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Validity of an Athletic Skills Track among 6- to 12-year-old children

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ABSTRACT

The purpose of this study was to examine the feasibility and validity of an Athletic Skills Track (AST) to assess fundamental movement skills among 6- to 12-year-old children in a physical education setting. Four hundred sixty-three Dutch children (211 girls, 252 boys) completed three tests: the Körperkoordinationstest für Kinder (KTK) and two Athletic Skills Tracks (AST-1, AST-2). The validity of AST-1 and AST-2 was examined by correlating the time (s) needed to complete the tracks and the KTK Motor Quotient (MQ).

Overall, there was a low correlation between AST-1 and the KTK MQ (r = –0.474 (P < 0.01)) and a moderate correlation between AST-2 and the KTK MQ (r = –0.502 (P < 0.01)). When split up by age group the associations were much higher and ranged between r = –0.469 and r = –0.767), with the exception of the low correlation coefficient of the AST-2 in 7-year-olds. The results indicate that fundamental movement skills of 6- to 12-year-old children can be assessed with a quick, convenient and low-cost motor competence test in a physical education setting, i.e., an Athletic Skills Track. Future studies should further assess the reliability, discriminative ability and validity of age-specific versions of the AST.

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Introduction

Despite the well-known health effects of an active lifestyle, physical activity ratings among children and adolescents seem to be decreasing in many countries (Dollman, Norton, & Norton, 2005; Hallal et al., 2012; Salmon & Timperio, 2007). In the Netherlands, the percentage of children under 17 years of age who reach the public health guideline to accumulate a minimum of 60 min of moderate to vigorous physical activity per day is 18% (Hildebrandt, Bernaards, & Stubbe, 2013). According to Wrotniak, Epstein, Dorn, Jones, and Kondilis (2006) motor skills competence is a crucial component for children's engagement in physical activity. In line with children's physical activity level, motor skills appear to have dropped significantly as well over the last decades among Dutch youth (Runhaar et al., 2010), a trend that is also seen among Flemish youth (Vandorpe et al., 2011).

Therefore, stimulating physical activity has become a public health priority. Physical education (PE) is suggested to be an important component in efforts to promote physical activity (Control & Prevention, 2011). The PE setting has the necessary resources and provides access to all youth (Hardy, King, Espinel, Cosgrove, & Bauman, 2013). One of the goals of PE is to increase children's movement repertoire by supporting the development of motor skills. Despite this goal, measurement of children's motor skills development is rare in The Netherlands (Reigersberg, van der Werff, & Lucassen, 2013).

Children's motor skills are positively correlated with physical activity (Bouffard, Watkinson, Thompson, Causgrove Dunn, & Romanow, 1996; Lubans, Morgan, Cliff, Barnett, & Okely, 2010; Okely, Booth, & Patterson, 2001; Wrotniak et al., 2006) and health-related physical fitness (Cantell, Crawford, & Doyle-Baker, 2008; Haga, 2008; Lubans et al., 2010; Stodden et al., 2008) in a cross-sectional research setting. There is some evidence that children's motor skills are also related to people's physical activity level on the long term. Lloyd, Saunders, Bremer, and Tremblay (2014) found a long-term relation between motor skills proficiency at age 6 and leisure time physical activity at age 26. This is in line with the conceptual models presented by Clark & Metcalfe and Stodden et al. (Clark & Metcalfe, 2002; Stodden et al., 2008; Stodden, Langendorfer, & Roberton, 2009). They hypothesise a relationship between physical activity and motor skill competence and state that Fundamental Movement Skill (FMS) competence is critical in encouraging a physically active lifestyle. To date, high-quality, large-scale, longitudinal studies on this topic are scarce (Cliff, Okely, Smith, and McKeen (2009); Lloyd et al. (2014)). In order to increase our knowledge of the relationship between motor skills at young age and physical activity later in life valid assessment tools are needed. These tools should be able to identify children with low motor coordination as early as possible, since the foundations of FMS are laid in early childhood (Lopes, Stodden, Bianchi, Maia, & Rodrigues, 2012; Runhaar et al., 2010).

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FMS can be examined with several assessment tools. The most frequently used assessment tools in early childhood are: Motoriktest für Vier- bis Sechjärige Kinder (MOT 4–6), Movement Assessment Battery for Children (Movement-ABC), Peabody Development Motor Scales (PDMS), Körperkoordinationstest für Kinder (KTK), Test of Gross Motor Development (TGMD), the Maastrichtse Motoriek Test (MMT) and the Bruininks-Oseretsky Test of Motor Proficiency (BOTMP) (Cools, Martelaer, Samaey, & Andries, 2009). Cools et al. (2009) reviewed these different assessment tools and concluded that in general the internal consistency and inter-rater reliability of those tools are high. In addition, the concurrent validity of most assessment tools is moderate. However, most tests are not very feasible in a PE setting. This is confirmed in a study among 1083 Dutch school principals (Reigersberg et al., 2013). It takes at least 20 min to measure one individual child. Furthermore, special test materials and extensive knowledge of the test protocols are required to be able to conduct the tests. Purchase price of the tests range between €175 and €1375. In summary, Cools et al. suggest that further research in measuring FMS should involve PE teachers. It seems important to screen and monitor children's FMS over time with reliable, valid and feasible assessment tools (Cools et al., 2009; Lloyd et al., 2014; Stodden et al., 2009). In addition to the clinimetric properties of an assessment tool, the experience of children when being tested should also be taken into account. Comparing children with standards can have a negative impact on the motivation of those most in need of encouragement (Cale et al., 2014). Cale et al. (2014) have formulated a number of recommendations that PE teachers should take into account in order to weaken this negative impact as much as possible. One of the recommendations is to test within the context of a regular PE lesson. In addition, they indicate that it is important that the test is a positive experience for the children.

Existing FMS assessment tools do not meet all these criteria. Therefore, a new screening tool, i.e., an Athletic Skills Track (AST), was developed by Wormhoudt, Teunissen, and Savelsbergh (2012) in cooperation with PE teachers. The AST is grounded in existing theories of children's movement development (Clark & Metcalfe, 2002; Wormhoudt et al., 2012) and the crucial role of FMS in these theories. Clark and Metcalfe introduced the Mountain of Motor Development as a metaphor. In this "mountain" four phases are described; the first phase is the reflex phase (e.g., grasping and tonic neck reflexes), followed by the rudimentary phase (e.g., rolling, creeping and walking). Internalization of the FMS takes place in the movement pattern phase. The FMS can be divided into the following categories: (1) locomotive skills (e.g., walking, crawling and jumping, (2) manipulative skills (e.g., throwing and kicking) and (3) stability skills (e.g., dynamic and static balance and axial movements like rolling). In the last phase of the Mountain of Motor Development, i.e., the growth and refinement phase, movement becomes more complex. The FMS are considered to be a prerequisite for the last phase (Clark & Metcalfe, 2002). With the help of PE teachers all three FMS categories (locomotive, manipulative and stability skills) were translated into a track that consisted of a sequence of 10 exercises that are feasible in a PE setting. Children are asked to complete the track as quickly as possible. The time to complete the track is the only parameter that is measured. With this approach the AST is a fundamentally different tool than conventional FMS assessment tools. The new tool took into account the disadvantages of existing assessment tools (i.e., high cost, time-consuming, not suitable for a PE setting) and aimed to assess motor competence in general among large groups of school-aged children in a PE setting. Ideally, the new tool can be used for (1) screening: from identifying individuals at risk to talent identification; (2) monitoring: monitoring of motor development of individuals and monitoring trends in motor skill at (sub)group and school level over a longer period; (3) benchmarking: comparing groups and schools on the motor skills of children; and (4) evaluation: the evaluation of interventions (methods, programmes, products) to improve the motor skills of children.

To our knowledge, no studies have assessed children's motor competence with a skills track in a PE setting by measuring only the time to complete a track. Thus, the purpose of this study was to examine the concurrent validity and feasibility of the AST to assess motor competence in general among 6- to 12-year-old children in a PE setting.

We hypothesise that by measuring time (a quantitative measurement) to complete the AST it is possible to find a moderate association with a qualitative measurement of children's motor skills (Hinkle, Wiersma, & Jurs, 2003). Furthermore, it is assumed that the AST is feasible in the PE setting (less time consuming and based on regular PE equipment).

Methods

First, a pilot study was performed to test if the AST offers opportunities for measuring FMS in a PE setting. Next, in the main study, the AST was refined and validated on a larger scale.

Pilot study

In the pilot study a convenience sample of 54 children (28 boys, 26 girls) aged 6–12 years participated, all of them attending the same Dutch primary school located in the centre of Amsterdam, the Netherlands. The children completed the AST and a valid and reliable motor competence test, the KTK (Kiphard & Schilling, 2007). The AST consisted of a series of locomotive, manipulative and stability skills that had to be completed as fast as possible (e.g., barefoot alligator crawl for 5 m on a mat, travelling jumps through five rings, throwing and catching a ball, forward roll and clambering over a vaulting box).

The pilot study showed that the AST is a feasible test to assess FMS among children aged 6–12 years in a PE setting. It was possible to measure 24 children in a PE lesson of 50 min with the equipment that is available in every PE setting in The Netherlands. The overall motor quotient scores on the KTK (KTK MQ) showed a moderate correlation with AST scores (i.e., time to complete the track in seconds) corrected for age ($r = -0.645$, $P < 0.001$). The results of the pilot test suggest that the AST is a feasible and a valid tool to determine children's general motor competence. The aim of the validation study was to repeat the pilot study in a different context, with a larger study population and with the help of several research assistants. Therefore, the AST test protocol and the track were refined and standardised in order to gather reliable data in different contexts. For example, cones were added in the track to make sure that all the children followed the exact same route.

Validation study

Subjects

Children aged 6–12 years were recruited from five primary schools in the The Hague region, the Netherlands. The schools were selected at random from a database of the The Hague University of Applied Sciences for internship schools. Informed consent was obtained from the parents or guardians of 623 children after they were given written information about the purpose and nature of the study. The study protocol was approved by the Medical Ethical Committee of the Faculty of Human Movement Sciences, VU University Amsterdam, The Netherlands (ECB 2015–31).

Measurements

Measurements included three tests: the KTK and two ASTs (AST-1, AST-2). All measurements were conducted in a separate section of the gym by a team of four research assistants (fourth year PE students of the The Hague University of Applied Sciences) during regular PE lessons. One of the assistants organised and administrated the AST tracks. The other three assistants were responsible for the KTK. They had been trained in conducting the tests according to the protocols in four meetings. The protocols provided guidelines about how to deal with adverse events, such as falling. In practice, adverse events were absent. Testing was spread out over a 2-week time period in May 2014. To measure all the children in this period a uniform schedule was developed: during the first week the children were measured on AST-1, during the second week on AST-2. In this 2-week time period all children also completed the KTK. Before and during the testing period the children received PE lessons as planned.

Körperkoordinationstest für Kinder

The KTK, developed and validated among German children (Kiphard & Schilling, 2007), was used as a reference measure to examine the concurrent validity of AST-1 and AST-2. The KTK is divided into four subtests;

(1) Walking backwards three times along each of three balance beams (3 m length; 6, 4.5 and 3 cm width, respectively; 5 cm height).
(2) 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.
(3) Jumping from one leg over an increasing pile of pillows (60 cm × 20 cm × 5 cm each) after a short run-up.
(4) Jumping laterally as many times as possible over a wooden slat (60 cm × 4 cm × 2 cm) in 15 s.

The test protocol for the Dutch language area (Lenoir et al., 2014; Vandorpe et al., 2011) was followed. Research assistants carried out the test protocol. It took ± 25 min to complete the KTK per child.

Athletic Skills Tracks

Based on the pilot study, two tracks were designed: AST-1 and AST-2. The tracks consisted of a series of fundamental motor tasks (*n* = 10) to be completed as fast as possible. AST-1 (see also Figure 1) consisted of the following locomotive, manipulative and stability skills: (1) alligator crawl, (2) bunny hops, (3) travelling jumps, (4) throwing and catching a ball, (5) kicking and stopping a ball, (6) forward roll, (7) backward roll, (8) running backwards, (9) clambering and (10) jumping.

AST-2 (see Figure 2) consisted of the following locomotive and stability skills: (1) alligator crawl, (2) walking forward, (3) travelling jumps, (4) forward roll, (5) backward roll, (6) flank vault, (7) pencil roll, (8) tumbling forward, (9) hopscotch and (10) straight jump. The skills are further described in Appendix 3.

All children were shown an instruction movie before they performed three try-out trials per track and two trials per track. During the three try-out trials the children received feedback from the research assistant if necessary.

A research assistant measured the time to complete the two trials with a stopwatch. After the first trial the children had 4–5 min rest before they performed the second trial.

Data analysis

Of the 623 children who were allowed by their parents or guardians to participate in the study, 463 children met the inclusion criteria (age: between 6 and 12 years; all three tests completed).

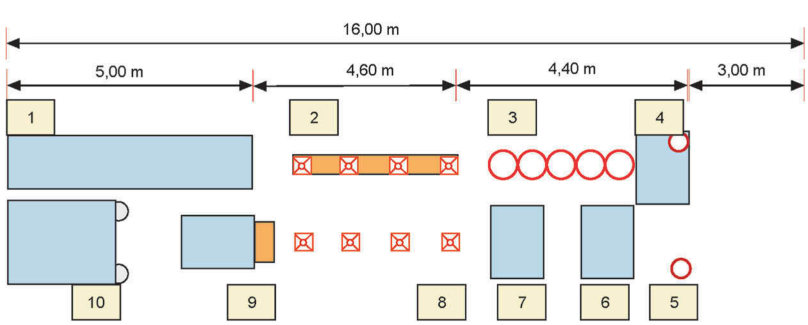

Figure 1. ST-1 schematically displayed. (1) crawling, (2) hopping, (3) jumping, (4) throwing and catching a ball, (5) kicking and stopping a ball, (6) front roll, (7) back roll, (8) walking backwards, (9) climbing and (10) jumping.

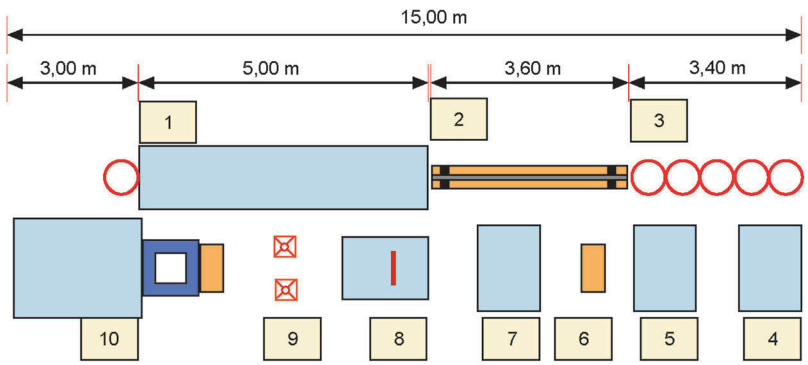

Figure 2. AST-2 schematically displayed. (1) crawling, (2) balancing, (3) jumping, (4) front roll, (5) back roll, (6) hopping, (7) longitudinal roll, (8) tumble over on the rings, (9) hopscotch and (10) stretch jump.

First, the raw test scores on the KTK were converted into age- and gender-specific motor quotients (KTK MQ) using the test protocol for the Dutch language area (Lenoir et al., 2014). Participants were then classified into five categories based on the classification of Kiphard and Schilling (2007). Children with a MQ value between 86 and 115 are considered as having a normal gross motor coordination (NMG), between 71 and 85 as having a moderate gross motor coordination disorder (MMD) and children scoring 70 or less as having a severe gross motor coordination disorder (SMD). Children scoring between 116 and 130 are considered as having a good motor coordination (GMG) and children scoring 131 and higher as high motor gifted (HMG).

Second, descriptive statistics were performed to characterise the sample. To analyse a normal distribution of the outcome parameters, histograms were plotted and the kurtosis and skewness values for each of the outcome parameters were assessed. Differences between boys and girls were tested using an independent samples *t*-test. In order to examine a potential learning effect between the two trials of the ASTs the intraclass correlation coefficient (ICC) was calculated with a two-way random model. In addition, the scores on separate trials were compared using a paired samples *t*-test. To examine the concurrent validity of the tracks, KTK MQ and AST-1 and AST-2 scores were correlated with a Pearson's correlation test. The following rules of thumb have been used to interpret the size of the correlation coefficients: negligible: <0.30; low: 0.30–0.50; moderate: 0.50–0.70; high: –0.70–0.90; very high: 0.90–1.00 (Hinkle et al., 2003).

To analyse the distinctiveness of the ASTs to identify children with low or high motor skills a one-way ANOVA was performed comparing the scores on AST-1 and AST-2 between the five groups based on the KTK MQ. All statistical analyses were performed using IBM SPSS 22.0 64-bit edition. Values were considered statistically significant at $P < 0.05$.

Results

In total, 463 children (252 boys and 211 girls) with a mean age of 9 ± 2 years completed all three tests. Data were normally distributed. The anthropometric characteristics of the children and the KTK MQ and AST scores are shown in Table 1 and 2. On average, it took about 44 s ± 11 to complete AST-1 and 45 s ± 12 to complete AST-2 per child. The average KTK MQ score was 104 ± 14. An independent-samples *t*-test showed that girls had a significantly higher KTK MQ than boys (106 ± 13.3 versus 102 ± 14.2; $t\ (461) = -3.242$, $P < 0.01$.). On the other hand boys were significantly faster on AST-1 than girls (42 ± 9.5 s versus 46 ± 11.5 s; $t\ (460) = -3.823$, $P < 0.01$). When looking into AST-1/KTK level in Table 2 it shows that 69.5% of the children were normally motor gifted. They completed AST-1 in 52 ± 14 s. These children completed AST-2 in less time, i.e., 45 ± 10 s.

Table 3 shows the results on the KTK, AST-1 and AST-2 per age group.

Learning effect ASTs

Both AST were measured twice to examine if there was a learning effect. The intraclass correlation coefficient between the first and second trial was 0.875 (95% CI [0.852–0.895]) for

Table 1. Descriptive statistics for each group of participants.

		N	Mean	(±SD)	95% CI Lower	95% CI Upper
Age (years)	Total	463	9	(2)	8.95	9.27
	Boys	252	9	(2)	8.88	9.33
	Girls	211	9	(2)	8.89	9.36
Length (cm)	Total	459	138.7	(12.1)	137.6	139.9
	Boys	250	138.4	(11.0)	136.9	139.7
	Girls	209	139.1	(13.4)	137.2	140.9
Weight (kg)	Total	459	33.7	(9.1)	32.9	34.6
	Boys	250	33.8	(9.1)	32.7	35.0
	Girls	209	33.6	(9.2)	32.3	34.9
BMI (kg/m^2)	Total	459	17.23	(2.68)	16.99	17.49
	Boys	250	17.39	(2.87)	17.0	17.8
	Girls	209	17.04	(2.43)	16.7	17.4

Table 2. Athletic Skills Tracks per KTK category.

		N	Mean	(±SD)
AST-1/KTK category (s)	Total	462	44	(11)
	SMD	6	67	(19)
	MMD	38	52	(14)
	NMG	322	44	(9)
	GMG	89	38	(7)
	HMG	7	35	(5)
AST-2/KTK category (s)	Total	463	45	(12)
	SMD	6	79	(16)
	MMD	39	57	(13)
	NMG	322	45	(10)
	GMG	89	38	(7)
	HMG	7	43	(18)

High motor giftedness = HMG, good motor giftedness = GMG, normal motor giftedness = NMG,
moderate motor disorder = MMD, serious motor disorder = SMD.

AST-1 and 0.891 (95% CI [0.870–0.908]) for AST-2 indicating a high degree of test–retest reliability (Shrout & Fleiss, 1979). However, a paired sample *t*-test showed a small, but significant learning effect between the two trials. On average, children completed the second trial 2 s faster than the first trial (AST-1 trial 1: 45 ± 11 s, versus trial 2: 44 ± 11 s; $t = 6.026$, $P < 0.05$; AST-2 trial 1: 47 ± 12 s versus trial 2: 45 ± 12 s; $t = 8.226$, $P < 0.05$). Because of the small difference between the two trials it was decided to continue with the data of the second trial of AST-1 and AST-2 to examine their relationship with the KTK.

Concurrent validity ASTs

Overall, there was a low correlation between AST-1 and the KTK ($r = -0.474$, $P < 0.01$), and a moderate correlation between AST-2 and the KTK ($r = -0.502$, $P < 0.01$) (see Table 4). The correlations between AST-1 and KTK were higher when split up for gender (girls: $r = -0.501$, $P < 0.01$; boys: $r = -0.533$, $P < 0.01$). For AST-2 the correlation between AST-2 and the KTK was lower for girls ($r = -0.448$, $P < 0.01$) and higher for boys ($r = -0.566$, $P < 0.01$) than the overall correlation. In general, correlations were also higher when examined per age group (see Appendices 1 and 2). With the exception of the low correlation coefficient of the AST-2 in 7-year-olds ($r = -0.290$, $P < 0.01$), the other correlation coefficients were near or far above 0.50 for each age group.

Discriminative ability ASTs

A one-way ANOVA revealed that both ASTs were able to categorise children's FMS into high, good or normal motor giftedness or moderate or serious motor disorder as indicated by the KTK. The time scores on AST-1 and AST-2 were significantly different between the five KTK categories (AST-1: Welch's F (4,21.011) = 22.968, $P < 0.05$; AST-2: Welch's F (4,20.366) = 27.746, $P < 0.05$)). On average, children with a higher motor giftedness completed the ASTs significantly faster than children with lower levels of FMS (see also Table 2). Tukey HSD post hoc analysis revealed that the differences between the KTK categories were all significant ($P < 0.05$) for AST-1 and AST-2 except for the difference between NMG–HMG (AST-1: mean difference NMG–HMG: 9.252 with 95% CI −0.107–19.57; AST-2: mean difference NMG–HMG: 1.392 with 95% CI −9.62–12.40) and GMG–HMG (AST-1: mean difference GMG–HMG: −2.693 with 95% CI −7.91–13.30; AST-2: mean difference GMG–HMG: −5.193 with 95% CI −16.50–6.12).

Table 3. Fundamental movement skills per test and age group.

		KTK (MQ)			AST-1 (s)			AST-2 (s)		
Age (years)		Total	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls
6	*N*	32	14	18	32	14	18	32	14	18
	Mean	110	110	111	55	52	57	54	54	54
	(±SD)	(13)	(15)	(11)	(10)	(8)	(11)	(11)	(14)	(9)
7	*N*	69	41	28	68	40	28	69	41	28
	Mean	105	104	106	51	48	55	50	47	54
	(±SD)	(14)	(14)	(15)	(11)	(7)	(13)	(12)	(10)	(14)
8	*N*	74	45	29	74	45	29	74	45	29
	Mean	105	103	108	44	43	46	46	45	48
	(±SD)	(12)	(12)	(13)	(8)	(9)	(8)	(9)	(8)	(10)
9	*N*	87	47	40	87	47	40	87	47	40
	Mean	100	97	103	44	43	46	47	48	46
	(±SD)	(15)	(15)	(14)	(10)	(11)	(8)	(12)	(14)	(10)
10	*N*	81	40	41	81	40	41	81	40	41
	Mean	103	101	105	41	39	43	41	41	41
	(±SD)	(14)	(15)	(12)	(11)	(8)	(13)	(10)	(10)	(9)
11	*N*	86	45	41	86	45	41	86	45	41
	Mean	105	102	108	37	37	38	39	39	39
	(±SD)	(13)	(12)	(13)	(6)	(6)	(6)	(8)	(9)	(7)
12	*N*	34	20	14	34	20	14	34	20	14
	Mean	102	103	101	37	35	40	43	41	45
	(±SD)	(15)	(17)	(12)	(9)	(9)	(7)	(15)	(16)	(13)
Total	*N*	463	252	211	462	251	211	463	252	211
	Mean	104	102	106	44	42	46	45	44	46
	(±SD)	(14)	(14)	(13)	(11)	(10)	(12)	(12)	(12)	(11)

KTK = Körperkoordinationstest für Kinder Motor Quotient, AST-1 = Athletic Skills Track 1, AST-2 = Athletic Skills Track 2.

Table 4. Pearson correlations between KTK and AST-1, AST-2 per gender.

			AST-1 (s)			AST-2 (s)		
		Total	Total	Boys	Girls	Total	Boys	Girls
KTK (MQ)	Total	1	−0.474**			−0.502**		
	Boys			−0.533**			−0.566**	
	Girls				−0.501**			−0.448**

**Correlation is significant at the 0.01 level (2-tailed).
KTK = Körperkoordinationstest für Kinder, MQ = Motor Quotient, AST-1 = Athletic Skills Track 1, AST-2 = Athletic Skills Track 2.

Discussion

In the last decade there is an increasing interest in children's physical activity level at a young age and its relation with an active lifestyle later on. Therefore measuring physical activity, as well as children's fitness level and motor competence level is now prominently featured within the curriculum of PE (Cale et al., 2014). In this study, a novel screening tool – the AST – has been refined and evaluated in order to provide PE teachers a valid, feasible and fun way to determine children's motor competence without them being aware that they are "evaluated".

The results show that an AST is a feasible screening tool in a PE setting. The track measures a broad range of FMS using sports equipment and materials that are available in every gym in The Netherlands. On average, it took less than 1 min per child to complete one of the tests (AST-1 or AST-2). A complete class (25–30 children) can thus be measured in one regular PE lesson of 50 min. Although a learning effect was found between the first and second trials (after three try-out trials), the test–retest reliability of both AST-1 and AST-2 was high. Furthermore, both AST-1 and AST-2 seem to be able to measure FMS in children aged 6–12 years as the correlation between the time to complete the tracks and the KTK MQ was moderate to high in most age groups.

In addition, the results show that the tracks are able to distinguish on group level between serious motor disorder, moderate motor disorder and normally to highly motor gifted children.

When comparing our results with those presented in the review of Cools et al. (2009), it can be concluded that the validity of both tests (AST-1 and AST-2) is in the same range as the most frequently used assessment tools (range r: 0.43–0.87). However, the AST is more feasible in a PE setting than the MOT 4–6, Movement-ABC, PDMS, BOTMP, TGMD, MMT and the KTK. In other words, the AST seems to be a valuable alternative for the current motor competence tests to assess children's FMS in a PE setting. Another advantage of the AST is that it can be implemented within the context of the regular PE lessons (Cale et al., 2014).

In order to increase its value, it is recommended to develop age-specific ASTs in future studies since the current tracks were less distinct for the more gifted children. This may in part be due to the small sample sizes in the good to high motor gifted groups. However, a trend towards a difference between these groups was apparent, which may be indicative for a more pronounced difference in assessments with a larger sample size. Next, certain constraints cannot be ruled out at this point. Further study is required to establish the discriminative ability of the AST for more gifted children. The AST could be adjusted by using different tracks for different age groups (for instance by taking into account coordinative abilities per age group), providing more information for the younger age groups and increasing the discriminative ability of the test. If, after further refinement, the AST would be capable of distinguishing between different motor skill categories, this track could also be used to identify potential athletes in different sports. Vandorpe et al. (2012) concluded that a non-sports-specific motor competence test could contribute positively in the process of talent identification. In addition, a motor competence test could also provide insight into talent development (Faber, Nijhuis-Van Der Sanden, Elferink-Gemser, & Oosterveld, 2014). PE teachers and physiotherapists might also use the AST to identify the less motor gifted children. It is estimated that 5–10% of children are diagnosed with a Developmental Coordination Disorder (Kirby & Sugden, 2007). Based on the differences between the seriously motor disordered, the moderately motor disordered and the normally motor gifted group, the AST might be used as a screening tool to identify those children at risk for motor competence disorder such as DCD. Subsequently, AST screening should be followed by a more comprehensive diagnostic assessment. Since FMS are founded in early childhood, and FMS are predictors of people's physical activity level later in life (Lloyd et al., 2014), it is important to identify children with low motor coordination as early as possible (Lopes et al., 2012; Runhaar et al., 2010). By using the AST as a screening tool in PE, it is possible to identify this group in early childhood.

This study had several limitations. First, in this study, only time to complete the track was measured as an indicator of a child's motor skill level. Although this is a very feasible measure in a PE setting, there is no knowledge about the relation between time to complete a series of fundamental movement skills and the quality of the performed fundamental movement skills within the track. This may help to further refine the tracks. Second, no information was gathered on children's sports participation or physical activity level. Children who perform certain sports, such as soccer or basketball, might have been at an advantage since AST-1 consisted partly of manipulative skills, thereby influencing the correlation between the track and the KTK. In future studies, preferably, objective assessment methods should be employed to measure children's physical activity level as well as their motor skill level. The influence of children's BMI on the correlation between AST and the KTK also needs to be studied, since D'Hondt et al. (2011) showed that childhood overweight results in poorer KTK performances. Third, this study is cross-sectional. The responsiveness of the AST to change in the course of time needs to be established. This could be a focus in future studies. In addition, limited aspects of reliability and validity have been subject of inquiry in the present study. Other features of validity (such as ecological validity) and reliability (inter-rater reliability), and also the within person error and minimal detectable change, need to be addressed. In case the AST holds true to its expectations, norm values should be established in due course, in order to provide users with a reference to identify deviations from the norm.

In conclusion, this study shows that an AST might be a feasible alternative for the current motor competence tests to assess children's FMS in a PE setting. The tracks showed moderate to high correlation in most age groups compared to a frequently used but time-consuming motor competence test and provided an indication of children's motor skills level. Future studies should further assess the reliability, discriminative ability and validity of age-specific versions of the AST.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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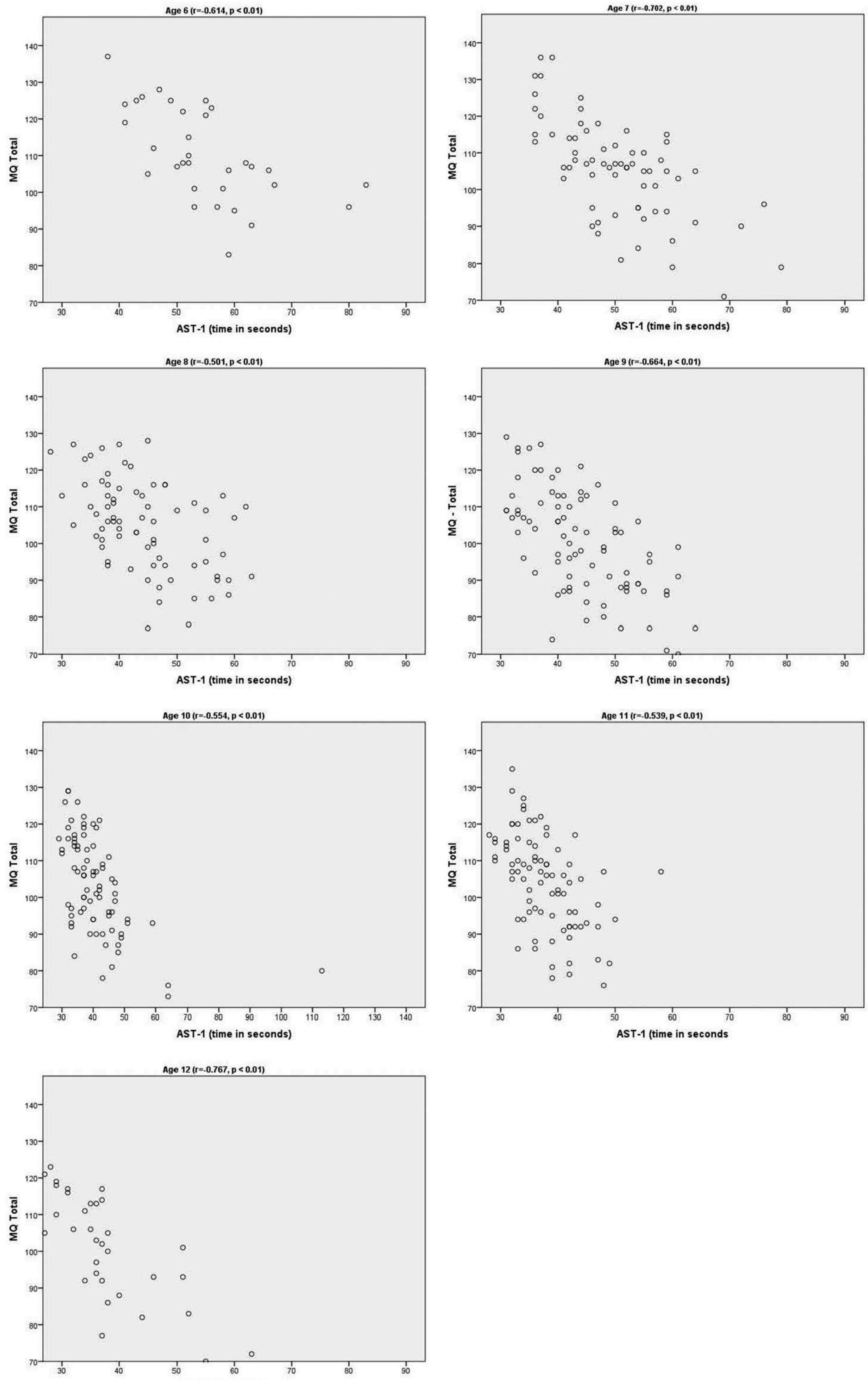
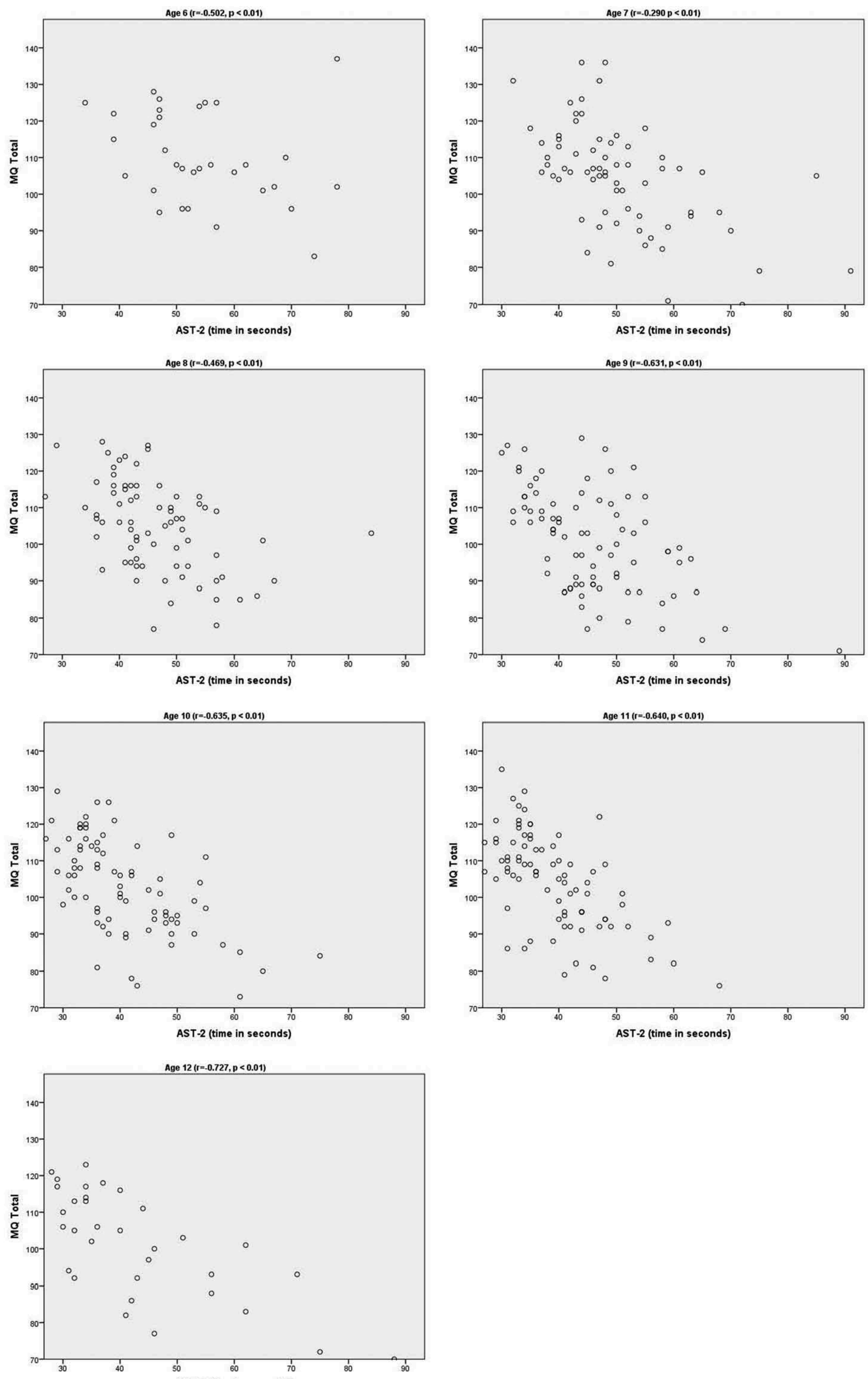
Appendix 1:
Scatter plots and Pearson correlations between MQ KTK and AST-1 per age group



Appendix 2:
Scatter plots and Pearson correlations between MQ KTK and AST-2 per age group



Appendix 3:
Description of the tracks

Description of the items concerning the AST-1

(1) Alligator crawl; lie on the floor with your belly touching the mat and crawl staying low, using your arms and legs to move forward like an alligator;
(2) Bunny hops over a bench; jump from side to side over the bench with hand support;
(3) Travelling jumps; jump on both feet from one hoop to the next;
(4) Throwing and catching a ball; throw the ball against the wall and catch it;
(5) Kicking and stopping a ball; kick the ball against the wall and stop it;
(6) Forward roll; bring the chin to the chest, use the hands to support the body, make floor contact with the back of the head, and role progressively to the spine;
(7) Backward roll; bring hands to ears as you bend your knees, begin rolling backwards in tucked position with the chin on the chest, place hands on the floor, and maintain in tucked position till the feet touch the floor;
(8) Running backwards; run backwards as fast as possible around the cones;
(9) Clambering; clamber over a vaulting box;
(10) Jumping; jump over a string, land on both feet on the mat.

Description of the items concerning the AST-2

(1) Alligator crawl; lie on the floor with your belly touching the mat and crawl staying low, using your arms and legs to move forward like an alligator;
(2) Walking forwards across a bench; keeping balance during walking forward on top of the bench;
(3) Travelling jumps; jump on both feet from one hoop to the next;
(4) Forward roll; bring the chin to the chest, use the hands to support the body, make floor contact with the back of the head, and role progressively to the spine;
(5) Backward roll; bring hands to ears as you bend your knees, begin rolling backwards in tucked position with the chin on the chest, place hands on the floor, and maintain in tucked position till the feet touch the floor;
(6) Flank vault; place hands shoulder wide apart on top of the vaulting box, swing both legs from one side to the other side of the vaulting box;
(7) Pencil roll; roll with your arms straight over your head (longitudinal);
(8) Tumbling forward over a static trapeze, start in front support, bring chin to the chest, move upper body forward in tucked position while tumbling forward and holding the trapeze with both hands;
(9) Hopscotch, jump on one leg around the cones;
(10) Straight jump; start on vaulting box, jump into the trampoline and make a straight jump, land on both feet on the mat.