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The KörperkoordinationsTest für Kinder: reference values and suitability for 6–12-year-old children in Flanders

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An adequate coordination level in children is important for their general development, but also for health, psychosocial, academic and well-being-related reasons. In this study, the suitability of the KörperkoordinationsTest für Kinder (KTK) as an assessment instrument for the gross motor coordination was evaluated in 2470 children from 26 elementary schools for general education spread over the Flemish and Brussels-capital region. All children performed four subtests: walking backwards (WB), moving sideways (MS), hopping for height (HH) and jumping sideways (JS). Age and gender-specific values were established for the Flemish children anno 2008. Overall, the current sample scored significantly worse than their 1974 German counterparts ($P < 0.001$). Score distribution showed 21% of the children being placed in the problematic range of gross motor coordination level. A decline in coordination was observed especially in those tasks relying primarily on coordinative capacities (WB and MS), while improvements or status quo in those tasks relying on strength and speed (JS and HH) were explained by secular trends. We suggest that the KTK is a valuable instrument for the assessment of the gross motor coordination of Flemish children and efforts should be made in order to face the decline in coordination.

In everyday life, an adequate motor coordination level, and more specifically, the mastering of motor skills, is required for normal functioning (Henderson & Sugden, 1992). Children need a repertoire of gross and fine motor skills ranging from running and jumping to writing and drawing to meet the demands of school, home, sports and the social environment. Poor motor coordination not only hampers the development of motor skills, but can also affect academic achievement, the children's perceived competence, their participation in physical activity and social interactions and success within their peer groups (Losse et al., 1991; Bouffard et al., 1996; Piek & Skinner, 2001). Children lacking gross motor skills are at a risk of being less physically active, which in turn will restrict opportunities for developing motor competence (Bouffard et al., 1996). Wrotniak et al. (2006) demonstrated that good motor competence is positively associated with physical activity and inversely related to sedentary activity. From this point of view, increasing the gross motor skill level of children might help promote increased physical activity. Recently, Barnett et al. (2008) found that object control in childhood is predictive of cardiorespiratory fitness in adulthood. Also, Stodden et al. (2008) contend that the level of gross motor skill in childhood plays a crucial role in the initiation and maintenance of physical activity and fitness through adulthood, which is important in the fight against obesity and a number of chronic heart diseases (Gutin et al., 2004). Overall, there is consensus that good motor coordination is important for the health and well-being of children (Henderson & Sugden, 1992; Hay & Missiuna, 1998; Piek & Skinner, 2001; Prätorius & Milani, 2004; Kölle, 2006; Haga, 2008).

Gross motor coordination cannot be evaluated independently from the pure fitness characteristics like strength, speed, endurance and flexibility. The majority of test batteries consist of items measuring physical capacities and items measuring coordinative capacities of children, for example the Bruininks-Oseretsky Test for Motor Proficiency 2 (Bruininks & Bruininks, 2005), a test primarily used to identify children with motor problems. Other test batteries contain items that clearly appeal to both the physical and the coordinative properties of the child. In terms of health, the physical components in relation to gross motor coordination have been evaluated extensively. For example, in the Eurofit test battery (Council of Europe, 1988), the test "plate tapping" builds upon speed as well as upon coordination of the upper limbs. From this observation, it is clear that an evaluation of a child's motor coordination level relatively independent of his/her physical development is not straightforward. Such tests are, however, available in diagnostic settings, for example the Movement Assessment Battery for Children (M-ABC) (Henderson & Sugden, 1992). This test contains items measuring gross motor coordination as well as fine motor coordination and is especially used to identify children with motor problems.

In the context of physical education (PE) and sports, a reliable instrument for the gross motor coordination, relatively independent from a child's physical capacities, is of great use. PE teachers could use such tests to evaluate the gross motor coordination of their pupils in a simple and objective way. The Test of Gross Motor Development (Ulrich, 2000) is a qualitative test instrument that can be used by the PE teacher. However, its focus is mainly on identifying children with motor development problems. One of the few tests that mainly focuses on gross motor coordination of both normal children without motor problems as well as children with motor and/or mental problems is the KörperkoordinationsTest für Kinder (Body Coordination Test for Children, referred to as KTK from here on) published by Kiphard and Schilling (1974, 2007). It consists of four subtests that measure gross motor coordination: walking backwards on a balance beam of different widths (WB), moving sideways on boxes (MS), hopping for height (HH) and jumping sideways with both feet together (JS). The same tests are used for all age groups (5–15 years.), which is an advantage with respect to a longitudinal follow-up of the children tested. The test is easy to administer and takes about 15 min per child. The KTK allows an objective and straightforward evaluation of a child's gross motor coordination only, with only limited interference of the child's physical fitness, which discriminates this test from most other instruments.

The raw test scores from each of the four tests can be transformed into motor quotients (MQ). The norms for the MQ are based on the performance of 1228 normally developing German children in 1974. The MQ score is standardized by age and gender. The total MQ (mean = 100; SD = 15) for the entire test battery produces a measure of the gross motor coordination of children, ranging from "gifted children" to "children with motor dysfunctions" (Kiphard & Schilling, 1974, 2007). As stated by Kiphard and Schilling, in a normal population, an MQ score below 85 represents a motor performance level below the 15th percentile and is considered problematic. Motor therapy is then recommended in favor of the child's well-being. The psychometric characteristics of the KTK have been documented by the original authors. For the raw score on the total test battery, a test–retest reliability coefficient of 0.97 was reported. For the raw scores on the four subtests, sufficiently reliable coefficients were reported as well (WB: 0.80; MS: 0.84; HH: 0.96; JS: 0.95). Validity was proved through differentiation from disabled children. With the KTK, 91% of children with brain damage could be differentiated from normal children. Also, construct validity was indicated by intercorrelations and factor analysis. Intercorrelations between the four subtests varied from 0.60 (WB/JS) to 0.81 (HH/JS) for the reference group of 1228 children. Factor analysis revealed that the four subtests all load on the same factor, namely gross motor coordination. The percentage of total variance of the KTK explained by the four subtests varied from 80.9 (age 6) to 97.7 (age 9) (Kiphard & Schilling, 1974, 2007).

The KTK has been used extensively in Germany to test gross motor coordination of children for general, medical, psychiatric, social and health-related purposes. As indicated by recent publications, its popularity has grown. Studies used the KTK to test the gross motor development of children with medical problems (Stieh et al., 1999), to compare gross motor development of children from different social groups and to study the relationship between gross motor coordination level and physical activity (Krombholz, 1997; Prätorius & Milani, 2004) or body composition (Graf et al., 2004). The increasing popularity necessitates a careful evaluation of the norms and cut-off values that are based on the German test population 35 years ago. There is no doubt that in Western populations, the increased standard of living has been accompanied by a dramatic decrease in physical activity levels and a general trend toward a much more sedentary lifestyle (Livingstone, 2001; Photiou et al., 2008), an evolution that may affect gross motor coordination as well.

Several German studies claimed that in general, the mean MQ value has not significantly declined over the last 30 years (Kretschmer, 2003; Prätorius & Milani, 2004). However, the percentage of children identified as having a motor disorder has increased. Prätorius and Milani (2004) tested 163 German children aged 6–13 and found a mean MQ of 89, with 38% of the children being classified as "motor impaired" as opposed to 16% of the children being classified as such in the original manual (Kiphard & Schilling, 1974, 2007).

As for the use of norms and cut-off values that are not population specific, Miyahara et al. (1998) and Chow et al. (2006) showed that application of norms to other populations is not without risk. Smits-Engelsman et al. (1998) compared the gross motor coordination of 143 children between 5 and 13 years old by means of the KTK and the M-ABC. They reported that 29% of the children were classified as "motor impaired" and indicated that the KTK is "oversensitive" to impairment in comparison with the M-ABC when applied to the Dutch population.

In spite of the reservations with respect to the potential effects of the increasing degree of sedentarity and the population specificity of the norms and cut-offs, today, the KTK might be of great use to evaluate the gross motor coordination of Flemish children.

This study critically evaluates the usefulness of the KTK in Flanders anno 2008. The KTK was administered with a threefold aim. The first is to produce current gender- and age-specific reference values for the gross motor coordination of Flemish children between 6 and 12 years old and second, to compare the raw scores and MQ values with the norms of the original German standardization sample. Finally, the suitability of the KTK cut-off scores in a Flemish population was critically analyzed.

Materials and methods

Participants

Twenty-six primary schools for general education spread over the northern part of Belgium took part in this study. A total of 2470 children aged 6–12 years were tested on the KTK (Table 1). To obtain a representative sample of the Flemish school children, schools were randomly selected from all five provinces of the Flemish region and the Brussels-capital region. Furthermore, schools situated in city centers as well as in rural areas were selected. Permission for this study was granted by the local ethics committee of the Ghent University Hospital. Written informed consent was obtained from the parents of the children. Subjects and parents were informed that participation was voluntary and that they could withdraw from the study at any time.

Table 1. Age and gender distribution of the participants with mean and standard deviation (between brackets) of their respective body height (in cm), weight (in kg) and body mass index (BMI)

Age	Girls	Boys
6		
N	162	135
Height	119.85 (5.50)	120.02 (5.57)
Weight	22.81 (3.92)	22.86 (3.52)
BMI	15.80 (1.79)	15.80 (1.55)
7		
N	191	237
Height	125.83 (5.83)	127.50 (5.36)
Weight	26.02 (4.53)	26.58 (4.63)
BMI	16.36 (2.12)	16.29 (2.16)
8		
N	238	248
Height	131.95 (5.47)	132.86 (5.50)
Weight	29.67 (5.95)	29.28 (5.57)
BMI	16.96 (2.69)	16.50 (2.34)
9		
N	279	266
Height	137.07 (6.08)	137.47 (6.07)
Weight	32.17 (6.23)	32.00 (5.81)
BMI	17.03 (2.51)	16.85 (2.20)
10		
N	147	212
Height	142.59 (6.69)	142.71 (6.33)
Weight	35.93 (7.01)	36.15 (7.23)
BMI	17.58 (2.64)	17.66 (2.74)
11		
N	156	199
Height	149.47 (6.64)	148.31 (7.22)
Weight	41.52 (8.77)	39.98 (8.36)
BMI	18.48 (3.12)	18.08 (2.97)

Anthropometric and coordinative assessments

This study is part of a large-scale investigation on the coordination and physical abilities of Flemish children. Height (0.1 cm, Harpenden Portable Stadiometer, Holtain, UK) and weight (0.1 kg, Tanita BC-420SMA, Japan) of all participants were measured before administering the four subtests of the KTK. Height and weight values were used to calculate body mass index (Table 1). The assessment of the coordination consisted of the following KTK subtests:

1. WB: walking backwards three times along each of three balance beams (3 m length; 6, 4.5 and 3 cm width, respectively; 5 cm height). A maximum of 24 steps (eight per trial) were counted for each balance beam, which comprises a maximum of 72 steps (24 steps × 3 beams) for this test.
2. MS: moving across the floor in 20 s by stepping from one plate (25 cm × 25 cm × 5.7 cm) to the next, transferring the first plate, stepping on it, etc. The number of relocations was counted and summed over two trials.
3. HH: jumping from one leg over an increasing pile of pillows (60 cm × 20 cm × 5 cm each) after a short run-up. Three, two or one point(s) were/was awarded for successful performance on the first, second or third trial, respectively. A maximum of 39 points (ground level+12 pillows) could be scored for each leg, yielding a possible maximum score of 78.
4. JS: jumping laterally as many times as possible over a wooden slat (60 cm × 4 cm × 2 cm) in 15 s. The number of jumps over two trials was summed.

Administration and scoring of the KTK test was performed according to the manual (Kiphard & Schilling, 2007): the raw scores for each subtest were transformed into gender- and age-specific MQ values, which were based on the performance of 1228 normally developing German children in 1974.

A team of 11 trained examiners of the Department of Movement and Sports Sciences assessed the tests. The children were tested during the PE lesson in the school gymnasium in the same order for each child. A standardized warm-up for 15 min consisting of a set of running, jumping and stretching exercises preceded test assessment. Before each subtest, the children received an oral explanation about the test procedure. Participants performed all tests barefooted.

Data analysis

Filemaker Pro 9 Advanced was used to input all data in a stand-alone database. All data were analyzed using SPSS 15.0 for Windows. A 2 (gender) × 6 (age) ANOVA was used to elucidate the age and gender differences on each item of the KTK. The results of the Flemish population anno 2008 were compared with the norms of normally developing German children from 1974 ($n = 1228$) using one-sample t-tests with the German average as the reference value. Significance level was set at $P < 0.05$. Score distribution based on the original cut-offs was compared using chi-square statistics.

Results

Gender and age differences of the Flemish sample

Gender and age differences for the Flemish sample are presented in Table 2.

A 2×6 ANOVA with the raw scores as dependent variables revealed that performance on the four subtests improved significantly with increasing age (all P-values <0.001). *Post hoc* analysis showed that each age group scored significantly better than their 1-year younger counterparts on all four subtests, with all P-values <0.001.

Significant gender differences were found for the subtests WB ($P<0.001$) and HH ($P<0.001$). On the dynamic balance task, *post hoc* results revealed girls scoring significantly better than boys for all but one age groups (6 years: $P=0.007$; 7 years: $P=0.002$; 8 years: $P=0.007$; 9 years: $P=0.016$; 10 years: NS; 11 years: $P=0.002$). On the hopping task, boys outscored the girls in every age group. However, *post hoc* results elucidated those differences as significant at ages 7 ($P=0.017$), 8 ($P=0.027$), 9 ($P<0.001$) and 10 ($P<0.001$), but not at ages 6 and 11.

Both genders did not score significantly different on MS and JS at all ages. No significant interactions occurred.

Comparison between German and Flemish children

An overview of the *raw* subtest scores from boys and girls from 2008 as compared with boys and girls from 1974 is presented in Fig. 1. Boys and girls of all age groups from 2008 performed significantly worse on the subtests WB and MS than the 1974 sample population. The Flemish boys scored significantly better on the subtests HH and JS for all age groups. The results of the Flemish girls for those tasks varied with the age group: in the youngest and the oldest age groups (6, 7 and 11 years), the differences between 1974 and 2008 were small or not significant. In the middle age groups (8, 9 and 10 years), a shift was found toward lower performance of the Flemish girls.

The comparison of our results with the *norms* of the German population from 1974 is reported in Table 3. Overall, the children in the Flemish sample scored generally lower on the total KTK than the German standardization sample from 1974. The mean MQ (all age groups, both genders) of the German sample was 100 ± 15. The mean result of the total test battery (MQ KTK) for the Flemish sample (96.50 ± 14.3) was significantly lower than the mean of the German sample ($t=-12.029$, $P<0.001$). The Flemish boys scored significantly better than the Flemish girls (boys: 98.03 ± 14.10; girls: 94.86 ± 14.49, $P<0.001$), with both genders scoring significantly worse than their German counterparts (girls: $t=-12.165$, $P<0.001$; boys: $t=-5.029$, $P<0.001$).

Comparing the overall results on the four subtests, the Flemish children scored significantly worse on WB (total: $t=-31.947$, $P<0.001$; boys: $t=-26.924$, $P<0.001$; girls: $t=-18.212$, $P<0.001$) and MS (total: $t=-26.732$, $P<0.001$; boys: $t=-19.776$, $P<0.001$; girls: $t=-17.987$, $P<0.001$), whereas they outperformed the German children

Table 2. Raw scores [mean (SD)] on the four items of the KTK of the Flemish boys and girls for all age groups

WB	6	7	8	9	10	11	Age	Gender	Age × gender
Boys	23.99 (12.31)	31.13 (13.17)	36.55 (13.88)	41.04 (12.87)	44.07 (12.64)	47.25 (14.14)	$F=148.273$	$F=39.705$	$F=0.407$
Girls	27.70 (11.13)	34.99 (11.62)	39.82 (12.54)	43.81 (13.73)	46.15 (12.46)	51.75 (13.07)	$P<0.001$	$P<0.001$	$P=0.844$
Mean	26.01 (11.81)	32.85 (12.63)	38.15 (13.33)	42.46 (13.38)	44.92 (12.59)	49.23 (13.84)			
MS	**6**	**7**	**8**	**9**	**10**	**11**	**Age**	**Gender**	**Age × gender**
Boys	28.65 (4.91)	33.84 (5.39)	36.73 (5.83)	40.07 (6.61)	42.25 (5.36)	44.43 (7.26)	$F=328.477$	$F=1.193$	$F=1.973$
Girls	29.99 (5.42)	32.75 (5.16)	37.11 (5.34)	40.03 (6.23)	42.24 (5.86)	45.45 (6.79)	$P<0.001$	$P=0.275$	$P=0.080$
Mean	29.38 (5.23)	33.35 (5.31)	36.92 (5.59)	40.05 (6.41)	42.24 (5.56)	44.88 (7.06)			
HH	**6**	**7**	**8**	**9**	**10**	**11**	**Age**	**Gender**	**Age × gender**
Boys	32.76 (9.84)	42.30 (11.33)	50.09 (11.96)	58.18 (11.69)	63.15 (11.34)	66.32 (12.99)	$F=376.165$	$F=47.611$	$F=2.686$
Girls	31.57 (11.02)	39.69 (11.15)	47.65 (12.30)	52.92 (12.61)	56.84 (11.65)	64.06 (11.30)	$P<0.001$	$P<0.001$	$P=0.020$
Mean	32.11 (10.50)	41.14 (11.32)	48.90 (12.18)	55.49 (12.44)	60.57 (11.87)	65.33 (12.31)			
JS	**6**	**7**	**8**	**9**	**10**	**11**	**Age**	**Gender**	**Age × gender**
Boys	35.16 (8.33)	44.45 (10.02)	50.16 (11.15)	57.95 (10.45)	62.16 (9.91)	68.05 (11.28)	$F=433.741$	$F=0.017$	$F=1.456$
Girls	36.03 (9.37)	44.49 (10.81)	52.19 (10.07)	57.17 (11.04)	61.13 (10.86)	67.25 (9.73)	$P<0.001$	$P=0.896$	$P=0.201$
Mean	35.64 (8.91)	44.47 (10.37)	51.15 (10.67)	61.74 (10.31)	61.74 (10.31)	67.70 (10.62)			

Post hoc analysis showed significant differences ($P<0.001$) between all age groups for the four different items.

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

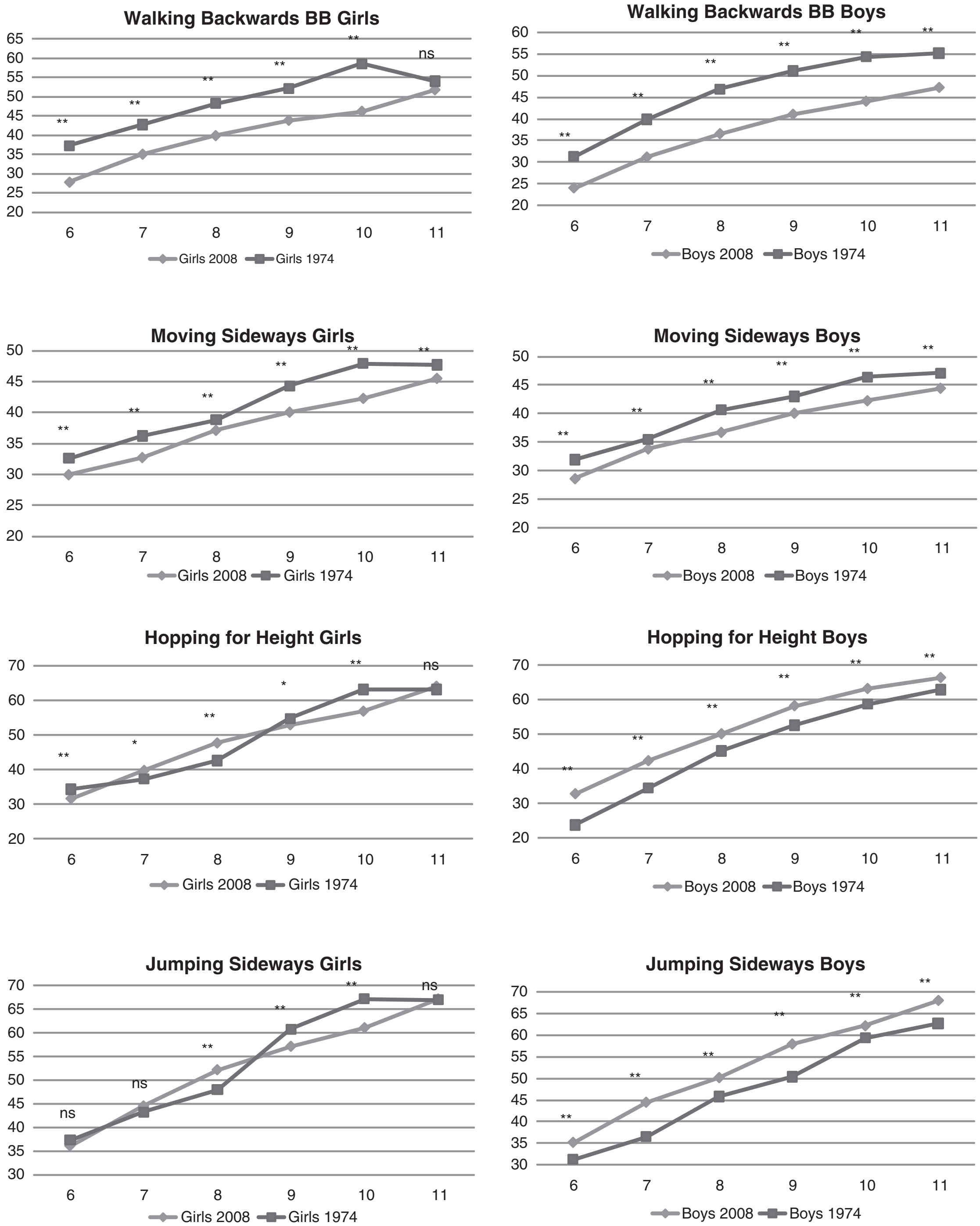

Fig. 1. Comparison between the German sample from 1974 and the Flemish sample from 2008 for the raw score on each KTK item (**$P<0.001$; *$P<0.05$; NS, non-significant).

from 1974 on HH (total: $t=11.382$, $P<0.001$; boys: $t=16.827$, $P<0.001$; girls: $t=0.215$, NS) and JS (total: $t=10.577$, $P<0.001$; boys: $t=18.353$, $P<0.001$; girls: $t=-2.288$, $P=0.022$). As described previously, on the latter two tests, the Flemish boys scored better than the German boys. For the girls, the total Flemish and German sample scored similarly on HH and JS. At some ages, the Flemish girls score better than the German reference group, and at other ages worse.

KTK MQ values and cut-off scores in a Flemish population

The distribution of scores of the Flemish sample compared with the German sample is displayed in Fig. 2. According to the classification of Kiphard and Schilling, children with an MQ value between 86 and 115 are considered as having normal gross motor coordination, children scoring between 71 and 85 as having a moderate gross motor coordination disorder

Table 3. MQ values [mean (SD)] of the four items of the KTK and the total test battery of the Flemish boys and girls for all age groups

WB	6	7	8	9	10	11	Age	Gender	Age × gender
Boys	87.66 (14.10)**	88.78 (14.57)**	87.95 (15.17)**	88.76 (13.73)**	89.67 (13.40)**	91.39 (16.67)**	$F = 4.677$	$F = 40.995$	$F = 0.551$
Girls	91.97 (12.78)**	93.06 (12.86)**	91.49 (13.71)**	91.69 (14.65)**	91.93 (13.14)**	96.73 (15.37)*	$P < 0.001$	$P < 0.001$	$P = 0.738$
Mean	90.01 (13.55)**	90.69 (13.98)**	89.68 (14.57)**	90.26 (14.27)**	90.59 (13.32)**	93.74 (16.31)**			
MS	**6**	**7**	**8**	**9**	**10**	**11**	**Age**	**Gender**	**Age × gender**
Boys	91.11 (11.86)**	95.18 (12.82)**	93.01 (14.35)**	92.30 (14.19)**	88.48 (11.99)**	93.37 (16.21)**	$F = 8.927$	$F = 1.285$	$F = 2.076$
Girls	94.30 (13.06)**	92.56 (12.32)**	93.95 (13.28)**	92.29 (13.21)**	88.52 (13.34)**	95.63 (15.48)**	$P < 0.001$	$P = 0.257$	$P = 0.066$
Mean	92.85 (12.61)**	94.01 (12.65)**	93.47 (13.83)**	92.29 (13.68)**	88.50 (12.54)**	94.37 (15.78)**			
HH	**6**	**7**	**8**	**9**	**10**	**11**	**Age**	**Gender**	**Age × gender**
Boys	109.36 (10.49)**	108.72 (12.53)**	105.19 (12.78)**	105.24 (11.57)**	104.49 (11.91)**	104.35 (16.53)**	$F = 13.451$	$F = 137.535$	$F = 13.130$
Girls	95.74 (15.90)**	103.06 (14.23)**	105.82 (14.14)**	97.99 (13.28)*	94.37 (13.77)**	101.18 (12.94)	$P < 0.001$	$P < 0.001$	$P < 0.001$
Mean	102.04 (15.23)**	106.19 (13.59)**	105.49 (13.45)**	101.53 (12.98)**	100.35 (13.63)	102.96 (15.12)**			
JS	**6**	**7**	**8**	**9**	**10**	**11**	**Age**	**Gender**	**Age × gender**
Boys	103.92 (10.98)**	111.22 (13.94)**	105.61 (14.39)**	108.62 (12.11)**	103.48 (13.06)**	106.82 (14.43)**	$F = 19.046$	$F = 183.123$	$F = 13.499$
Girls	97.86 (14.78)	101.91 (15.87)	105.27 (12.81)**	94.72 (15.78)**	93.12 (13.95)**	100.24 (12.40)	$P < 0.001$	$P < 0.001$	$P < 0.001$
Mean	100.61 (13.51)	107.06 (15.52)**	105.44 (13.63)**	101.50 (15.72)**	99.24 (14.35)	103.93 (13.94)**			
KTK	**6**	**7**	**8**	**9**	**10**	**11**	**Age**	**Gender**	**Age × gender**
Boys	97.30 (11.62)*	101.09 (13.79)	97.19 (14.83)**	98.22 (13.08)*	95.36 (12.55)**	98.53 (17.05)	$F = 11.51$	$F = 30.295$	$F = 4.862$
Girls	93.40 (13.69)**	96.83 (13.91)**	98.56 (13.87)	92.34 (14.91)**	89.50 (13.60)**	97.81 (14.49)	$P < 0.001$	$P < 0.001$	$P < 0.001$
Mean	95.17 (12.91)**	99.19 (13.99)	97.87 (14.37)**	95.21 (14.34)**	92.96 (13.29)**	98.22 (15.99)*			

Significantly different from the data from 1974 (Kiphard & Schilling) at the
**0.001 or
*0.05 level (mean MQ = 100).
KTK, KörperkoordinationsTest für Kinder; WB, walking backwards; MS, moving sideways; HH, hopping for height; JS, jumping sideways; MQ, motor quotients.

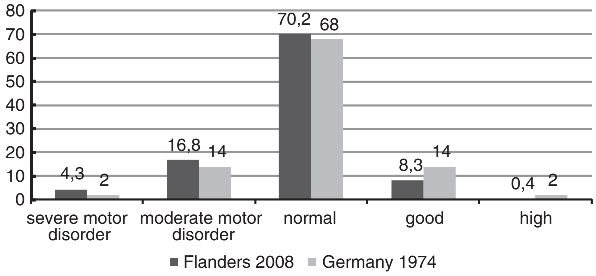

Fig. 2. Distribution of Motor Quotients of the total samples based on Kiphard and Schilling's classification (%).

and children scoring 70 or less as having a severe gross motor coordination disorder. Children scoring between 116 and 130 are considered as having good motor coordination and children scoring >131 as having a high MQ. When comparing the expected percentages of the German classification with the observed percentages in the Flemish sample, a significant chi-square value was found ($\chi^2 = 167.570$, df = 4, $P < 0.001$). The percentage of children with motor problems according to the norms of Kiphard and Schilling (1974) was 16% in the original German sample. In the Flemish sample, 21.1% of the children were indicated as such. At the other end of the continuum, 8.7% of the Flemish children scored better ("good" and "high" scores summed) than the average Flemish child, in contrast with 16% of the German children being identified as above-average performers.

Discussion

Given the growing awareness that the motor coordination level in childhood plays a crucial role in the physical and psychological health in childhood and even throughout the lifespan, a reliable and valid instrument to test the gross motor coordination of children is of importance. This study evaluates the usefulness of the KTK in Flanders anno 2008. The main aim was to provide age- and gender-specific reference values for the gross motor coordination of Flemish children between 6 and 12 years of age. In addition, the suitability of the KTK cut-off scores in a Flemish population was analyzed by comparing the MQ of the Flemish sample with the original German standardization sample.

In our sample of 2470 children, a significant improvement with increasing age was found on all four subtests, with each age group scoring significantly better than their 1-year younger peers. This is in-line with a recent longitudinal study by Ahnert et al. (2009) showing a gradual improvement in gross motor coordination across the elementary school years. Our results confirm the need for separate age-related reference values for the Flemish children. Moreover, the results indicate that the KTK is a sufficiently discriminating instrument for the developmental evaluation of the gross motor coordination of Flemish children.

With regard to gender, the picture is not equivocal over the different test items, nor are the differences the same as in the original KTK standardization sample. For the subtest WB, the raw scores reveal the girls in our sample performing significantly better than boys in all but one (10 years old) age groups, in which only a trend in the same direction was found. Smits-Engelsman et al. (1998) also reported girls scoring better than boys in a sample from the Netherlands. These findings are in contrast with the absence of gender differences in the original KTK sample (Kiphard & Schilling, 1974), who consequently did not develop separate reference values for boys and girls for this item. In this respect, Beunen et al. (1991) found that girls at elementary school age performed better on a static balance test (the flamingo balance test of the Eurofit test battery), which provides support for the notion that girls are slightly ahead of boys on general balance control between 6 and 12 years of age. At least for the Flemish 2008 population, it is advised that separate reference values for boys and girls should be used for the dynamic balance item of the KTK.

With respect to the raw scores on HH, in our sample, boys jumped higher than girls at all ages but at ages 6 and 11, those differences were not significant. Differences in performance in HH might be explained by anthropometric differences. However, boys and girls in our sample did not differ much in height and weight, except for the oldest age group (see Table 1). A more plausible explanation is that boys of this age have better physical fitness, especially in the domain of strength, endurance and explosivity (Beunen et al., 1991). Thomas (2001) stated that few differences in growth characteristics exist between boys and girls before puberty, but differences in motor coordination, physical activity and physical fitness do exist. He found that those differences are generally small before puberty, favor the boys and increase across the elementary school years. This might explain the temporary larger difference between boys and girls on the HH task at the age of 7, 8 and especially 9 and 10 with a decline at age 11 to the magnitude of difference at age 6 in our study. In the oldest age group, some girls are possibly already reaching puberty as shown by the larger height and weight measurements (Table 2), which might allow them to catch up with the boys of the same calendar age. Hence, although the KTK primarily focuses on coordination, it is plausible that physical properties also play a considerable role, particularly in this test item (Prätorius & Milani, 2004). Interestingly, in the German sample from

1974, a general advantage of girls over boys was present, leading the authors toward gender-specific scales for this item. The manual however, did, not provide any explanation for these differences. These differences might be explained by gender-specific leisure activities. The development of specific skills before puberty is influenced by the environment. As a rule, girls are found to be better than boys in flexibility, balance and (rope) jumping activities, considering the typical games of girls in social surroundings (Jürimäe & Jürimäe, 2001).

For JS, the raw scores revealed boys and girls scoring similarly in our study. This might be explained by the specific task requirements of this jumping task. According to Prätorius and Milani (2004) and Bös (1994), WB and MS test primarily coordination, while the other two tests, HH and JS, also require strength and/or endurance for good performance. As opposed to HH, it is clear that JS is a more speed-oriented task, and thus requires speed next to strength and/or endurance. Kiphard & Schilling (1974), however, reported girls performing significantly better than the boys at the ages of 6, 7, 9 and 10. In concordance with these results, the German manual used gender-specific scaling. Again, the manual did not provide an explanation for these differences. As stated above, girls being better at jumping activities is probably due to rope jumping being predominantly carried and played with by girls, although this is changing somewhat as jump rope activities become more athletic and competitive (Boyle et al., 2003). Moreover, it is assumed that the popularity of traditional games such as hopscotch and rope jumping has declined.

Malina (1984) reported that girls and boys have more or less similar physical characteristics before puberty and that these differences become more pronounced after puberty. In accordance with Malina and the results on the Flemish fitness study (Beunen et al., 1991), we might expect that the gender differences found for the hopping tasks, requiring strength and endurance, will increase as the children become older. In a recent study, Ahnert et al. (2009) reported hardly any performance differences in the total KTK between males and females in elementary school. Only after elementary school did males increase their performance in those tasks requiring strength and endurance, such as JS and HH. In the less strength-oriented subtests such as WB and MS, males and females did not improve their performance over time, showing equal or in some cases even worse performance at age 23 than at the age of 12.

Both the German study (Kiphard & Schilling, 1974) and the current study show no different performances from both genders on MS at all ages. Logically, no separate scaling is used in the German manual. Again, this might be explained by the task requirements of the subtest MS, with Bös (1994) and Prätorius and Milani (2004) stating that the subtest MS measures primarily coordination, which does not lead to favoring either gender with respect to physical or morphological characteristics.

Although the gender differences for the subtests are not in-line with the original German sample, our results, with the girls scoring better on the balance task and the boys on the strength-oriented task, are in-line with the previously mentioned studies (Beunen et al., 1991; Smits-Engelsman et al., 1998; Prätorius & Milani, 2004). Opting for separate reference values for boys and girls on those two KTK subtests (WB and HH) is advised, at least for the current Flemish population.

In order to evaluate the suitability of the original norms anno 2008, the raw scores and MQ values of our sample were compared with the ones from 1974. As shown by the results on the individual subtests, the superiority of either sample seems to be dependent on the given task. On the subtests WB and MS, the Flemish girls as well as boys show lower scores when compared with the German sample at all age groups. On the contrary, the Flemish boys from 2008 outscore the German boys from 1974 on the HH and JS subtests. The Flemish girls, however, score more or less the same or better than their German counterparts in the youngest age groups and worse in the older age groups. At the age of 11, no significant differences were found between the two samples.

These differences might be explained by secular trends. As Butte et al. (2007) reported, positive secular trends have been documented in European, European-origin and Asian populations, where mean heights and weights across generations have been shown to be greater whereas sexual maturation and adolescent growth spurts have taken place at progressively younger ages. Cole (2000) documented that while height has largely stabilized since 1975, weight has continued to increase. Moreover, he reported that menarcheal age has declined steeply in the past and has now stabilized at approximately 13 years of age. Overall, there is consensus of a secular trend toward earlier puberty (Karlberg, 2002).

Likewise, comparison of our results with data published in 1993 by Lefevre et al. shows that height in school-aged children in Flanders has not changed whereas weight has increased with 0.5–3 kg in boys and girls. These anthropometric and hormonal differences might explain the superiority of Flemish boys of 2008 over German boys of 1974 on hopping tasks in the oldest age groups. Children nowadays reach puberty earlier than 35 years ago. In boys, this leads to an earlier increase in testosterone levels, resulting in an increased muscle mass (Rogol et al., 2000). Flemish boys might have reached puberty earlier than the German boys from 1974. Similarly, the Flemish girls might have reached puberty earlier than the German girls from 1974, which might be a disadvantage on hopping tasks in the oldest age groups, considering the weight gain before the onset of menarche, mediated by a critical leptine blood level (Matkovic et al., 1997).

Generally, the children in the Flemish sample scored lower on the total KTK than the German standardization sample from 1974, as shown by MQ values of, respectively, 96.5 vs 100. There is evidence that physical activity in clearly defined contexts such as active transport, school PE and organized sports is declining in many countries (Dollman et al., 2005). Unlike what was expected to be a consequence of the sedentary lifestyle, however, these results show that no dramatic decline in gross motor coordination occurred over the last 35 years, although, considering the above-mentioned secular trends, the possibility of a true decline in coordination being masked by a compensation mechanism due to better physical qualities, must receive further attention. The results of the subtests measuring primarily coordination have declined (WB and MS), whereas scores on the tests relying more on strength and speed have improved or remained more or less consistent.

At first glance, in the evaluation of the cut-off points of the MQ values, the graphs show a similar score distribution between the two samples. The scores of the Flemish children are spread over all five classification areas, meaning the KTK is able to classify the whole spectrum of children. The test cannot only distinguish between children with normal and poor gross motor coordination levels but also between normal and advanced gross motor coordination levels. However the chi-square test showed that, the distribution over the categories deviates from 35 years ago. Although there is not much difference in the middle range, the distribution at the extreme ends of the continuum has changed. In our Flemish sample, the curve is situated more to the lower end of the continuum, meaning that a considerable percentage of children scoring from the good to high range are now situated in the normal range. Similarly, a part of the normal range has shifted toward the motor disorders group. However, despite 21% of the children being classified as having a certain motor problem seems problematic, we feel there is no reason to adjust the norms for use in a current population, but rather to solely use them as reference values. Instead of lowering the norms, extra efforts should be made in order to stop this decline in motor coordination from proceeding. Considering the importance of the development of the motor skill level in childhood for lifetime health, well-being and academic reasons, teachers, particularly of PE, sports coaches, and the government should all make efforts so that as many children as possible could fit within the normal range or higher (Barnett et al., 2008; Stodden et al., 2008).

The KTK might be of great use for displaying the gross motor coordination of a population, comprising the whole spectrum of children. The test not only distinguishes between normal and motor-impaired children but also between normal and advanced children. The possibility to use the KTK in search of talented children is an attractive research possibility. This suggestion was also posted by Ahnert et al. (2009). They stated that the stability of motor abilities is important across the field of talent selection and development and the early identification of clumsy and motor-impaired children. Recent results of a longitudinal study showed moderate to high long-term stability of motor skills from elementary school until early adulthood measured by the KTK (Ahnert et al., 2009). In this context, we suggest that children with an MQ above 115 receive further guidance in sports to develop their talent.

There are limitations to this study that need to be addressed. The anthropometrical data of the original German sample of 1974 were not available. Therefore, the differences in scoring on the subtests between the actual Flemish and the older German population being explained by secular trends cannot be fully substantiated. Generally, we might reasonably expect, for example, Flemish girls weighing more nowadays than their German counterparts of 1974, but this assumption lacks hard data for now.

Moreover, this study only focused on the gross motor coordination of children. It should, however, be noted that both fine and gross motor skills play a key role in the overall learning abilities of children. Fine and gross motor skills are crucial contributors to the social and academic development of children and therefore both should be considered in future research.

Perspectives

This study provides representative values on the KTK test for 6–12-year-old boys and girls in the northern part of Belgium. In general, a decline in coordination in comparison with 35 years ago can be observed, especially at the extreme ends of the continuum. There is a decline in coordination, primarily in those tasks relying on the coordinative capacities, which could not be explained by anthropometric or hormonal differences. In tasks influenced by secular trends, boys and girls seem to compensate a lack of coordination with greater strength and speed-related physical properties. Rather than to adjust the norms for a current population, we suggest that the necessary efforts should be made to stop this decline in motor coordination or to prevent it from proceeding. The KTK proved to be a valuable instrument for the

assessment of the gross motor coordination of all children in Flanders.

Key words: coordination, elementary school children, motor skill assessment.

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