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Validity and feasibility of an obstacle course to assess fundamental movement skills in a pre-school setting

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ABSTRACT

Failure to master age-appropriate fundamental movement skills (FMS) at a young age can limit motor skill competence affecting health. Assessments often have issues with feasibility and implementation in a field setting. As such, the purpose of this study was to investigate the validity and feasibility of the Athletic Skills Track (AST), in a pre-school setting. For the validation study sixty-five 3–6 year old children (25 boys and 40 girls) from five pre-schools across Adelaide, Australia participated. Correlations and linear regression analysis (adjusted for age and gender) were used to investigate the association between the time to complete the AST and the raw score of the Test of Gross Motor Development 2 (TGMD-2). For the feasibility study pre-school staff completed a semi-structured interview regarding the feasibility of the AST. The AST took less than a minute per child and the TGMD-2 around 20 minutes for two children. There was a strong negative correlation (r = −0.63, p < 0.01) between the AST scores and the TGMD-2 scores. All five staff reported strengths of the AST to be its short administration time, setup and appropriateness. These results suggest that the AST could be a feasible and valid method of FMS assessment in Australian pre-schools.

Introduction

Fundamental movement skills (FMS) are typically categorised as locomotion (e.g. running, jumping), object-control (e.g. throwing, catching) and stability skills (e.g., balance and body rolling) (Gallahue, Ozmun, & Goodway, 2006). According to Clark and Metcalfe (2002), FMS are considered to be a key component of motor competency (MC).

The importance of FMS and MC in children has been repeatedly studied worldwide. From this continual investigation, three important relationships appear; better FMS/MC are related to greater cardiorespiratory and musculoskeletal fitness (Barnett, Van Beurden, Morgan, Brooks, & Beard, 2008; Lubans, Morgan, Cliff, Barnett, & Okely, 2010), healthier weight status in children (Barnett, Lai, et al., 2016; Cattuzzo et al., 2014; D'Hondt et al., 2014) and finally, better FMS and MC are associated with higher physical activity (PA) levels (Cohen, Morgan, Plotnikoff, Callister, & Lubans, 2015; Lloyd, Saunders, Bremer, & Tremblay, 2014; Logan, Kipling Webster, Getchell, Pfeiffer, & Robinson, 2015).

The critical time period for the development of FMS is early childhood (Clark, 1994; Seefeldt, 1980) with recent systematic reviews concluding that FMS interventions in early childhood are an effective way to improve FMS (Engel, Broderick, van Doorn, Hardy, & Parmenter, 2018; Logan, Robinson, Wilson, & Lucas, 2012). Therefore, it is important to screen and monitor FMS levels of pre-school aged children (3–6 years).

There are two main approaches used to assess FMS, process-oriented and product-oriented. Process-oriented assessments consider how a movement is performed giving a qualitative description, whereas product-oriented assessments consider quantifiable outcomes (Gabbard, 2012). For example, a product-oriented assessment might record the time taken for a child to run 10m whereas a process-oriented assessment would examine how a child ran 10m (by observing the quality of the leg and arm movements) (Logan, Barnett, Goodway, & Stodden, 2016).

Recent studies found significant positive (but only moderate) correlations (0.37–0.49) between process- and product-oriented assessments measuring the same construct (Logan et al., 2016; Logan, Robinson, & Getchell, 2011; Valentini, 2015). Some researchers state that both types of assessments (product- and process-oriented) should be conducted to provide a more complete evaluation of motor skill competence (Logan et al., 2016), however possibly counterproductive to being a feasible assessment for use.

There are numerous FMS assessments available for use in a clinical setting to identify disabilities or delays, such as the Korper Koordination Test fur Kindern (KTK), Motor Assessment Battery for Children-2 (MABC-2), Motor-Proficiency-Test (MOT 4–6), and the Test for Gross Motor Development-2 (TGMD-2). However, none have been recognised as being the most reliable and valid for use in a practical setting such as physical education classes or pre-school (Cools, Martelaer, Samaey, & Andries, 2009; Piek, Hands, & Licari, 2012). These assessments differ extensively in factors that can affect the feasibility of the use of FMS assessments in pre-school settings, such as administration time, training, space and equipment requirements

(Klingberg, Schranz, Barnett, Booth, & Ferrar, 2018). More feasible assessments could allow for evaluations to be conducted by non-clinicians and hence may result in earlier interventions for children with poor FMS.

The Athletic Skills Track (AST) is a recently developed product-oriented obstacle course MC assessment that is able to address some of these issues (Hoeboer, Krijger, Savelsbergh, & de Vries, 2017). The AST is designed to measure 25 to 30 children in a one-hour PE lesson. The AST is fundamentally different to most conventional MC tests because it doesn't consist of isolated movements but rather, the obstacle course is designed around a series of 5–7 concatenated FMS (e.g., hopping and balancing). The underlying structure of the AST is based upon the idea that coordinative abilities (e.g., coupling, spatial orientation, and balance ability) are crucial in developing MC (Wormhoudt, Teunissen, & Savelsbergh, 2012) and are one of the underlying components of FMS (Barnett, Lai, et al., 2016). The AST has been criterion tested against the product-oriented Körperkoordination-Test für Kinder (KTK) in 930 (4- to 12-year old) Dutch children, with results in young children (4- to 6-year olds) on the AST-1, favourable (r = −0.75) (Hoeboer et al., 2017). The test-retest reliability of the AST-1 was high (ICC = 0.88 (95% CI: 0.78–0.93) and the internal consistency above the acceptable level of Cronbach's α > 0.70 (α = 0.76).

Yet, the validity of the AST against a process-oriented assessment, such as the Test of Gross Motor Development 2 (TGMD-2), is unknown. It is also unclear if the AST is feasible in the pre-school setting. As such, the following study aims to assess: i) the validity of the AST when compared to a process-oriented assessment in a population of pre-school aged children (age 3–6 years old) and ii) the feasibility of the AST when administered by pre-school staff in a field-based setting.

Methods

This study consisted of two concurrently run studies. The first was a validation study, using a cross-sectional design in which associations were tested between scores from the AST (Hoeboer et al., 2017) and a reference standard, the TGMD-2 (Ulrich, 2000). Secondly, feasibility of the AST was investigated within a pre-school setting, using semi-structured interviews to gather feasibility data from pre-school staff and gaining feedback from the children on their enjoyment of the AST using a Smileyometer. Both studies were conducted in pre-schools within 2-hours' drive of metropolitan Adelaide, South Australia, Australia.

Validation study

Participants

Sixty five pre-school children (25 = boys, 40 = girls) aged 3–6 years old; independently ambulant; and able to understand English were recruited from pre-schools selected randomly from each of the socio-economic quartiles (Australian Bureau of Statistics, 2011). A staff member was also nominated by the director of each pre-school site to assist with research administration.

Children were excluded if they had current injury; pain; medication that may affect ability to participate; and/or a medical history making it unsafe to participate. Using a power calculation, it was determined that a sample size of 65 children was required for 80% power with an alpha of 0.05 and an expected correlation in a single tailed test of at least a medium effect size (0.3) between the reference test (TGMD-2) and the AST. The recruitment process was ongoing from October 2016 until January 2017.

Procedure

Researcher training: Before assessment administration the research team underwent training with the AST developer, Joris Hoeboer (The Hague University of Applied Sciences, The Netherlands) in October 2016 and was supplied with the Standard Operating Procedures Manual (translated into English for this study). This translation was checked by the developer during the training. This training session took approximately 30 minutes to complete. The developer of the AST also ensured the research team were able to consistently educate others regarding the AST due to experience in training in the Netherlands. The research team also received training in the administration of the TGMD-2 from a qualified paediatric physiotherapist.

Pre-school staff training: The research team trained the nominated staff member from each pre-school in administering and setting up the AST at their pre-school site in a 30 minutes training session. The training sessions comprised of practicing set up, demonstration and scoring clarification. The training session also involved tuition in the appropriate levels of encouragement and amount and type of instruction to be provided, based on the Standard Operating Procedures Manual, and with experience from the training sessions completed in the Netherlands by the developer.

Data collection occurred between November 2016 and February 2017. On the day of data collection, the children were assessed using the AST and the TGMD-2. When not being tested the children were participating in regular activities during a pre-school day. The order in which the children performed each assessment was varied. The TGMD-2 was administered and filmed by the research team, taking approximately 20 minutes for two children to complete, the videos were scored later. The AST was set up, administered and timed by the staff member and supervised by the research team. The AST was scored live. The AST was completed in outdoor spaces available in the pre-school and the TGMD-2 was completed in indoor and outdoor spaces.

Measurements

Athletic skills track. The AST requires children to perform five to seven discrete locomotor and stability skills. These skills are set up in an obstacle course which is demonstrated by the assessor; see Figure 1 for course set up. Then the children complete two practice trials and one test attempt as fast as possible while still performing each skill correctly, taking less than a minute to complete the trial per child. There are three age-specific versions of the AST. In this study, the AST-1
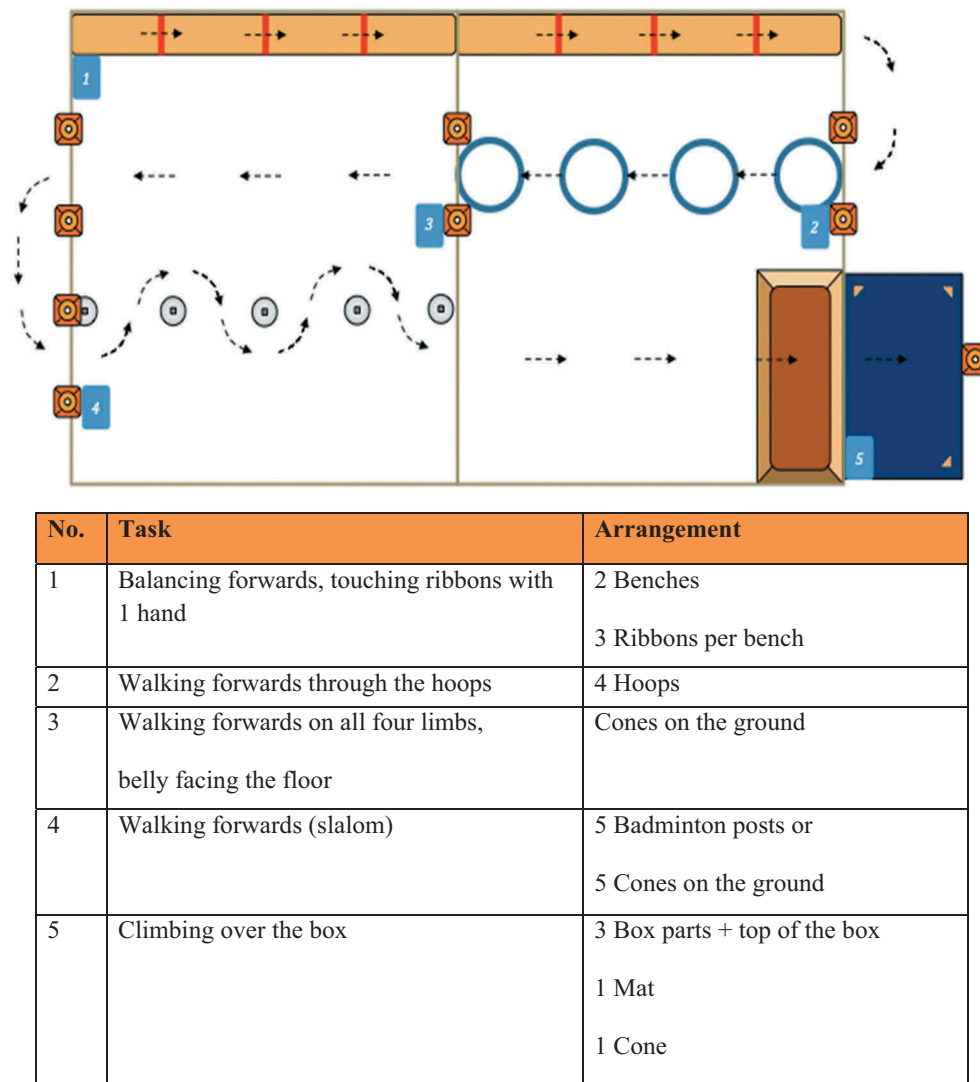
Figure 1. Diagram of athletic skills track.

No.	Task	Arrangement
1	Balancing forwards, touching ribbons with 1 hand	2 Benches 3 Ribbons per bench
2	Walking forwards through the hoops	4 Hoops
3	Walking forwards on all four limbs, belly facing the floor	Cones on the ground
4	Walking forwards (slalom)	5 Badminton posts or 5 Cones on the ground
5	Climbing over the box	3 Box parts + top of the box 1 Mat 1 Cone

developed for 4-to 6-year old children was administered, which consisted of five skills: balancing, forward leaps, alligator crawl (hands and feet), slaloming (weaving between poles) and clambering (climbing over a box). The score obtained was the time to complete the track (Hoeboer et al., 2017). The time can be converted to a motor quotient (Hoeboer et al., 2018) however raw scores of the AST were used in the analysis due to the quotient being developed in a different country.

Test of gross motor development 2. The TGMD-2 is a process-oriented FMS assessment for children aged between 3 and 10 years old (Ulrich, 2000). The TGMD-2 consist of six locomotor skills: run, gallop, hop, leap, horizontal jump, and slide; and six object control skills: striking, dribble, catch, kick, overhand throw, and underhand roll. The assessor demonstrates these skills, then participants perform each skill twice after a practice trial, with the skills scored using set performance criteria. This assessment is reported to take 35 minutes to complete per child (Ulrich, 2000) (shorter in this study as performance video recorded and scored later). These scores are summed to form a raw score which can then be converted to a standard

score or gross motor quotient (Ulrich, 2000), however raw scores of the TGMD-2 were used in the analysis as this is recommended for research purposes (Ulrich, 2000). In this study to ensure interrater accuracy, the coder (author removed for anonymity) and an experienced coder (author removed for anonymity) scored a random 10% of videos (seven children's videos of all 12 skills). Inter-rater reliability for the total raw score and subset scores (locomotor and object control) were assessed using intraclass correlation (ICC), using a two way mixed model for consistency for single measures (Koo & Li, 2016). The ICC was excellent for locomotor (ICC = 0.97, 95% CI = 0.85, 0.99), object control (ICC = 0.98, 95% CI = 0.91, 0.99), and total scores (ICC = 0.98, 95% CI = 0.92, 0.99).

Data analysis. The time taken to complete the AST, in seconds accurate to a tenth of a second, was measured with a stopwatch and recorded onto a data sheet. The score for each criteria of the TGMD-2 was also recorded in raw score form onto the data sheet and used to generate the subset score and total raw score of the TGMD-2 for each participant. The data sheet was then transferred to SPSS version 21 for analysis.

Data analysis to detect normality was conducted by plotting histograms, examining the skewness and kurtosis, and using Shapiro-Wilks normality test. Due to normality assumptions being met, the strength of the correlation between the time to complete the AST and the raw scores of the TGMD-2 (total and subsets) was analysed using Pearson correlation coefficient. The data were checked against the six assumptions necessary for linear regression analysis, and as it met the assumptions, multiple linear regression was then calculated to predict the TGMD-2 score based on the AST score, with age (decimal age) and gender as covariates, as they are both known correlates of FMS (Barnett, Lai, et al., 2016; Sterdt, Liersch, & Walter, 2014). A correlation of 0.20–0.39 was considered weak, 0.40–0.59 moderate, 0.60–0.79 strong and >0.80 very strong (Evans, 1996).

Feasibility study
Participants.
The sample group for the semi-structured interviews comprised one staff member from each pre-school who was nominated by the director and whom agreed to participate. The sample group for the Smileyometer (to determine child enjoyment) consisted of the children who completed the AST in the validation study. The Smileyometer was administered to 64 children, as one child declined due to behavioural issues.

Procedure.
After the pre-school staff had administered the AST, they were requested to complete a semi-structured interview that took approximately 20 minutes for each staff member. Five interviews took place in total, one with each staff member involved. This interview was audio recorded then transcribed and sent back to the staff member for confirmation and clarification as required. These confirmed transcripts were considered complete and used for data analysis. Immediately after completing the AST children were asked to individually score how much they enjoyed performing the AST on the Smileyometer (Read, MacFarlane, & Casey, 2002).

Measurements.
The semi-structured interview questions for staff members were created by the research team and framed around the AST and feasibility critical concepts (Bowen et al., 2009). These questions were open ended and guided to cover the topics of acceptability, demand, implementation, practicality, and integration; see Table 1 for interview questions.

The Smileyometer, that was used to assess children's enjoyment of the AST, is based around a 1–5 Likert scale using smiley faces to represent "awful" to "brilliant" (Read et al., 2002) (Figure 2). The usefulness, reliability and age effect of the Smileyometer have all been investigated and shown to be positive and recommended for continued use (Read, 2008). The Smileyometer has also been used in studies involving children (aged 7–8 years) rating enjoyment of different activities (Sim, MacFarlane, & Read, 2006) as well as to assess children's enjoyment of the AST in a sample of 4- to 12-year old Dutch children in a school setting (Hoeboer, De Vries, Mast, & Savelsbergh, 2017)

Data analysis.
The transcribed interviews with the staff members were analysed by the research team for feasibility concepts, based on literature (Bowen et al., 2009), and described narratively. This was done by collating the transcribed interviews and comparing the responses from each staff member, looking for common answers or contradicting answers and/or key important feedback. The children's score on the visual Smileyometer was recorded as a numerical 1–5 score in the data sheet.

Results and discussion

Validity results

Participants
Parental consent was obtained from 74 children (consent rate of 51%), with data being collected from a total of 65 children, 25 boys and 40 girls (aged 3–6 years). The nine children who had parental consent from whom data was not collected declined to

Table 1. Semi structured interview questions.

Feasibility Concepts	Questions
Acceptability	To what extent do you think this new assessment tool is suitable and attractive for use by staff members?
	How appropriate do you think it was for the children? How successful do you feel it was it for the children?
	What did you find positive or negative about using this assessment?
	How best do you think the tool could be trained to staff members/how was your training?
Demand	To what extent is the new assessment tool likely to be used by your pre-school?
	How much of a demand do you think there is for a tool like this?
Implementation/practicality	What are your thoughts regarding how easy or hard it would be for you and other staff to use the tool with the children?
	Would it be practical? How do you feel about the space/time/equipment required?
	Was there anything restricting its use in your pre-school?
Integration	What are your thoughts on how well the testing tool could be integrated into your current curriculum/plans?
	If the tool is shown to be accurate what benefits or negatives do you think there would be to the children?

Awful   Not very good   Good   Really good   Brilliant

Figure 2. Smileyometer scale.

participate on the day of testing. The children were sourced from five pre-schools within 2-hours of metropolitan Adelaide, South Australia, with a pre-school response rate of 63%. See Table 2 for comprehensive descriptive data of results.

Relationship between AST and TGMD-2

There was a strong negative correlation between the time to complete the AST and the total raw score from the TGMD-2 ($r = -0.63$, $p < 0.01$). A moderate negative correlation between the AST and the locomotor subset ($r = -0.52$, $p < 0.01$) and a strong negative correlation with the object control subset ($r = -0.62$, $p < 0.01$) were also found.

The multiple linear regression, after adjustment for age ($p < 0.038$) and gender (not significant), demonstrated the AST score was a statistically significant predictor of the TGMD-2 total raw score ($p < 0.001$, $\beta = -0.55$). The total amount of adjusted variance explained in the model was 35% (adjusted $R^2 = 0.35$). This process was repeated for the subsets of the TGMD-2. For the object control subset after adjustment for age and gender (both not significant), the AST score was shown to be a statistically significant predictor of the object control subset ($p < 0.001$, $\beta = -0.53$) with the total amount of adjusted variance explained in the model was 32% (adjusted $R^2 = 0.32$). For the locomotor subset after adjustment for age ($p < 0.019$) and gender (not significant), the AST score was shown to be a statistically significant predictor of the locomotor subset ($p < 0.001$, $\beta = -0.46$) with the total amount of adjusted variance explained in the model was 27% (adjusted $R^2 = 0.27$). See Tables 3-8 for results from regression analysis.

Validity discussion

The strength of relationship between assessments was encouraging considering the AST is still being validated and this is the first time it was compared against a process-oriented assessment. A study conducted by Hoeboer, Krijger, et al. (2017) with 930 Dutch children obtained similar results ($r = -0.75$) when comparing the AST to a product-oriented assessment, the KTK. The reduced strength of relationship between the assessments in the current study may reflect the weaker association between a product- and process-oriented assessment and potentially, the smaller sample size. Interestingly, the correlations reported in this study

Table 2. Descriptive data.

	n	Mean	SD	Min.	Max.
Age (decimal years)	65	4.66	0.54	3.5	5.5
TGMD-2 (possible range 0–96)	65	41	11	8	65
Locomotor (possible range 0–48)	65	23	6	8	39
Object control (possible range 0–48)	65	18	5	0	29
AST (seconds)	65	27.5	6.0	17.3	40.9
Smileyometer (possible range 1–5)	64	4.5	0.8	2	5

Table 3. Multiple linear regression model summary for TGMD2 total score.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.62	0.38	0.35	7.99

Predictors: (Constant), AST, Age, Male/Female

Table 4. Multiple linear regression coefficients for TGMD2 total score.

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	50.30	9.83		5.12	.000
AST	−.94	.18	−.55	−5.15	.000
Male/Female	1.39	2.16	.07	.64	.523
Age	3.25	1.53	.22	2.12	.038

Dependent Variable: TGMD2 total raw score

Table 5. Multiple linear regression model summary for TGMD2 object control subset.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.59	0.35	0.32	4.12

Predictors: (Constant), AST, Age, Male/Female

Table 6. Multiple linear regression coefficients for TGMD2 object control subset.

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	28.53	5.07		5.63	.000
Age	.79	.79	.11	.10	.324
Male/Female	−.91	1.11	−.09	−.82	.415
AST	−.45	.09	−.53	−4.83	.000

Dependent Variable: Object control subset

Table 7. Multiple linear regression model summary for TGMD2 locomotor subset.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.55	0.30	0.27	5.31

Predictors: (Constant), AST, Age, Male/Female

Table 8. Multiple linear regression coefficients for TGMD2 locomotor subset.

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	21.77	6.54		3.33	.001
Age	2.46	1.02	.27	2.42	.019
Male/Female	2.30	1.44	.18	1.60	.115
AST	−.49	.12	−.46	−4.01	.000

Dependent Variable: Locomotor subset

are stronger than that found in previous comparisons of process- and product-oriented assessments, in particular the TGMD-2 and the MABC-2, with correlations ranging from 0.37 to 0.49 (Logan et al., 2011; Valentini, 2015). This may suggest that the product-oriented AST is able to produce similar information regarding motor skill competence as the process-oriented TGMD-2. This might be the result of the underlying construct on which the product (AST) and process (in general) MC instruments are based on. The AST is developed based on the idea that coordinative abilities are crucial in the development of MC (Hoeboer et al., 2017). These coordinative abilities might also be measured indirectly with a process orientated assessment such as the TGMD-2.

When considering the subsets, there was a moderate relationship ($r = -0.52$) with the locomotor subset and a strong

relationship ($r = -0.62$) with the object control subset of the TGMD-2 against the AST. These results are also reflected in the regression results after adjusting for age and gender. The stronger relationship with the object control subset is counter-intuitive as there are no object control skills specifically assessed in the AST. There are a few possible explanations for this, overall, the scores for the object control subset were lower than the scores for the locomotor subset, reflective of the young age group where object control skills are only just developing (Clark, 1994). This may offer a possible explanation, in that the AST scores were more aligned with the lower scoring subset regardless of the skills within it. Alternatively, it could be that the object control skills are more complex than locomotor skills and thus relate better to an assessment that needs to be completed in a coordinative manner as fast and as proficiently as possible. Furthering on this, as the AST contains balance and stability skills, both of which are critical during the early childhood years (Cliff, Okely, Smith, & McKeen, 2009; Robinson, Wadsworth, & Peoples, 2012) this may explain the stronger relationship (Rudd et al., 2015). This aligns with motor development literature, as locomotor skills develop earlier than object control/manipulative skills (Robinson et al., 2015). The relationship between the AST and FMS subsets has yet to be studied elsewhere for comparison. However, a previous study looking at the MOT 4–6, containing locomotor and object control subsets, and the KTK (which assess motor coordination), can be considered. This study found that the relationship between the KTK and the locomotor subset ($r = 0.56$) was stronger than with the object control subset ($r = 0.37$) (Bardid et al., 2016) which is what might be expected as the KTK does not contain object control skills. The findings of this current study however appears to contrast the little literature available (Bardid et al., 2016) and as such further investigation is required.

Feasibility results

Participants
All five staff members (5 females, aged 32–34 years) involved in this study, four teachers (diploma level) and one early childhood worker (certificate level), completed the semi-structured interview.

Staff feedback
In response to questions regarding *acceptability*, all staff mentioned that the AST was quick and easy to use and was at the appropriate skill level for the children. Four staff commented that the style (obstacle course) was enjoyable for the children, three commented that the space requirements were appropriate, and one staff member mentioned that the skill slaloming (weaving between cones) may be too advanced for younger children. Three out of five staff commented they wanted more information regarding each skill assessed. Three staff members also mentioned that the map of the course could be made clearer to aid in setting up and understanding the course.

Responding to questions surrounding the *demand* for the AST, four staff commented that something like the AST is needed to allow staff to assess children. All staff noted that they would likely use the AST in their pre-school again. One staff member said they would be more likely to use the AST again if support material was provided (e.g., activity suggestions) to help the children improve their motor skills.

Asking about the *implementation* and *practicality* of the AST, all five staff thought the assessment would be accessible for all staff members to use, however one mentioned the physical requirements of demonstrating the courses may be inappropriate for some staff. Staff all noted that time to administer would make it practical and three thought the equipment was practical, with a fourth staff member commenting that their pre-school would purchase the equipment (foam climbing box) if necessary. Reported restrictions to the implementation of the AST were site specific including, behaviour issues of children at specific sites, staff training, space requirements and difficulty of use with younger children. Two staff members mentioned that their pre-school site lacked the specific equipment for the AST (foam climbing box).

With regard to *integration*, staff commented that if in line with the goals of their pre-school, the AST could fit into their curriculum and would benefit the children.

Smileyometer
The mean score of the children's rating of their enjoyment of the AST was 4.5 out of 5, with only one child scoring below a three.

Feasibility discussion

The feasibility study investigated pre-school staff's opinions on the use of the AST in their pre-schools. Overall the results from the feasibility study suggest that staff found the AST to be feasible, therefore it could be considered an alternative to current FMS assessments such as the TGMD-2.

All staff felt the administration time for the AST was feasible. This is in line with a recent systematic review (reference removed for anonymity) where the AST scored the highest with regards to administration time compared to commonly available FMS assessments. Overall, the staff thought the skills were appropriate for the children; although one staff member raised concerns that the skills within the AST are slightly different to commonly taught skills in Australia. Since the AST was developed in Europe, different skills can be considered fundamental in different cultural settings, and hence differ worldwide (Barnett et al., 2016). In fact, a recent conceptual model suggests that culture and geographical location are important to consider in movement skill development (Hulteen, Morgan, Barnett, Stodden, & Lubans, 2018). The implication being that staff may have to decide whether there is value in assessing skills not typical for pre-school teaching and activities in Australia such as slaloming. However, slaloming represents movement coordination (lateral weight shifting and moving in different directions) required in all ball games worldwide and is similar to a dodge, which is assessed in an Australian FMS assessment (New South Wales Department of Education and Training, 2000). So in this respect it could still be considered as a relevant skill to assess in an Australian context.

The majority of staff reported wanting more information regarding what skills they are assessing and how to promote those skills. This is not an entirely new concept as the incorporation of possible intervention strategies appears in previous assessments including the MABC-2, PDMS-2 and the MOT 4–6 (Cools et al., 2009). It is predicted that demand for interventions coupled with assessments may increase as more pre-schools implement their own self-administered FMS assessments (Kambas & Venetsanou, 2014; Lam, Ip, Lui, & Koong, 2003).

Regarding the implementation of the AST, a concern was highlighted with regards to the physical demand on staff members to demonstrate the course. This may be a consideration affecting how well this assessment can be implemented across all pre-schools. This could be overcome using iPads with expert demonstrations to show children the course, as done previously for an FMS obstacle course for 10–14 year old children (Tyler, Foweather, Mackintosh, & Stratton, 2018). Although the efficacy of this method in terms of pre-school children understanding how to mimic the skill in real space and time would need to be tested. These suggestions will be provided to the developer of the AST for their consideration for implementation in future research.

Strengths and limitations

A strength to the methods of this study is it clear reporting on the feasibility of a new FMS assessment, this was identified to be usually reported poorly by studies (Klingberg et al., 2018). We reported clearly on the training we provided to the teachers involved in the study which is critically important but also rarely reported (Lander, Eather, Morgan, Salmon, & Barnett, 2017).

The obstacle course design of the AST appears to have two possible sides. On one side, the use of an obstacle course makes this assessment closer to real world FMS which is though not to be captured in common FMS assessments (Tidén, Lundqvist, & Nyberg, 2015), possibly improving its ecological validity. However, there is also the possibility that being an obstacle course design means children may practice it using it for training rather than testing. Maybe improving their ability to complete the track rather than actually improving their FMS, i.e. habituation. Research does however support the use of obstacle courses to improve FMS skills (Lander, Morgan, Salmon, & Barnett, 2017). In fact, the recent intervention by Lander et al used an obstacle course in this way, with evidence of successful improvement in FMS and perception of FMS. Further study will need to be done to investigate these theories but initial results from Hoeboer, Krijger, et al. (2017) showed high degree of test re-test reliability (ICC = 0.881, 95% CI: 0.780–0.934) when children completed the test twice two weeks apart.

There is currently no normative data for the AST to create cut off ranks to allow interpretation of the children's scores in the AST. Past studies of the AST in the Netherlands has shown that the AST scores could categorise and discriminate children into seriously motor disordered, moderately motor disordered and normal motor gifted groups as indicated by the MQ of the KTK (Hoeboer et al., 2016). Also, specific to this study we had

one child score well below the other in the TGMD-2, 15 points lower than next closest score scoring 0 for object control subset. This child was anecdotally also identified by the AST as they scored 4.7 seconds slower than the next closest child, with all other scores split by less than a second. Future research may wish to determine the discriminant properties of the AST at identifying FMS levels to allow for targeted intervention by the user.

In the validation study the recruitment process was sufficient to reach power, but insufficient to account for potential sample and location bias. Due to a lack of funding, pre-schools were only considered if they were within a 2-hour drive of metropolitan Adelaide. This means the data may not represent all South Australia, particularly the outer regional areas.

Also, even though the validation test was carried out in typical pre-school settings, the variation in each setting may have influenced the between pre-school results. Each pre-school had different areas available for the filming of the TGMD-2 and setup of the AST (outside on grass, paving, bark chips). Future, larger validation studies will have the potential to account for differences at the pre-school level.

Finally, as the testing was occurring throughout the day, the time of testing may have affected their energy levels. So, if they were assessed at the end of the day they may have performed poorer relative to others due to low energy levels.

Conclusion

This study has addressed an important topical area regarding the validity and feasibility of the AST in the pre-school setting. The results from this study suggest that the AST could be a feasible and valid FMS assessment to use in Australian pre-schools. With the development of normative data and cut off levels for pre-school aged children in Australia this assessment could provide pre-school staff the ability to formally assess the FMS of their children without referring to clinical experts, thus allowing for more frequent evaluations and earlier interventions for children with poor FMS.

Disclosure statement

No potential conflict of interest was reported by the authors.

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