factors contribute to tracking of biological variables, such as time span between observations, age at first observation, biological variation, environmental change, measurement variation, and individual differences in timing and tempo of the growth spurt (Malina, 1996). As is well known in tracking literature, the coefficients were lower for the longer time interval than the shorter time interval (Malina, 1996). It is difficult to take into account differences in timing and tempo in the growth spurt and differences due to age at initial observation. Even though all

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children were pre-pubertal at the time of the first assessment, it is not possible to tell how maturity status and tempo could have already affected measures at that point in time. We were able to partially control for this by accounting for growth- and maturation-related factors in the analysis. Additionally, many environmental factors could have been at play that we could not capture in this study, and of course gene by environment interactions played an undetermined role as well (Bouchard, 1994). We do not believe measurement issues were responsible for much variation in tracking in the current investigation because two highly trained individuals took all measures at all time points. Therefore, lower motor coordinated children may be genetically predisposed to continue along that path unless the path is disrupted by intervention. Interventional studies have succeeded in improving skills in lower motor coordinated children (D'Hondt, Deforche, Bourdeaudhuij, & Lenoir, 2009; Graf et al., 2004; Hardy et al., 2012; Laukkanen et al., 2014; Lubans et al., 2010; Morgan et al., 2013; Morrison et al., 2012), which leads us to believe this is the case.

This study had some limitations: (a) This was an observational study, and it was not possible to control for all the possible confounders (e.g. ensure all the children exhibited similar baseline characteristics); (b) This longitudinal study was part of an intervention project that doubled the amount of physical activity lessons in which school children engaged. The main aim was to increase the physical activity level of the participants, and some results could theoretically be influenced by the intervention. However, the motor coordination was not influenced by the intervention and accelerometer data did not show difference between intervention and control children (data not presented).

The study also had strengths: (a) This study measured the children's motor coordination in an early period in life (six years old), and followed the participants with two more measurements across a period of seven years; (b) There was a high participation rate at

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all three time points (76%); (c) To the best of our knowledge, this study is the first to analyze motor coordination performance of 6-year old children followed for 7 years, with tracking analysis in two different follow-up periods, with direct measures of motor coordination in a representative sample of children. This study also includes statistical adjustment for BMI and pubertal status.

Motor coordination performance tracked through childhood to early adolescence, and heavier children had at least five times higher odds to be in the low motor coordination group during the seven-year follow-up.

What Does This Article Add?

Motor coordination level in childhood is related to motor coordination in early adolescence (13 years). The tracking coefficients presented in this study imply that motor coordination level tracks during childhood to early adolescence, but also indicate it may be feasible to change motor coordination with appropriate intervention, as has been shown in a few motor skill intervention studies thus far. It is recommended that interventions aiming to improve health-related behaviors in children and adolescents address motor coordination. This is particularly important for heavier children during childhood because they have higher chance of presenting lower motor coordination level during childhood and early adolescence. Therefore, interventions aiming to improve motor coordination level, particularly in lower-skilled individuals, could be helpful in the effort of making children and adolescents more active and healthier.

Conflict of interest

There is no conflict of interest among the authors.

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Table 1. Mean (SD) Physical and Motor Characteristics of Participants by Age and Sex.

	All			Boys			Girls		
	6 years	9 years	13 years	6 years	9 years	13 years	6 years	9 years	13 years
n	649	600	495	337	316	222	304	289	205
Age	6.75 (0.37)	9.59 (1.07)	13.35 (0.34)	6.81* (0.37)	9.59 (1.31)	13.39 (0.34)	6.67 (0.35)	9.58 (0.71)	13.31 (0.33)
BMI	16.02 (1.79)	17.26 (2.44)	19.20 (2.71)	15.99 (0.09)	17.24 (0.13)	18.99 (0.17)	16.05 (0.11)	17.29 (0.15)	19.24 (0.19)
KTK score	118.97 (27.58)	195.17 (34.64)	248.55 (30.12)	120.07 (28.42)	194.77 (34.89)	251.37 (29.88)	118.18 (26.79)	195.62 (34.43)	247.26 (28.81)
MQ-Score	98.05 (14.46)	96.32 (14.35)	97.30 (16.42)	101.23* (13.61)	97.66* (14.04)	100.90* (15.65)	94.80 (14.67)	94.82 (14.57)	94.32 (16.03)
KTK _{BEAM}	95.55 (14.07)	94.57 (13.84)	96.59 (15.50)	93.59 (14.05)	92.72 (13.67)	95.49 (16.16)	97.70* (13.90)	96.62* (13.76)	98.74* (14.68)
KTK _{BOARD}	100.30 (15.21)	98.58 (14.21)	68.14 (10.23)	101.06 (14.79)	98.51 (14.33)	70.23* (9.34)	99.68 (15.59)	98.67 (14.10)	66.42 (10.29)
KTK _{JUMP}	98.27 (16.64)	94.77 (13.22)	94.75 (18.71)	104.41* (14.29)	96.36* (12.85)	98.90* (15.56)	91.91 (16.51)	93.01 (13.42)	91.01 (20.34)
KTK _{HOP}	100.50 (14.10)	101.20 (16.28)	101.25 (16.31)	105.32* (12.63)	105.88* (14.30)	108.70* (14.88)	95.42 (13.80)	96.02 (16.77)	93.67 (13.90)

* $p < .05$ significant difference between boys and girls

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Table 2. Percent of children in each KTK MQ-score classification group

	6 years		9 years		13 years	
	n	%	n	%	n	%
Lower MQ-score	128	19.7	128	21.3	116	23.4
Medium MQ-score	454	70.0	425	70.8	316	63.8
Higher MQ-score	67	10.3	47	7.8	63	12.7

Tracking of gross motor coordination

Table 3. Tracking coefficients (Pearson correlation [r]) between KTK tests at different ages for all participants and stratified by sex.

KTK Tests/Score*	All participants					
	6 - 9 years		9 - 13 years		6 - 13 years	
	n	r	n	r	n	r
MQ-Score	551	0.62	415	0.60	398	0.49
KTK _{BEAM}	568	0.49	428	0.40	415	0.40
KTK _{HOP}	557	0.45	419	0.54	403	0.37
KTK _{JUMP}	564	0.58	428	0.55	413	0.45
KTK _{BOARD}	564	0.32	428	0.42	412	0.20
KTK Tests/Score*	Boys					
	6 - 9 years		9 - 13 years		6 - 13 years	
	n	r	n	r	n	r
MQ-Score	270	0.63	197	0.60	198	0.54
KTK _{BEAM}	275	0.49	202	0.45	204	0.46
KTK _{HOP}	271	0.45	198	0.57	199	0.40
KTK _{JUMP}	274	0.59	202	0.51	199	0.44
KTK _{BOARD}	274	0.35	203	0.48	205	0.23
KTK Tests/Score*	Girls					
	6 - 9 years		9 - 13 years		6 - 13 years	
	n	r	n	r	n	r
MQ-Score	254	0.61	197	0.60	186	0.45
KTK _{BEAM}	263	0.49	204	0.35	195	0.31
KTK _{HOP}	258	0.45	199	0.53	190	0.34
KTK _{JUMP}	260	0.58	204	0.59	191	0.45
KTK _{BOARD}	260	0.30	202	0.39	191	0.17

*All $p < .001$; and adjusted for the school in which the children were enrolled (control, intervention), sex (only for all participants), age, and BMI (kg/m^2) for each follow-up and pubertal status for nine and 13 years of age.

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Table 4. Maintenance of the motor coordination group at first test in relation to classification at the following test.

Motor coord. group**	MC 6 y – MC 9 y			MC 9 y – MC 13 y			MC 6 y – MC 13 y		
	Higher	Medium	Lower	Higher	Medium	Lower	Higher	Medium	Lower
Higher	25%	75%	0%	46%	51%	3%	37%	55%	8%
Medium	6%	79%	14%	12%	74%	14%	11%	70%	20%
Lower	0%	41%	59%	0%	27%	74%	0%	48%	52%
Kappa*	0.46			0.51			0.37		
Agreement	92.47%			92.65%			89.95%		

*Significant difference across all comparison ($p < 0.001$)

** Indicates motor coordination group at first assessment point

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Table 5. Odds ratios [CI 95%] for being classified in the lower motor coordination group depending on BMI, weight and height tertile.

Variables	Lower motor coordination group	
	OR	(95% CI)
BMI	1 st Tertile	1
	2 nd Tertile	1.72 (0.99: 2.99)
	3 rd Tertile	5.44 (3.00: 9.87)
Weight	1 st Tertile	1
	2 nd Tertile	1.62 (0.90: 2.93)
	3 rd Tertile	5.15 (2.61: 10.14)
Height	1 st Tertile	1
	2 nd Tertile	0.53 (0.30: 0.92)
	3 rd Tertile	0.56 (0.29: 1.09)

* Models adjusted for the school in which the children were enrolled (control, intervention), sex, and age for each follow-up and pubertal status for nine and 13 years of age.