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ORIGINAL ARTICLE

A longitudinal analysis of gross motor coordination in overweight and obese children versus normal-weight peers

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BACKGROUND: The relationship of childhood overweight (OW) and obesity (OB) with motor skill and coordination is gaining due attention; however, longitudinal evidence is currently lacking.
OBJECTIVE: The dual purpose of this study was (1) to investigate the short-term evolution in the level of gross motor coordination according to children's weight status, and (2) to identify those factors predicting their gross motor coordination performance over a 2-year interval.
SUBJECTS: Participants were 50 children with OW, including 8 with OB (aged 6–10 years at baseline, with 52% boys), and 50 with normal-weight (NW) matched for gender and age.
MEASUREMENTS: Anthropometrics (body height, body weight, body mass index (BMI), %body fat) and level of gross motor coordination (Körperkoordinationstest für Kinder, KTK) were assessed in 2007 (baseline) and 2 years later in 2009 (follow-up). At baseline, participants completed a survey based on the Flemish Physical Activity Questionnaire (FPAQ) to obtain socio-demographic information and to determine physical activity levels in diverse domains.
RESULTS: The evolution in the level of gross motor coordination over time was strongly related to children's weight status. Participants in the NW group showed more progress than their OW/OB peers, who demonstrated significantly poorer performances. Accordingly, between-group differences in KTK outcomes (that is, raw item scores and total motor quotient) became more evident over time. Multiple linear regression analysis further indicated that, in addition to BMI *per se* (negative predictor), participation in organized sports within a sports club (positive predictor) determines gross motor coordination performance(s) 2 years later.
CONCLUSION: Our results provide conclusive evidence for an increasingly widening gap of OW/OB children's gross motor coordination relative to NW peers across developmental time in the absence of targeted initiatives. Special attention is thus needed for OW/OB children, especially for those not practicing sports in a club environment, in terms of motor skill improvement to promote regular participation in physical activity.

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Keywords: body mass index; children; longitudinal study; gross motor skills; overweight

INTRODUCTION

In the past decade, research on the relationship between excess body weight or fatness and the level of motor competence in children has become increasingly important.[1,2] Motor competence refers to the degree of skilled performance in a wide range of motor tasks as well as the movement coordination and control underlying a particular motor outcome.[3,4] An adequate level of motor skill is not only considered a key factor in children's general development but also the foundation for an active lifestyle.[5,6] Only recently, it has been demonstrated that motor skill and coordination indeed act as a predictor of consequent physical activity participation in children.[7,8] As physical activity is a central component in both prevention and treatment of childhood overweight (OW) and obesity (OB),[9,10] which has become a global epidemic,[11] the gradually increased focus on motor competence levels in OW and OB children appears to be justified.

The studies conducted to date consistently report low to moderate negative correlations and therefore an inverse relationship between body mass index (BMI) and motor skill performance in childhood and early adolescence.[4,12–15] Based on different field-based tests, several authors suggested that OW and OB are associated with non-optimal motor development in children. Mond *et al*.,[16] for example, found that the prevalence of impairment in gross motor skills already tends to be higher among OB versus non-OB preschoolers. Other comparative studies within this emerging area of research clearly demonstrated significant differences in motor competence according to children's weight status. In general, it has been shown that OW and particularly OB children display markedly poorer performance and are less competent in motor tasks requiring support, propulsion or movement of a great proportion of body mass compared with normal-weight (NW) peers.[4,12–15,17–21]

As noticed by Lopes *et al*.,[14] most of the above cited cross-sectional studies examined the relationship of childhood OW/OB with motor skill performance only within a small age range (that is, 1–3 years apart). Yet, taking into account multiple ages across developmental time, these authors found a general pattern of

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increasing negative correlations between BMI and level of gross motor coordination during childhood (that is, from 6 to 12 years).[14] Likewise, previous work by Marshall and Bouffard,[17] and D'Hondt *et al*.[20] already pointed out that OB-related differences in motor competence become increasingly clear as children belong to an older age group in the absence of targeted initiatives. In the latter of both studies, this finding was further substantiated by the growing percentage of OW and OB children that could be identified as motor impaired with increasing age.[20] However, the apparent deterioration in OW and OB children's gross motor coordination relative to the performance of NW peers over time cannot be considered truly developmental owing to the lack of within-subject follow-up.

Therefore, conducting longitudinal research is imperative and needs to be intensified to provide a more complete picture of the relationship between childhood OW/OB and motor competence across developmental time as well as to confirm the current indication(s) for a widening gap in gross motor performances of OW/OB versus NW children with increasing age. Hence, the first aim of our study was to investigate the short-term evolution in gross motor coordination according to children's weight status. To know which children require special attention in the pursuit of adequate physical activity levels, our second aim was to identify which factors besides those related to weight status *per se* may predict a child's future gross motor coordination performance.

MATERIALS AND METHODS

Study design and participants

The present study analyzed data from a large-scale project (Flemish Sports Compass), in which anthropometric characteristics as well as motor skill and physical activity levels of Flemish primary school children were evaluated to gain insight into the longitudinal development thereof. A total of 712 pupils from 13 randomly selected primary schools for general education across Flanders and the Brussels-Capital region (Belgium) were assessed at baseline (autumn 2007) and 2 years later (autumn 2009). Weight status was classified using the age- and gender-specific BMI cutoff points for children of the International Obesity Task Force.[22] Within the subsample of 487 children (aged 6–10 years at baseline), who completed the assessment of gross motor coordination in both test years as well as a self-administered questionnaire in 2007, 50 children were identified as being OW ($N = 42$) or OB ($N = 8$) with no change in weight status over time. In order to match this selection of OW/OB participants based on gender and age (within the range of 2 months), 50 NW children, also meeting the aforementioned conditions, were retained for further analysis. Mean age at baseline was 8.2 ± 1.2 years in both groups, each including 52% boys. Our study was approved by the University Hospital Ethical Committee and written informed consent from the parent(s) or guardian was obtained for all the 100 participants.

Measurements

Assessments of anthropometry and children's level of gross motor coordination were conducted in 2007 and 2009 by a group of trained examiners using standardized instructions. During the measurements and tests taking place in the gymnasium of the school, all participants wore light sportswear and were barefoot. At baseline, children were also asked to fill out a self-administered questionnaire at home together with their parent(s) or guardian. The latter were instructed to assist their child in completing the entire questionnaire in order to gather adequate information on socio-demographic characteristics and physical activity, including sports participation. These questionnaires were collected back in school.

Anthropometry. Body height and sitting height were measured to the nearest 0.1 cm using portable stadiometers (Harpenden, Holtain Ltd, Crymych, UK). Body weight (0.1 kg) and an estimation of percentage body fat (0.1%) were determined using a digital scale with bioelectrical impedance analysis (Tanita, BC-420 SMA, Weda BV, Naarden, Holland). Participant's BMI was calculated as body weight divided by square height ($kg\,m^{-2}$) in order to determine weight status.[22] In addition, BMI *z*-scores were computed based on Flemish reference data to obtain a relative measure of adiposity adjusted for gender and age and to document its change between baseline and follow-up.[23] Finally, age at peak height velocity (APHV) was predicted in 2007 by means of a gender-specific regression equation as an indicator of participant's somatic maturity.[24,25]

Gross motor coordination. The level of gross motor coordination was assessed using the Körperkoordinationstest für Kinder (KTK), which is a standardized normative German test battery.[26,27] The KTK is suitable for all children between 5 and 15 years of age and considered a highly reliable (that is, test–retest reliability coefficients of 0.90 and 0.97 for the total test battery) and valid instrument (that is, construct validity: $r = 0.60–0.81$ for the intercorrelations between KTK subtests, all loading on the same factor; concurrent validity: $r = 0.62$ with respect to the total score of the Movement ABC).[8,26–29] Administration of the KTK battery takes approximately 20 min per child with four test items to be completed: (1) walking backwards along balance beams of decreasing width: 6.0, 4.5, and 3.0 cm (KTK_{BEAM}), (2) moving sideways on wooden boards for 20 s (KTK_{BOARD}), (3) one-legged hopping over a foam obstacle with increasing height in consecutive steps of 5 cm (KTK_{HOP}) and (4) two-legged jumping from side to side for 15 s (KTK_{JUMP}). As each test item is identical for all ages, the KTK is a very useful tool for longitudinal research. Another advantage of the KTK is its ability to identify both children with above and below average levels of gross motor coordination. Therefore, the raw performance score on every item has to be converted into a standardized 'motor quotient' (MQ) relative to the test battery's original age- (all items) and gender-specific (KTK_{HOP} and KTK_{JUMP}) reference values. The sum of those standardized item scores provides a total KTK MQ based on which children's level of gross motor coordination can be classified in the low ($MQ \leqslant 85$; $\leqslant$15th percentile), normal ($MQ = 86–115$; 16–84th percentile) or high range ($MQ > 115$; $\geqslant$85th percentile).[26,27]

Questionnaire. Socio-demographic data and information on children's physical activity levels were obtained using a self-administrated questionnaire based on the Flemish Physical Activity Questionnaire (FPAQ).[30] The pen and paper version of this questionnaire has been shown to be a reliable (that is, test–retest reliability coefficients ranging from 0.69 to 0.93, with exception from $r = 0.26$ for the index related to active transportation during leisure time) and reasonably valid instrument (that is, concurrent validity: $r = 0.27-0.44$ with respect to accelerometer data) to assess different dimensions of usual physical activity and sedentary behavior in children, especially when completed with parental assistance.[31] The FPAQ consists of items regarding screen behavior (that is, average time spent on watching television, playing video games and/or using the computer, expressed in hours per day), active transportation (that is, average time spent on cycling, walking and/or skating to and from school and during leisure time, expressed in minutes per week), physical activity at school (that is, average time spent in sports or physical activities during playtime, lunch and after school hours as well as during physical education lessons, expressed in minutes per week) and physical activity in leisure time (that is, average time spent in both organized and non-organized sport during leisure time, expressed in minutes per week). Sports participation was assessed by asking the participants to indicate their main sport(s) practiced in leisure time (with a maximum of three sports). For each sport, children also had to report the frequency, the usual time spent on that activity and whether or not they practiced their sport(s) in a sports club (that is, organized versus non-organized sport).

Statistical analysis

Data were analyzed using IBM SPSS Statistics 19.0 (SPSS Inc., Chicago, IL, USA). Significance level was set at $P < 0.05$. For descriptive analyses, the results are presented as means ± s.d. A 2 (baseline versus follow-up) × 2 (NW versus OW/OB) × 2 (boys versus girls) Repeated Measures ANCOVA with APHV correcting for maturity dissimilarities was applied for both raw performance scores and total KTK MQ to examine the evolution in gross motor coordination over time according to children's weight status, taking into account any gender differences. In addition, a stepwise multiple linear regression analysis was executed to investigate the variance in the level of gross motor coordination at follow-up explained from anthropometric, socio-demographic and physical activity-related variables measured at baseline. Pearson correlation coefficients were calculated to identify the potential predictors of total KTK MQ in 2009. For predictors showing intercorrelations higher than 0.70, only the independent variable with the highest bivariate correlation with total KTK MQ was entered in the regression model in order to address the issue of multicollinearity.

RESULTS

Descriptive and comparative statistics for the main anthropometric characteristics of both NW and OW/OB participants at baseline (2007) and follow-up (2009) are presented in Table 1.

Table 2 provides descriptive statistics as well as a summary of the Repeated Measures ANCOVA for all the four KTK test items (that is, raw performance scores), while total KTK MQ outcome is displayed in Figure 1. APHV was found to be a significant covariate for the item scores ($P \leqslant 0.001$). In absolute figures, all participants demonstrated an improvement in KTK performance over the time frame of 2 years. However, a significant main effect of time was only found for KTK_{JUMP}. Significant main effects of group were reported for every single test item as well as for total KTK MQ, with the OW/OB children showing poorer performances than their NW peers both at baseline and follow-up. More importantly, all KTK variables were featured by a significant time × group interaction, with the exception of a trend for KTK_{BOARD}. The progression in the level of gross motor coordination over a period of 2 years was found to be different depending on the weight status of children. Our data revealed a significantly greater increase in KTK outcome scores from baseline to follow-up for the NW compared with the OW/OB participants. Consequently, the performance curves of both groups were shown to grow further apart, indicating a widening gap in gross motor coordination between NW and OW/OB children over time (see Figure 1 for total KTK MQ). Given that no three-way interactions with gender occurred, this finding applies to both boys and girls.

Only those baseline anthropometric, socio-demographic and physical activity-related variables that significantly correlated with total KTK MQ in 2009 were included in a multiple linear regression model after controlling for multicollinearity (see Table 3 for an overview). Results of the corresponding stepwise analysis are presented in Table 4. According to our model, which met the basic assumptions for linear regression, both BMI (negative relationship) and organized sports participation in a sports club (positive relationship) were significant predictors of participant's level of gross motor coordination 2 years later. Together they explained a significant proportion of variance in total KTK MQ at follow-up (adjusted $R^2 = 0.444$; $F = 40.551$, $P < 0.001$). BMI at baseline alone explained 37.6% of the variance in gross motor coordination performance, whereas practicing sports in a club environment added another 6.8% to the predictive value of the model.

DISCUSSION

To the best of our knowledge, this paper represents the first longitudinal study investigating the evolution in gross motor coordination according to children's weight status across developmental time. The main finding of the present study was a growing difference in KTK performance(s) of OW/OB versus NW children with increasing age. Our results further demonstrated that, in addition to BMI *per se*, participation in organized sports in a sports club predicts the level of gross motor coordination over a time frame of 2 years in childhood.

In recent years, it has become increasingly apparent that OW/OB in children is associated with a lower competence in motor skill and coordination.[4,12–15,17–21] Hence, several authors put forward the idea of non-optimal motor development within the OW/OB childhood population despite the cross-sectional nature of their studies. As in previous work within this emerging area of research, significantly poorer gross motor performances in OW/OB children as compared to NW peers were also found in the present study, regardless of the test moment (that is, both in 2007 and 2009).

Based on the raw scores, both groups of participants showed a general improvement in KTK performance from baseline to follow-up. However, this evolution over time was not statistically

Table 1. Means, standard deviations and summary of comparative statistics for the main anthropometric characteristics of the NW and the OW/OB group

Anthropometric characteristics	Baseline (2007)		Follow-up (2009)		Independent samples t-test or Repeated Measures ANOVA			
	NW N = 50	*OW/OB* N = 50	*NW* N = 50	*OW/OB* N = 50	t	F_{TIME}	F_{GROUP}	$F_{TIME \times GROUP}$
APHV (years)	12.1 ± 0.8	11.6 ± 0.8	—	—	2.60**	—	—	—
Body height (cm)	128.7 ± 7.3	132.7 ± 9.9	140.3 ± 7.1	144.5 ± 10.4	—	3447.21***	5.41**	0.59
Body weight (kg)	26.0 ± 4.1	36.1 ± 8.1	32.2 ± 4.8	47.2 ± 9.9	—	1100.22***	79.78***	85.83***
Body fat (%)	16.8 ± 3.1	27.6 ± 4.9	16.3 ± 4.3	28.9 ± 5.5	—	1.49	187.37***	9.73**
BMI ($kg\,m^{-2}$)	15.58 ± 1.15	20.28 ± 2.22	16.27 ± 1.43	22.34 ± 2.37	—	220.56***	221.90***	54.12***
BMI z-score[range]	− 0.28 ± 0.64 (− 1.82; 0.87)	1.55 ± 0.39 (1.00; 2.64)	− 0.38 ± 0.73 (− 1.92; 0.81)	1.55 ± 0.36 (0.96; 2.42)	—	2.82*	309.01***	2.56

Abbreviations: APHV, age at peak height velocity; BMI, body mass index; NW, normal-weight; OW/OB, overweight/obese. $^*P < 0.10$; $^{**}P < 0.05$; $^{***}P \leqslant 0.001$.

Table 2. Means, standard deviations and summary of Repeated Measures Analyses for the KTK raw performance scores of the NW and OW/OB group

KTK items	*Baseline (2007)*		*Follow-up (2009)*		*Repeated Measures ANCOVA*			
	NW N = *50*	*OW/OB* N = *50*	*NW* N = *50*	*OW/OB* N = *50*	F_{TIME}	F_{GROUP}	$F_{TIME \times GROUP}$	$F_{TIME \times GROUP \times GENDER}$
KTK_{BEAM}	38.04 ± 12.81	28.52 ± 12.92	51.50 ± 12.34	37.28 ± 12.93	1.27	12.30***	3.96**	0.03
KTK_{BOARD}	37.56 ± 5.91	32.36 ± 5.63	50.22 ± 7.61	42.14 ± 6.20	0.34	16.29***	3.56*	1.31
KTK_{HOP}	50.16 ± 13.97	34.74 ± 10.66	70.76 ± 15.87	49.84 ± 12.23	0.74	30.68***	6.92**	0.88
KTK_{JUMP}	50.72 ± 11.97	43.60 ± 11.21	69.82 ± 12.12	58.96 ± 10.02	15.49*	6.08**	11.64***	0.11

Abbreviations: KTK, Körperkoordinationstest für Kinder; NW, normal-weight; OW/OB, overweight/obese. Repeated Measures ANCOVA: all analyses were corrected for maturity dissimilarities using the predicted age at peak height velocity. *$P < 0.10$; **$P < 0.05$; ***$P \leqslant 0.001$.

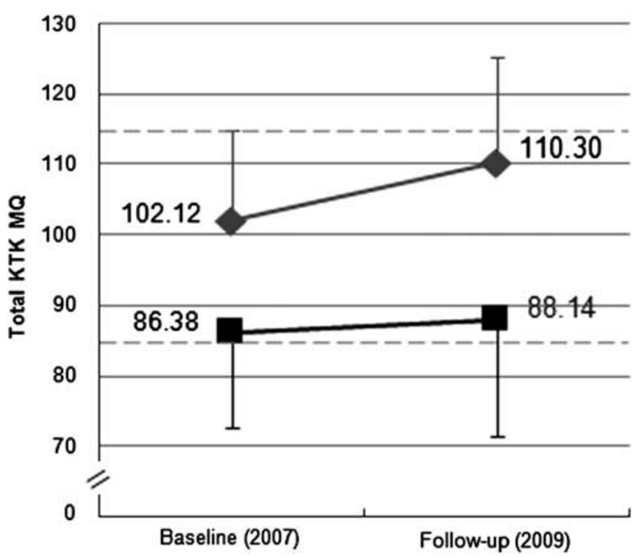

Figure 1. Total MQ on the KTK according to weight status at baseline and follow-up. Mean values (with vertical bars representing s.d.) observed for participants in the NW (◆) and OW/OB group (■). Dashed lines indicate the original limits of the test battery for low (total KTK MQ ⩽ 85) and high levels (total KTK MQ > 115) of gross motor coordination in children. Repeated Measures ANCOVA results: $F_{TIME} = 0.25$, $P = 0.620$; $F_{GROUP} = 47.80$, $P < 0.001$; $F_{TIME \times GROUP} = 6.62$, $P = 0.012$; $F_{TIME \times GROUP \times GENDER} = 0.523$, $P = 0.471$.

significant for all test items of the KTK. Given that APHV proved to be a significant covariate in our analysis, the usual time effect has probably been overruled by the variance in maturity status within our study sample.[29,32,33] With respect to total KTK MQ, it is important to note this outcome is determined by age- and gender-specific standards. Therefore, equal or comparable MQ values over time simply reflect children's gradual improvement in gross motor coordination with increasing age when there is no apparent change in their level of performance.[26,27] Nevertheless, the non-significant effect of time for the KTK raw performance scores of the entire sample is probably due to the between group difference in the degree of progress.

Accordingly, the main message of this paper relates to the consistent time × group interaction, which indicates that the evolution in gross motor coordination from baseline to follow-up was strongly related to children's weight status. As mentioned earlier, OW/OB participants were not as competent in gross motor tasks as their NW peers. Regardless of gender, the observed BMI-related difference in KTK outcomes (that is, raw item scores and total KTK MQ) became more evident over a 2-year interval. This phenomenon of a widening gap in gross motor performances of OW/OB versus NW children has already been tentatively suggested in previous cross-sectional research.[17,20] Using the same test battery, D'Hondt *et al*.[20] reported a relative decline in average motor competence levels within the OW/OB childhood population. As they belonged to an older age group, OW/OB children's gross motor coordination did not only appear to deteriorate relative to the age- and gender-specific standards of the KTK but also with respect to the performance of NW peers.[20] The present longitudinal study, however, made clear that the growing difference in KTK performance(s) according to weight status across developmental time is mainly attributable to the fact that NW children show greater improvement with age in the short term than OW/OB peers.

In addition, multiple linear regression analysis indicated that participant's baseline BMI predicts their gross motor coordination performance 2 years later with an explanatory variance up to 37.6%. Hence, children's BMI significantly contributes to the level of gross motor coordination that can be expected in relation to their increasing age. This is an important finding, especially when taking into account the reported inter-individual differences in KTK performance(s) between OW/OB and NW participants as well as the divergence in intra-individual changes across developmental time. Our prospective longitudinal design, however, does not allow to make causal inferences and address causation in one direction. Therefore, to date, it remains unclear whether a low level of motor skill coordination is a precursor or a consequence of OW/OB in children, with physical (in)activity as a likely intermediate mechanism.[34-37] More longitudinal studies are definitely needed in this respect. An interesting topic for future research is to scrutinize the relationship between a possible shift in weight status and the associated change in gross motor skill performance over time.

Our results further revealed that children's participation in organized sport within a sports club contributes an additional 6.8% to our model in predicting the level of gross motor coordination over a period of 2 years. Several previous studies have shown a positive relationship between gross motor skills and organized sports participation in early and later childhood.[12,38–41] Hence, gross motor competence may be considered an important condition for engagement in organized physical activities. Cross-sectional[40] and longitudinal research[38] could indeed demonstrate that motor skill and coordination determine subsequent sports participation. Alternatively, the present study could illustrate that participation in organized sport also has a role in children's future level of gross motor coordination. In line with earlier suggestions,[34,40] evidence has now been provided for a reciprocal relationship between both factors. That is, superior (gross) motor competence leads to increased sports participation and vice versa. As a primary context for physical activity in most children today, organized sport may be highly beneficial for motor skill

Table 3. Pearson correlations between total KTK MQ at follow-up and the examined predictors (that is, anthropometric, socio-demographic and physical activity-related variables at baseline)

Variables	*Total KTK MQ*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
Anthropometric													
APHV (years)	− 0.06	—											
Body fat (%)	− 0.59***	− 0.39***	—										
BMI (kg m^{-2})	− 0.62***	− 0.13	− 0.89***	—									
BMI *z*-score	− 0.54***	− 0.23	− 0.86***	− 0.92***	—								
Socio-demographic													
Age (years)	− 0.25**	− 0.60***	− 0.05	− 0.27**	− 0.00	—							
Gender (♂ vs ♀)	− 0.04	− 0.80***	− 0.20*	− 0.06	− 0.08	− 0.26**	—						
SES—parental occupation(blue-collar vs white-collar)	− 0.15	− 0.11	− 0.02	− 0.11	− 0.11	− 0.10	− 0.14	—					
PA related													
Screen time (hours per day)	− 0.04	− 0.05	− 0.15	− 0.07	− 0.07	− 0.02	− 0.04	− 0.12	—				
Active transport (min per week)	− 0.12	− 0.15	− 0.14	− 0.12	− 0.12	− 0.08	− 0.09	− 0.06	− 0.28**	—			
PA school (min per week)	− 0.07	− 0.10	− 0.18	− 0.21	− 0.17	− 0.17	− 0.21	− 0.06	− 0.02	− 0.08	—		
PA leisure time (min per week)	− 0.22**	− 0.19*	− 0.19*	− 0.09	− 0.13	− 0.12	− 0.19*	− 0.08	− 0.05	− 0.12	− 0.20	—	
Sports club (yes vs no)	− 0.30**	− 0.09	− 0.10	− 0.04	− 0.09	− 0.01	− 0.03	− 0.01	− 0.09	− 0.02	− 0.00	− 0.50***	—

Abbreviations: KTK, Körperkoordinationstest für Kinder; MQ, motor quotient; APHV, age at peak height velocity; BMI, body mass index; SES, socioeconomic status; PA, physical activity. The variables highlighted in bold font were included in the stepwise multiple linear regression analysis. *$P<0.10$; **$P<0.05$; ***$P \leqslant 0.001$.

Table 4. The variance in total KTK MQ at follow-up explained from anthropometric and physical activity-related variables at baseline after controlling for multicollinearity and inclusion in the stepwise multiple linear regression analysis

	Unstandardized coefficients		*95% CI for B*		*Standardized coefficients*	
Independent variables	*B*	*s.e.*	*Lower bound*	*Upper bound*	*β*	*t*
Constant	164.17	9.18	145.96	182.38	—	17.89***
BMI (kg m^{-2})	− 3.98	0.49	− 4.95	− 3.00	− 0.61	− 8.09***
Sports club (yes vs no)	10.60	2.94	4.76	16.44	0.27	3.60***

Abbreviations: BMI, body mass index; CI, confidence interval; KTK, Körperkoordinationstest für Kinder; MQ, motor quotient. ***$P \leqslant 0.001$.

development and thus encourage a (more) physically active lifestyle.[7,8,42,43]

As noted in the conceptual framework of Stodden *et al*.,[34] the developmental dynamic relationship of children's actual and perceived motor competence, or the lack thereof, with physical (in)activity is critically important, especially in view of the current OB epidemic. According to this model, children with lower motor competence levels will be drawn into a negative spiral of disengagement in a variety of physical activities, which in turn impairs opportunities to develop adequate motor skill and coordination and also increases the risk of (further) unhealthy weight gain and/or accumulation of body fat. Consistent with indirect evidence from several other studies,[6,7,14,36,44] the degree of motor skill competence thus appears to be one of the crucial factors contributing to a physically active and healthy lifestyle. Promotion of physical activity as a health protective measure should therefore include motor skill instruction and improvement in childhood. Because of the increasingly widening gap in KTK performance(s) relative to NW peers with increasing age, our results highlight the need to specifically target OW/OB children for an early screening of poor gross motor coordination and related intervention.

Programs aimed at gradually improving motor competence levels within this population (whether in a clinical setting or, maybe even better, community- and school based) should be tailored in order to maximize successful experiences while practicing various activities. Targeted initiatives may be particularly important for those OW/OB children who are not practicing organized sports in a club environment. An increased focus on learning and refinement of motor skills aimed at lifelong physical activity is considered to be paramount during preschool and primary school years, when children are at an optimal age in terms of (neuro)motor development and BMI-related differences in gross motor coordination are still less pronounced.[6,17,20,44,45] A recent systematic review and a meta-analysis of the effectiveness of motor skill interventions in (young) children indicated that the majority thereof are successful in significantly enhancing motor skill development and are therefore an important means to promote (lifelong) physical activity, regardless of weight status.[46,47] Likewise, it has been shown that specific programs within the childhood OW/OB population including regular physical activity as a central component also result in short-term improvements in the level of motor competence.[48,49] This means that it is possible for OW/OB children to (partially) catch up their motor skill impairment compared to NW peers and counter the widening gap in gross motor coordination across developmental time, although appropriate movement programs are needed to reach that goal.[47]

The present research is topical and makes an important contribution to the growing body of literature on motor (in)competence in relation to childhood OW/OB. A major strength of this study lies in its longitudinal design, which is in contrast with earlier work and therefore pioneering within this emerging area of research. Another plus point is that our findings are solely based on objective quantitative measurements using reliable and valid test instruments (that is, the KTK in 2007 and 2009; the FPAQ in 2007). Furthermore, data were present for a relatively large sample according to the type of research performed, which might benefit the generalization of our study outcomes.

Nevertheless, a number of limitations need to be considered too. The use of a sub-sample with complete data recordings from a larger pool of participants in the Flemish Sports Compass Project may have biased the reported results to some extent. In addition, there was an under-representation of OB children ($N = 8$) within the OW/OB group, which might have weakened the relationship with (future) gross motor coordination. Future research should actually examine the performance of OB children as a separate group compared with both NW and OW peers. To correct for maturity dissimilarities, APHV was included as a covariate in the Repeated Measures Analyses. The prediction of this indicator of somatic maturity, however, may have lost some of its accuracy by applying population-specific regression equations to another sample. Caution is also required when estimating APHV in very young children. Yet, it can be assumed that any systematic errors that may have occurred in our study would be similar for children with a different weight status. Another potential concern relates to the use of a self-administered questionnaire that is subject to recall bias. Unfortunately, information on children's socio-demographics and their level of physical activity in diverse domains was obtained only at baseline. Therefore, it remains unknown whether the evolution of these aspects would alter the relationship of childhood OW/OB with motor competence over time. Finally, it should be noticed that in addition to improved motor skill and coordination, other factors may also need to be addressed in order to boost physical activity among OW/OB children in pursuing a healthy lifestyle in the long-term.[10,50]

In conclusion, this study constitutes a novel contribution to the emergent research on motor competence in relation to children's weight status. Conclusive evidence could be provided for an increasingly widening gap in gross motor coordination performances of OW/OB children relative to NW peers across developmental time. The adverse relationship between excess body weight and fatness and motor development was demonstrated by a smaller rate of progress in the KTK. In addition to BMI *per* se, organized sports participation was also found to have a role in predicting future motor competence in childhood. There is a crucial need for an early focus on motor skill improvement in OW/OB children, especially if they are not practicing sports in a club environment, by means of structured and tailored activity programs in various settings. Future research is warranted to gain greater insight into the mechanisms underlying motor (in)competence associated with childhood OW/OB and to identify additional targets to promote regular physical activity within this population.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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