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Development of a Tool to Assess Fundamental Movement Skills in Applied Settings

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The main aim of this study was to evaluate a new combination of test items on its practical use as a tool for determining the fundamental movement skills performance in 6- to 10-year old primary school children. This combination of tests should cover the different aspects of fundamental movement skills (i.e., locomotion, balance and object control), measure performance levels within the broad spectrum of this age range in both boys and girls and be able to detect the existing performance differences between ages. For this purpose, 1121 primary school children (6–10 years) were assessed during their regular PE class using three test items of the Korper Köordinations Test für Kinder (KTK-3), i.e., walking backwards (WB), moving sideways (MS), jumping sideways (JS), and an eye hand coordination test item (EHC). Univariate General Linear Model analyses were used to evaluate main and interaction effects of sex and age on the test outcomes. Pearson's correlation coefficients were calculated to confirm the different constructs measured by the four test items. Moreover, in line with previous studies the raw scores were converted into movement quotients (i.e., MQ^{KTK-3} and $MQ^{KTK-3+EHC}$) to classify the children's performance level. Accordingly, percentage of agreement and Cohen's kappa between both classifications was determined to gain insight in the influence of the addition of the EHC to the KTK-3. Significant effects for sex and age were found. Girls outperformed boys on WB and boys outperformed girls on EHC ($P < 0.05$). On all test items children of a certain age group scored better than their 1-year younger peers, except at WB between 10- and the 8- and 9-year olds and at MS and JS between 10-year olds and 9-year olds. Moderate positive associations between the test items were found ($P < 0.05$). An 80.8% agreement of classification of children was found based on the MQ^{KTK-3} or the $MQ^{KTK-3+EHC}$ [Cohen's kappa 0.59 ($P < 0.001$)]. Consequently, The KTK-3+EHC appears to adequately cover different aspects of the fundamental movement skills. It provides practitioners a tool that can objectively assess the broad performance spectrum within young children in applied settings, which better meets children's individual developmental needs.

Keywords: motor skill, FMS assessment, child, KTK-3, schools, physical education and training

INTRODUCTION

All children could benefit from an instrument which assesses a child's fundamental movement skills (FMS). Such an instrument would provide opportunities for professionals working with young children in the context of sport and physical education to (1) have a more objective understanding of children's skills, (2) better meet children's developmental demands, and (3) analyse the effectiveness of their interventions. Currently, there are several instruments, which can measure children's FMS performance level, e.g., the Movement Assessment Battery for Children 2 (Henderson et al., 2008), the Bruininks-Oseretsky Test for Motor Proficiency 2 (Bruininks and Bruininks, 2005), and the Test of Gross Motor Development (Ulrich, 1985, 2000). Most of these instruments focus on identifying children with fundamental movement skill development disorders and are rather time-consuming. Yet, in the context of sport training and physical education an instrument for measuring FMS that covers not only children at risk but rather a broad performance spectrum and can be conducted in only limited time can be of great value (Vandorpe et al., 2011).

FMS are mainly build up by gross motor coordinative skills which are the building blocks for the more specific sports skills learned at later developmental stages (Clark, 2007; Lloyd et al., 2014; Loprinzi et al., 2015; Cattuzzo et al., 2016). Specifically, adequate FMS are considered as a requirement for functioning in regular daily activities (Henderson et al., 2008), and a positive element to stimulate the initiation and maintenance of physical activity (Stodden et al., 2008). It includes locomotor skills (e.g., walking, running, hopping), balance/stability skills (e.g., balancing, turning, dodging), and object control (e.g., throwing, catching, kicking) (Gallahue et al., 2012). From around the age of 6–10, typically developing children are in a sensitive stage to improve these FMS (Clark, 2007; Platvoet et al., 2016). Of course, also after the age of 10 children will still develop their FMS, but generally not as fast as within this sensitive period (Ahnert and Schneider, 2007; Vandorpe et al., 2011; Fransen et al., 2014). Results from a longitudinal study showed moderate to high long-term stability of FMS performance level from elementary school until early adulthood (Ahnert and Schneider, 2007). Moreover, the level of motor competence at age of 9 and 10 was related to the children's physical activity levels 32 months later (Haga, 2009). Consequently, it seems sensible to first focus on children within the age span of 6–10 years when developing an instrument to assess FMS.

Nevertheless, although monitoring children's FMS is considered to have several advantages, currently the implementation of FMS measurement in settings like sport training and physical education is rather limited and the number of large-scale longitudinal studies on this topic are scarce (Lloyd et al., 2014). A reasonable explanation is that as stated before most instruments were originally developed to identify children with motor disorders in a clinical setting (one-on-one setting). Consequently, most existing instruments do not cover the whole performance spectrum (from low to high performance), but present a skewed distribution with ceiling effects. This means that it is difficult to differentiate between performance levels. Additionally, the instruments score low on feasibility aspects (instruction and demonstration are not short and simple) and/or have too many test items, which makes testing rather time consuming (Cools et al., 2009). Only instruments that overcome these issues are eligible for the sport training and physical education setting. As such, we searched for an instrument with a high level of practical feasibility that covers the different aspects of FMS and is able to measure within the broad performance spectrum of young children (6–10 years).

It was suggested by our colleagues (Ahnert and Schneider, 2007; Vandorpe et al., 2011) that from all the available measurements the Korper Köordinations Test für Kinder (KTK) might be of added value in the determination of a part of children's FMS. The KTK measures especially the locomotor and balance/stability skills of children (Kiphard and Schilling, 1974, 2007), and allows a relatively straightforward and objective evaluation with limited interference of physical fitness (e.g., strength, speed, endurance and flexibility; Vandorpe et al., 2011). The KTK is one of the few FMS measurements that comprises the whole performance spectrum (Fransen et al., 2014). For that reason, it is not only suitable to identify children with motor disorders, but also to distinguish typically developing children's performances. Moreover, the test is also valuable to determine the effectiveness of interventions (Cools et al., 2009). The KTK measures FMS by means of four test items: walking backwards, jumping sideways, moving sideways and hopping for height. Recently, our colleagues (Novak et al., 2017) showed a strong correlation between the KTK motor quotient (MQ) scores based on all four subtests and the KTK MQ scores when hopping for height was excluded ($r = 0.98$, $p < 0.001$). The KTK without hopping for height (KTK-3) is suggested to be more applicable in sport and educational settings, since hopping for height is a time-consuming test item including a risk for getting injured (e.g., ankle sprain).

Although the KTK measures two of the three important FMS, it lacks a test item focusing on object control. This construct is considered as highly important for motor behavior in daily life and specifically for performance in (ball and racket) sports (Butterfield et al., 2012). Consequently, adding a valid and reproducible test item to the KTK-3 that (1) measures this construct, (2) covers the broad performance spectrum of primary school children, and (3) only needs limited administering time, seems beneficial. The eye hand coordination test proposed by our colleagues (Faber et al., 2014) might fulfill this purpose. This test measures the level of controlling a ball while conducting repetitive movements (i.e., throwing and catching) in a time-constraint task of only 30 s. Earlier studies confirmed its capability to discriminate between children with different motor performance levels (Faber et al., 2014, 2017). The KTK-3 together with the inclusion of Faber's eye hand coordination test ensure a broader perspective on a child's FMS. It responds to the necessity of using multiple tests to accurately assess FMS performance without being time-consuming (Fransen et al., 2014; Bardid et al., 2015; Logan et al., 2017).

Based on these theoretical considerations, it seems reasonable that the proposed combination of tests (i.e., the KTK-3+EHC) to assess FMS performance (i.e., locomotion, balance and object control) in children (6–10 years) will be useful in practice. Still, the KTK-3+EHC needs to be evaluated for further practical use. More specifically, this study investigated whether the KTK-3+EHC is valuable as a tool for determining the broad spectrum of FMS performance in both boys and girls and to detect existing performance differences between ages. For that purpose, the distribution of scores and effect of sex and gender on the item scores have been studied. Moreover, the KTK3+EHC was evaluated to confirm the different constructs measured by the four test items.

MATERIALS AND METHODS

Ethical Statement

This study procedure was approved by the ethical advisory committee at the Faculty of Health of the HAN university of applied sciences (reference number EACO 17.12/89). All parents were informed by the schools prior to the testing and were asked to communicate with the school in case they did not want their child(ren) to participate. All data were anonymously recorded in a secured dataset.

Design

A cross-sectional study design was used in which primary school children were assessed between February and March 2017.

Participants

Participating children were recruited at 13 regular primary schools in the Netherlands. To obtain a representative sample a selection of schools situated in rural and more urbanized areas in four different provinces of the Netherlands was made. A total of 1121 children, of which 559 boys and 562 girls, of the third through sixth grade class were included. Injured children were excluded. See **Table 1** for more details about the participants.

Fundamental Movement Skill Assessment

The assessment of the children's FMS, consisted of four test items, i.e. three test items of the KTK short form, walking backwards (WB), moving sideways (MS) and jumping sideways (JS), and Faber's eye hand coordination test (EHC). The standardization of all test items is captured in protocols, which includes a detailed description of materials, set-up, assignment, demonstration, training phase, testing phase and registering test scores (Kiphard and Schilling, 2007; Faber et al., 2014). The test-retest reliability of the test items is considered good; WB 0.80, MS 0.84, JS 0.95, EHC 0.87 (Kiphard and Schilling, 2007; Faber et al., 2014).

TABLE 1 | Participants' characteristics.

		Primary school (n = 13)		
		Total group	Boys	Girls
N		1,121	559	562
Age group (*n*)	6	192	89	103
	7	265	121	144
	8	266	143	123
	9	277	157	120
	10	121	49	72

A child was classified within a age group corresponding to the actual age at the day of testing (e.g. a child was classified as 6 year old from 6.00 through 6.99).

Walking Backwards (WB)

The children were instructed to walk backwards three times along of three balance beams (3 trials × 3 beams) with the same length (3 m) but differences in width (6, 4.5, and 3 cm). The number of successful steps was scored as final raw outcome with a maximum of eight steps per trial, which comprises a maximum of 72 steps (8 steps × 3 trials × 3 beams).

Moving Sideways (MS)

The children started with standing on a first box and holding a second box in their hands. After the start signal the children needed to place the second box alongside the first and step on it. Then the child needed to pick up the first box and place it again alongside the second one to step on it and so on as quickly as possible. Each child performed two trials of 20 s. The number of correct relocations of both trials summed up was scored as final raw outcome.

Jumping Sideways (JS)

At this task the children needed to jump sideways over a wooden lath (60 × 4 × 2 cm) as many times as possible within 15 s. The number of correct jumps of two trials was summed and used as final raw outcome.

Eye Hand Coordination (EHC)

During the eye-hand coordination test the children needed to throw a tennis ball at a rectangle target (height 137 cm, width 152.5 cm; positioned at 1 m from the ground) on a flat wall at 1 m distance with one hand and to catch the ball correctly with the other hand as many times as possible in 30 s. The best number of correct catches of two attempts was recorded as raw outcome score. A modification on the original protocol was introduced for the children of the third and fourth grade classes (mEHC); they were allowed to use both hands for catching. This resulted in mEHC scores for all 6- and 7-year olds, and for some of the 8-year olds. EHC of the 8-year olds in grade five was assessed by the original EHC test. This resulted in two groups (i.e., mEHC and EHC) for the 8-year olds.

Movement Quotient (MQ)

In line with the original manual of the KTK, a movement quotient (MQ) was obtained as a total score for the FMS assessment. For this purpose, the raw scores of each test item were converted into norm values for each test item, separately, based on the available dataset. Consecutively a movement quotient (MQ) was established by combining the norm values. The KTK's transformation methods described in the original manual were used for both the conversion of the raw scores into norm values per item and the conversion of the item norm values into a combined MQ. As such 100 and 15 points reflects the mean and the standard deviation of the norm population, respectively. Two calculations of the MQ were conducted: 1) the MQ^{KTK-3}

based on the results of the KTK-3 and 2) $MQ^{KTK-3+EHC}$ based on the KTK-3 and the EHC test. All children were classified twice, based on the MQ^{KTK-3} and based on $MQ^{KTK-3+EHC}$, into one of the categories of FMS performance as suggested by Kiphard and Schilling (1974, 2007): severe disorder (≤70), moderate disorder (71–85), normal performance (86–115), good performance (116–130), high performance (≥131).

Data Collection

All children completed the assessment as part of their regular physical education classes in an indoor facility. The testers were physical education students in the final stage of their study or physical education teachers. All testers were well-trained to ensure that the test protocols were used in a standardized way. They first familiarized themselves with the test protocols and instructions and then they were given feedback during a training session by an expert. At all assessments an experienced tester supervised the measurements. The children's sex and date of birth were provided by the school before the assessment.

Statistical Analysis

IBM SPSS Statistics 24 (IBM Corp., Armonk, New York, United States of America) was used for the statistical analyses. The test items' scores of WB, MS and JS were normally distributed. The distribution of the (m)EHC outcomes was positively skewed. Since transformation did not solve this non-normality, it was decided to check the normality of the model's residuals of bootstrapping in further analyses that included the (m)EHC outcomes to ensure the robustness of the analyses (Williams et al., 2013). Descriptive statistics of the assessment outcomes are presented by sex and age, separately.

First, univariate General Linear Model (GLM) (i.e., ANOVA) analyses, including the raw test item scores one by one as dependent variables and sex and age as a fixed factors, were used to elucidate main and interaction effects of sex and age. Additional Sidak's *post hoc* tests were conducted in case of significant main effects of age. Second, for construct validity partial Pearson's correlation coefficients were calculated, while correcting for sex and age in line with the original procedures of the test items (Kiphard and Schilling, 1974; Faber et al., 2014), to present the interrelationship between the raw test item outcomes in a correlation matrix. Additionally, bootstrapping (1,000 samples) was performed to calculate 95% confidence intervals for the Pearson's correlation coefficients. Finally, the agreement between the classifications of MQ^{KTK-3} and $MQ^{KTK-3+EHC}$ was evaluated using the percentage agreement and Cohen's kappa. Alpha was set at 0.05 for significance for all analyses.

RESULTS

The results of the performance on the test battery per age group for boys and girls are shown in **Table 2** and presented in **Figure 1**, respectively.

Sex and Age Differences

The univariate GLM analyses (**Table 2**) showed significant effects for sex in WB and (m)EHC ($P < 0.05$) with small effect sizes (partial η^2: WB 0.037, EHC 0.028, mEHC 0.017). At WB the girls outscored the boys and at (m)EHC the opposite was shown as the boys outscored the girls. A significant main effect of age was presented in all test items ($P < 0.001$) with medium to large effect sizes (partial η^2) between 0.095 and 0.294. *Post-hoc* tests revealed that children of a certain age group scored significantly better than their 1-year younger peers on all test items ($P < 0.05$). Only at WB no significant differences were shown between the 10-year olds and their 8- or 9-year peers and at MS and JS between the 10-year olds and the 9-year olds. No interaction effects were found between sex and age ($P > 0.05$), except at JS ($P = 0.041$) with a small effect size (partial $\eta^2 = 0.010$) (Cohen, 1992).

Interrelationship Between Test Items

The correlation matrix (**Table 3**) showed low to moderate positive associations between the test items with the 95% confidence intervals not including zero. The highest association was found between MS and JS (Pearson's $r = 0.46$; 95% confidence interval 0.42–0.51), the lowest between MS and EHC (Pearson's $r = 0.14$; 95% confidence interval 0.05–0.22).

Agreement Between MQ^{KTK-3} and $MQ^{KTK-3+EHC}$

The children who completed all test items were included to obtain the MQ^{KTK-3} and $MQ^{KTK-3+EHC}$ and were classified into the fundamental movement skill categories. There was an agreement between the classification based on the MQ^{KTK-3} and $MQ^{KTK-3+EHC}$ in 811 of the 1004 children included, which corresponds to 80.8% agreement with a Cohen's kappa valuing 0.59 ($P < 0.001$) (**Table 4**). When there was no agreement, the difference was one category only; 10.0% of the children were classified in a higher category based on the MQ^{KTK-3} and 9.2% of the children were classified in a higher category by the $MQ^{KTK-3+EHC}$.

DISCUSSION

This study evaluated the combination of the KTK-3 and Faber's eye hand coordination test, the so-called KTK-3+EHC, to assess FMS in primary school children within the age-span of 6–10 years. The results indicate that the KTK-3+EHC is generally able to cover a broad performance spectrum. Moreover, the test items appear to adequately cover different aspects of the FMS as the items present only low to moderate interrelationships. The low associations between the (m)EHC test item and the KTK-3 items, suggests that the (m)EHC test item measures another aspect than the other three items. Consequently, the (m)EHC test is considered to complement the KTK-3 assessing locomotor and balance skills with a new aspect, i.e. object control, to measure fundamental movement skills. Also the differences between the classifications of the children when using the MQ^{KTK-3} or the $MQ^{KTK-3+EHC}$ supports that the (m)EHC test item is of adding new insights on a child's motor performance. Finally, the four tests appear easily applicable and do not place burden on professionals' time; in this study 25 children were tested

TABLE 2 | Raw scores (mean ± SD) of the FMS assessment test items including univariate GLM analysis for effects of sex and age of 6- (n = 192), 7- (n = 265), 8- (n = 266), 9- (n = 277), and 10- (n = 121) year olds.

	6	7	8	9	10	Sex	Age	Age × Sex
Boys	25 ± 9.8	30 ± 10.8	37 ± 12.1	40 ± 11.8	39 ± 14.3	$F = 41.695$	$F = 58.432$	$F = 1.014$
Girls	29 ± 10.5	37 ± 13.0	42 ± 14.3	46 ± 12.9	42 ± 13.9	$P < 0.001$	$P < 0.001$	$P = 0.399$
Total	27 ± 10.3	34 ± 12.6	39 ± 13.4	43 ± 12.6	41 ± 14.0	partial $\eta^2 = 0.037$	partial $\eta^2 = 0.175$	partial $\eta^2 = 0.004$
MS	6	7	8	9	10	Sex	Age	Age × Sex
Boys	32 ± 7.3	38 ± 7.9	43 ± 7.8	46 ± 6.9	45 ± 6.8	$F = 0.047$	$F = 114.844$	$F = 0.510$
Girls	33 ± 7.3	38 ± 7.3	42 ± 6.5	46 ± 6.6	46 ± 8.1	$P = 0.828$	$P < 0.001$	$P = 0.728$
Total	33 ± 7.3	38 ± 7.6	43 ± 7.2	46 ± 6.8	45 ± 7.5	partial $\eta^2 < 0.001$	partial $\eta^2 = 0.294$	partial $\eta^2 = 0.002$
JS	6	7	8	9	10	Sex	Age	Age × Sex
Boys	39 ± 13.2	48 ± 14.4	58 ± 13.7	61 ± 11.6	67 ± 12.3	$F = 0.501$	$F = 105.355$	$F = 2.505$
Girls	40 ± 12.7	49 ± 14.6	53 ± 14.0	62 ± 10.9	65 ± 14.9	$P = 0.479$	$P < 0.001$	$P = 0.041$
Total	39 ± 12.9	49 ± 14.5	56 ± 14.0	61 ± 11.3	66 ± 14.0	partial $\eta^2 = 0.001$	partial $\eta^2 = 0.292$	partial $\eta^2 = 0.010$
EHC[1]	6	7	8	9	10	Sex	Age	Age × Sex
Boys	–	–	8 ± 6.1	11 ± 6.5	15 ± 6.4	$F = 15.827$	$F = 29.021$	$F = 1.094$
Girls	–	–	7 ± 6.1	9 ± 6.1	12 ± 6.0	$P < 0.001$	$P < 0.001$	$P = 0.335$
Total	–	–	8 ± 6.1	10 ± 6.5	13 ± 6.3	partial $\eta^2 = 0.028$	partial $\eta^2 = 0.095$	partial $\eta^2 = 0.004$
mEHC[1]	6	7	8	9	10	Sex	Age	Age × Sex
Boys	4 ± 4.7	8 ± 7.0	10 ± 7.2	–	–	$F = 9.169$	$F = 39.267$	$F = 1.983$
Girls	3 ± 3.7	5 ± 5.1	9 ± 6.5	–	–	$P = 0.003$	$P < 0.001$	$P = 0.139$
Total	3 ± 4.2	7 ± 6.2	9 ± 6.8	–	–	partial $\eta^2 = 0.017$	partial $\eta^2 = 0.131$	partial $\eta^2 = 0.008$

WB, walking backwards; MS, moving sideways; JS, jumping sideways; EHC, eye hand coordination; mEHC, modified eye hand coordination. Post hoc analysis showed significant differences between all age groups for the four test items except between children of 10- and 8-years for WB and between children of 10- and 9-years for WB, MS and JS. [1]Children in grade 3 and 4 (6-, 7-, and 8-year olds) performed the mEHC. Children in grade 5 and 6 (8-, 9-, and 10-year olds) did the EHC.

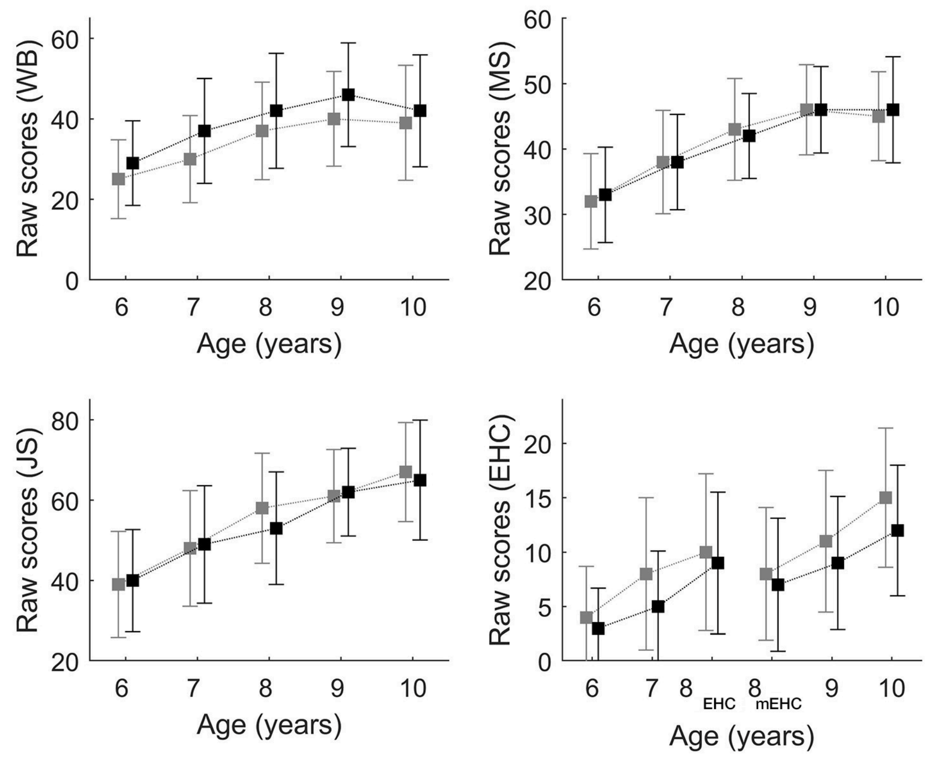

FIGURE 1 | Raw scores of the four test items for boys (gray line) and girls (dark line) per age.

TABLE 3 | Correlation matrix for interrelationship of the test items.

	MS	JS	EHC	mEHC
WB	0.40[a] (0.35–0.45)	0.42[b] (0.50–0.59)	0.17[c] (0.09–0.25)	0.21[d] (0.11–0.29)
MS		0.46[e] (0.42–0.51)	0.14[f] (0.05–0.22)	0.27[g] (0.18–0.35)
JS			0.32[h] (0.23–0.41)	0.28[i] (0.20–0.36)

Data represent partial correlations coefficients (95% confidence intervals) correcting for sex and age. WB, walking backwards; MS, moving sideways; JS, jumping sideways; EHC, eye hand coordination; mEHC, modified eye hand coordination. [a]*df = 1106,* [b]*df = 1026,* [c]*df = 555,* [d]*df = 520,* [e]*df = 1029,* [f]*df = 555,* [g]*df = 523,* [h]*df = 510,* [i]*df = 499.*

within 45 min with four test leaders. Consequently, the KTK-3+EHC seems to have good prospects to measure fundamental movement skills in applied settings.

To our understanding, adding the Faber's test to the MQ^{KTK-3} enriches the FMS measurement. The KTK-3 was recommended by its quick screening ability, and for its reliable, accuracy and standardization (Cools et al., 2009). It was also favored because of the capacity to measure locomotor and balance skills of all children, even those with well-developed skills (Ahnert and Schneider, 2007; Vandorpe et al., 2011; Cattuzzo et al., 2016). The use of several test items to determine a child motor competence is recommended to decrease the influence of one-time testing (Kiphard and Schilling, 1974). With an object control skills measurement included, the KTK-3+EHC test measures a broader range of the FMS of children as defined by our colleagues (Gallahue et al., 2012). The low associations found between EHC test and the KTK-3 test items was therefore expected. Locomotion and balance are closely connected to each other, since balance skills are underlying abilities for locomotion skills (Burton and Rodgerson, 2001; Logan et al., 2017). Object control as measured with the EHC test on the other hand requires different abilities like eye hand coordination, ball control and anticipatory movement skills. Provided the importance of object control for motor behavior in daily life and specifically for performance in ball and racket sports (Butterfield et al., 2012), adding the (m)EHC test item to the KTK-3 to measure fundamental movement skills is recommended. Especially because it has been shown that object control skill competence at a young age is associated with a greater likelihood of vigorous physical activity engagement in adolescence (Barnett et al., 2008). It is important to acknowledge that this will change classification of around 20% of the children, which is considered relevant for practice.

The ability to cover a broad performance spectrum is confirmed in this study by the fact that no bottom and ceiling effects were present in the data of the subsamples. Children with already high FMS competence are challenged by the test even though the four tests items are applicable for those children with weak competences. For primary education settings this is highly relevant as children's competence generally vary to a high extent. Most other tests are developed to identify children with motor problems (Vandorpe et al., 2011), and are not able to distinguish between better movers and not applicable to analyse intervention studies due to ceiling effects (Cools et al., 2009). Only the EHC showed a bottom effect in the 6- and 7-year olds in both sexes. This test item seemed to be rather difficult to perform for most of the younger children. Therefore, a modified version of the original test in which catching was allowed with both hands was implemented. Nevertheless, the mEHC, like the EHC and the KTK-3 items, was able to discriminate between the performances of the included age groups and the bottom effect seemed to have a negligible effect on the distribution of the $MQ^{KTK-3+EHC}$ outcomes.

In addition of the absence of ceiling effects, the increase of the performance level per age-group represent the capacity of the KTK-3+EHC to measure within the full performance spectrum and probably also to monitor performance development over time. In line with the results of other studies (Ahnert and Schneider, 2007; Vandorpe et al., 2011; Fransen, 2014), this study revealed that there is a significant difference with medium to large effect sizes in fundamental movement skill performance with increasing age. This demonstrates that it is necessary to make use of age-related reference values for the four subtests. In contrary to the results of other studies, the 10-year olds did not outperform the 8- and 9-year olds on WB, and the 9-year olds on SP and JS. A possible explanation is the inclusion of the 10-year olds in this study. For practical reasons, only children from grade 3 through 6 were measured. As a result, we included only the relatively younger 10-years olds (mean age in this study was 10.38), which do not fully represent 10-year olds in general. In a next study more 10-year olds, for example those in grade 7, should be assessed to have a representative sample for this age group. It was shown before (Fransen et al., 2014), that with increasing age, the improvement in score at the three subtests of the KTK-3 diminishes, especially at WB. This might also provide an explanation for the results found in this study.

Besides the use of age-related reference values it might be recommended to use different norms for both sexes at the (m)EHC test and the WB test. Similar to the results found by our colleagues (Vandorpe et al., 2011) in this study girls scored higher on the WB test. On the EHC test boys outperformed girls, which is in line with our colleagues (Faber et al., 2017). The differences between boys and girls before puberty are probably not explained by differences in the amount of physical activity and physical fitness (Cherney and London, 2006). A more reasonable explanation is the different preference of activities of boys and girls. Girls practice outside more activities related to gymnastics (e.g., rope jumping, bar), whereas boys prefer to play with a ball (Thomas and Thomas, 1988). Sex related references values are considered to give a better evaluation of the fundamental movement skills performance level of an individual child compared to his/her peers. Nevertheless, the effect sizes for the main effect of sex are only small, which makes the necessity of sex-related reference values arguable.

Some limitations of this study need to be acknowledged. First, it is noteworthy that the four subtests do not measure all skills (e.g., walking, dodging) linked to FMS. It was decided to develop a set of four tests that measure all three different FMS skills as described by our colleagues (Gallahue et al., 2012).

TABLE 4 | Agreement between the classification of motor abilities using the MQ^{KTK-3} and $MQ^{KTK-3+EHC}$.

		MQ^{KTK-3}					
		Severe motor disorder	**Moderate motor disorder**	**Normal**	**Good**	**High**	**total**
$MQ^{KTK-3+EHC}$	Severe motor disorder	19 (1.9%)	7 (0.7%)	0 (0%)	0 (0%)	0 (0%)	26 (2.6%)
	Moderate motor disorder	6 (0.6%)	70 (7.0%)	44 (4.4%)	0 (0%)	0 (0%)	120 (12.0%)
	Normal	0 (0%)	32 (3.2%)	628 (62.5%)	43 (4.3%)	0 (0%)	703 (70.0%)
	Good	0 (0%)	0 (0%)	41 (4.1%)	85 (8.5%)	7 (0.7%)	133 (13.2%)
	High	0 (0%)	0 (0%)	0 (0%)	13 (1.3%)	9 (0.9%)	22 (2.2%)
	Total	25 (2.5%)	109 (10.9%)	713 (71.0%)	141 (14.0%)	16 (1.6%)	1004 (100%)

Data represent the number of children classified in a certain classification and percentage of the total. Percentage agreement between MQ3 and MQ4 is 80.8% with a Cohen's kappa of 0.59 (p <0.001). MQ, movement quotient; KTK-3 includes walking backwards, moving sideways and jumping sideways; KTK-3 + EHC includes walking backwards, moving sideways, jumping sideways and eye hand coordination (modified).

With these four subtests the broad performance spectrum of FMS performance of 25–30 children can be assessed within limited time. Measuring more items could increase the validity but will be too time consuming (Cools et al., 2009). Second, to generalize the results of this study more measurements are needed. In contrary to about 50% of the Dutch children, children in this study have at least once a week PE from a specialist PE teacher. Also, in this study only regular primary schools participated. More measurements are needed to set norms, with its limitations as described before, and evaluate the influence of age and sex, also in older age groups (i.e., 11- and 12-year olds). Finally, it needs to be acknowledged that children's development of FMS performance is not a linear process and the variability of FMS performance is high (Clark, 2007; Fransen, 2014). Our colleagues (Logan et al., 2017) stated the importance to make use of both product and process-oriented (i.e., a focus on the quality of movement) assessment tools to provide a more comprehensive view of FMS performance. To our understanding, a comprehensive view of FMS performance can be obtained by the KTK-3+EHC instrument and preferably in combination with more qualitative assessments made by the professional who observe children week in week out.

To conclude, this study focused on the evaluation of the KTK-3+EHC test to asses 6- to 10-year olds FMS performance in a simple and objective way. The feasibility of the instrument is high and to our understanding the KTK-3+EHC test could be of great value for professionals working with children in this age group. It gives them a tool with which they can objectively assess children FMS performance which provide opportunities to better meet children's individual developmental needs and evaluate the effectiveness of their own practices.

AUTHOR CONTRIBUTIONS

SP, IF, MdN, and JP contributed conception and design of the study. SP, MdN, and RK acquired the data. MdN and RK organized the database. IF and JP performed the statistical analysis. SP and IF wrote the first draft of the manuscript. All authors contributed to manuscript revision, read and approved the submitted version.

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