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### Original research

# The reliability and validity of an authentic motor skill assessment tool for early adolescent girls in an Australian school setting

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### ABSTRACT

**Objectives:** Proficiency in fundamental movement skills (FMS) is positively correlated with cardiorespiratory fitness, healthy weight status, and physical activity. Many instruments have been developed to assess FMS in children. It is important to accurately measure FMS competency in adolescent populations, particularly in girls, who are less proficient than boys. Yet these tests have not been validated or tested for reliability among girls in this age group.

**Design:** The current study tested the concurrent validity and reliability of two FMS assessment instruments; the newly developed Canadian Agility and Movement Skill Assessment (CAMSA), against the Victorian FMS Assessment from Australia, among a sample of early adolescent girls.

**Methods:** In total, 34 Year 7 females (mean age 12.6 years) from Australia were tested and retested on each instrument in a school setting.

**Results:** Test-retest reliability was excellent for the overall CAMSA score (ICC = 0.91) and for the isolated time and skill score components (time: ICC = 0.80; skill: ICC = 0.85). Test-retest reliability of the Victorian FMS Assessment was also good (ICC = 0.79). There was no evidence of proportional bias in either assessment. There was evidence of strong concurrent validity ( $r_s = 0.68$ ,  $p < 0.05$ ).

**Conclusions:** Both instruments were found to be reliable and valid. However, compared to the Victorian FMS instrument, the CAMSA has the advantage of both process and product assessment, less time needed to administer and higher authenticity, and so may be an attractive alternative to the more traditional forms of FMS assessment, for use with early adolescent girls, in school settings.

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## 1. Introduction

Fundamental movement skills (FMS) have been described as the building blocks of physical activity, typically classified into object control skills (e.g., catching), locomotor skills (e.g., running) and stability skills (e.g., balancing).<sup>1,2</sup> Developing proficiency in these skills has important health implications for young people,<sup>3</sup> in terms of increased physical activity<sup>4</sup> and cardiorespiratory fitness,<sup>5</sup> and obesity prevention.<sup>6</sup> Yet less than 50% of Australian Year 6 students have mastered the run, jump, kick, and throw.<sup>7</sup> This finding is indicative of a worldwide trend of lower FMS proficiency.<sup>8,9,10</sup> Low FMS proficiency often persists into adolescence and beyond,<sup>11,12</sup> and furthermore, globally, girls exhibit especially low levels of

object control proficiency, which is of great concern, as proficiency in object control skills is positively associated with future PA levels.<sup>13</sup>

Most children are developmentally able to master FMS by the end of Grade 4.<sup>1</sup> Therefore, primary school physical education (PE) should provide the ideal environment to assess, teach, and improve these skills. However, many students, especially girls, pass through primary school PE, and the early developmental stages, commonly known as the 'golden stage of development' without mastering the critical threshold of FMS necessary for successful participation in PA and the sports-based curriculum typical of secondary school PE.<sup>1,7</sup> Furthermore, research suggests that skill deficits in girls often remain unidentified in high school PE programs.<sup>14</sup> Subsequently, remediation instruction may be rare, and opportunities to improve may be limited.<sup>14</sup>

Accurate identification of skill deficiency is a critical step in the cyclic process of skill improvement. Assessment allows

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teachers to identify student needs and subsequently accommodate for individual skill learning, by providing specific feedback, targeted instruction and developmentally appropriate tasks.<sup>15</sup> Valid and reliable assessment provides purpose and meaning to instruction and enables effective program delivery to advance student learning.<sup>15</sup> Assessment of FMS has been researched extensively in childhood.<sup>15</sup> Therefore, the assessment criteria and protocols are developed specifically for younger age groups.<sup>16,17</sup> Despite the low levels of FMS proficiency in older children and adolescents, and even adults, there is a lack of appropriate FMS assessment available.<sup>12,15,16</sup> Indeed, in a recent review of five motor skill assessment instruments, none emerged as capable of consistently determining adolescents or young adults, as novice or expert performers of FMS.<sup>15</sup> As the quality of primary school Physical Education (PE) programs varies, and FMS instruction is often poor,<sup>18,19</sup> many students reach adolescence without mastering FMS, which can have lifelong consequences in terms of physical inactivity. Therefore, there is a need for a valid and reliable FMS assessment appropriate for adolescents, especially girls.

Many instruments are not ideal for use in 'real world' settings such as in schools, despite recommendations that FMS should be assessed in schools by PE teachers.<sup>18,19</sup> Assessment protocols have complex criteria, often require students to be tested one at a time, and can take 20–60 min per child.<sup>20</sup> Furthermore, existing instruments (e.g., TGMD-2<sup>2</sup>) often focus on isolated skill performance, in closed or controlled environments, and subsequently are not reflective, nor do they assess the complex series of skills involved in play, sport and physical activity.<sup>21</sup> Furthermore, PE teachers are faced with numerous barriers including: high student numbers per class; limited class time and a lack of preparation time; and assessment not being engaging nor fun for students.<sup>14</sup> Due to these barriers, many teachers resort to using levels of participation, attitude, appropriate clothing and attendance as criteria for assessing students, rather than movement skill based criteria to assess, monitor and advance student learning.<sup>14</sup>

The Canadian Agility and Movement Skill Assessment (CAMSA) was recently developed, as part of the Canadian Assessment of Physical Literacy (CAPL).<sup>22</sup> The CAMSA was designed to more authentically measure the 'real world' skills required for sport and physical activity, such as linking several skills together in succession, and transitioning from one skill to another efficiently (e.g., catching then throwing while on the move).<sup>21,22</sup> The feasibility, validity and reliability of the CAMSA has been demonstrated for Canadian children (8–12 years)<sup>21</sup> and feasibility has also been established in an Australian school setting.<sup>19</sup> The aim of the current study was to investigate the test-retest reliability and concurrent validity of the CAMSA when administered by teachers in an Australian school setting, against a commonly used FMS assessment instrument in Victorian schools, the Victorian FMS Assessment.<sup>23</sup>

## 2. Methods

A convenience sample of female Year 7 students ( $n = 34$ , mean age 12.6 years) from an independent girls' school in Melbourne, Australia, participated. Students were eligible if they were in Year 7, and could actively participate in a Physical Education class. All students who were invited, agreed to take part with their parents or legal guardians consent. The research was approved by Deakin University Human Ethics (HEAG) in August 2015.

The CAMSA requires students to cover a distance of 20 m of an agility and movement course, completing seven different movement skills in succession, namely: two-footed jump, side slide, catch, throw, skip, hop, and kick.<sup>21</sup> Therefore, skills cannot be added or omitted from the course. As the study aim was to test the CAMSA

against the Victorian FMS Assessment, skills measured by the latter instrument were matched to the CAMSA.

The Victorian FMS Assessment was selected as a benchmark for concurrent validity for the following reasons: (i) the reliability and validity for all skills used in this study from the Victorian FMS Assessment have been established ( $ICC > 0.7$ )<sup>23</sup>; (ii) it was designed for use by Australian teachers, and is the most common source of FMS assessment used in Victorian school<sup>14</sup>; (iii) the skills align to those required in the Year 7 PE curriculum; (iv) the instrument has been used in FMS research in school settings, in children of similar age<sup>24,25</sup>; (v) the skills selected closely align with those in the CAMSA.

Six skills from the Victorian FMS Assessment were selected. Four skills were identical in both assessments (i.e., overhand throw, catch, kick, and jump) (Supplementary Table 1). As the Victorian FMS Assessment does not include the skip, hop or side slide, two additional locomotor skills from the Victorian FMS Assessment instrument (i.e., dodge and the leap) were selected, as they comprise similar movement patterns to the aforementioned CAMSA locomotor skills (i.e., skip, hop and side slide). The 'dodge' was also included as it broadly measures agility (i.e., the ability to change the direction of the body in an efficient and effective manner).<sup>21</sup>

The CAMSA requires students to complete the seven different movement skills as fast and well as possible.<sup>21</sup> Performances of the CAMSA are evaluated using the aggregate of time taken to complete the course, and the quality of skill performance (process-oriented assessment e.g., 'Transfers weight and rotates body', and product-oriented assessment e.g., 'ball hits the target'). Time required to complete the course is recorded, and then converted to a predefined point score (range 1–14), the faster the course completion, the higher the score (Supplementary Table 2). The quality of each skill is scored as either performed (score of '1') or not (score of '0') across 14 reference criteria (Supplementary Table 3). The total score is calculated as the sum of the skill and the time scores, total score range 1–28, per single trial (Supplementary Table 4).<sup>23</sup>

In contrast to the CAMSA, the Victorian FMS instrument assesses individual skills in isolation, and has several more behavioral components per skill than the CAMSA (Supplementary Table 1). The assessment and administration protocol has been described in detail elsewhere,<sup>23</sup> however, in brief, behavioral components of each skill are scored '1' if the component was demonstrated and '0' if it was not demonstrated. The correctly performed components are summed to create a total score per trial, with a higher score indicating greater proficiency. In the current study the total skill score range for the Victorian FMS Assessment was 0–33, per trial (Supplementary Table 1).

All 34 students performed both assessments in Test 1, and all were retested in both assessment instruments seven days later (Test 2), using the same location, equipment, protocol, and staffing conditions as Test 1. For the purpose of this study, the administration protocol for both instruments aligned with the CAMSA. Specifically, the facilitators provided clear verbal instructions, and two practical demonstrations of each assessment. Each participant was then given two practice trials, followed by two consecutive test trials. When performing the CAMSA, the students were instructed to perform the movement course as fast and as well as possible.<sup>21</sup> When performing skills in the Victorian FMS Assessment they were instructed to perform with maximum effort, which produces the most advanced movement pattern of ballistic skills.<sup>26</sup>

All student test trials were video recorded and later analysed. All footage was observed and coded by the lead author, who had prior training and experience in administering and analysing both the CAMSA,<sup>19</sup> and the Victorian FMS Assessment instrument as well as with other motor skill assessments.<sup>28</sup> The two test trials, per assessment instrument, were combined to provide an overall score for Test 1, and the same procedure repeated for Test 2. Thus,

**Table 1**

Test 1 and Test 2 Means and Standard Deviations (SD), Intra-Class Correlation Coefficients (ICCs), and 95% Confidence Intervals (CI) for the CAMSA and the Victorian Fundamental Movement Skills (FMS) Assessment.

	Test 1 (mean $\pm$ SD)	Test 2 (mean $\pm$ SD)	ICC	95% CI
CAMSA: total score (potential range: 2–56)	44.15 $\pm$ 5.19 (actual range: 31–52)	45.44 $\pm$ 5.14 (actual range: 34–55)	0.91	0.83–0.95
CAMSA: time score (potential range: 2–28)	24.471 $\pm$ 3.077 (actual range: 14–28)	25.529 $\pm$ 2.2993 (actual range: 19–28)	0.80	0.63–0.89
CAMSA: skill score (potential range: 0–28)	19.68 $\pm$ 3.02 (actual range: 14–25)	19.918 $\pm$ 3.57913 (actual range: 14–27)	0.85	0.73–0.92
Victorian FMS (potential range 0–66)	49.59 $\pm$ 4.85 (actual range: 42–59)	49.97 $\pm$ 5.23 (actual range: 42–62)	0.79	0.62–0.89

the CAMSA had a total score range of 2–56, and the Victorian FMS Assessment 0–66. In addition, the CAMSA score was separated into independent scores on time (1–28) and skill (0–28). Furthermore, score data from Test 1 (the best score of the two trials, potential range 1–28) per student was extracted, to enable a comparison between the sample's performance and the predefined standards for 12-year-old children, as provided by the CAPL<sup>21,22</sup> 'Mastery' or 'near mastery'<sup>28</sup> levels (i.e., all skill components observed, or all but one skill component observed, respectively) of the Victorian FMS Assessment were identified for total skill. Standards and mastery levels are presented in Supplementary Tables 4 and 5, and in text in the results section.

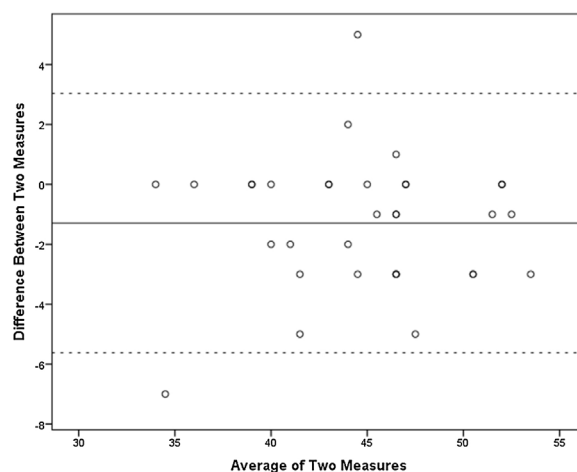
Data were analysed using SPSS (version 21). Test-retest reliability was determined by comparing results of Test 1 with Test 2 of each instrument using intra-class correlation coefficients (ICCs). Bland-Altman plots assessed whether there were any associations between the mean difference between the trials and the mean of the trials for each instrument. In addition, the bivariate correlation between the inter-trial difference (Test 2–Test 1) and the mean of trials [(Trial 2 + Test 1)/2] was conducted to determine proportional bias. Concurrent validity between the CAMSA and the Victorian FMS Assessment was assessed using Spearman's Rho rank-order correlations coefficients. Validity was rated as weak (0.10–0.29), moderate (0.30–0.49), or strong (>0.50).<sup>29</sup>

### 3. Results

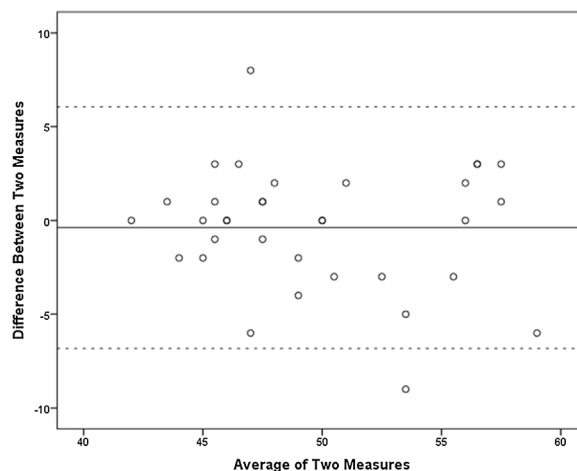
Of the sample of 36 girls, two were excluded due to incomplete Test 2 results, leaving 34 participants (mean age 12.6 years  $\pm$  0.04). Half were Australian (17/34), just over one-quarter Asian (9/34) and just under one-quarter (8/34) European. Just over half had parents with a tertiary education (20/34, 59%) and the remainder with secondary education. Just over half (56%) were involved in out-of-school-hours sports (school or community), while the remainder were not.

Time taken to finish one complete assessment trial (seven skills) was shorter for the CAMSA (mean: 15 s, range 13–25 s) than it was to finish one complete trial (six skills) of the Victorian FMS Assessment (mean: 1 min and 12 s, range: 1 min 4 s–1 min 21 s). When the data from one single CAMSA trial per student was extracted to identify the CAPL standards, 29.4% (10/34) were considered as *beginning* (<21), 52.94% (18/34) were *progressing* (21–24), 17.65% (6/34) were *achieving* (>24–27), and no student was ranked as *excelling* (>27). In the Victorian FMS Assessment, no student achieved 'mastery' or 'near mastery' for total skill. Means and standard deviations of performance scores for two trials for both instruments are presented in Table 1. A high degree of test-retest reliability was found for the overall CAMSA score (i.e., the aggregate of skill and time score) (ICC = 0.91), the isolated time score (time: ICC = 0.80) and isolated skill score (skill: ICC = 0.85). The test-retest reliability of the Victorian FMS Assessment was also good (ICC = 0.79)<sup>29</sup> (Table 1).

The Bland-Altman plots for both the CAMSA (mean –1.29, [LoA] –5.62 and 3.04) and the Victorian FMS Assessment (mean –0.38, limits of agreement [LoA] –6.82 and 6.06) did not show systematic bias (Figs. 1 and 2). In addition, the bivariate correlation between the inter-trial difference (Test 2–Test 1) and the mean of the tri-



**Fig. 1.** Bland-Altman plot of error scores across Test 1 and Test 2 of the CAMSA against the average of the two assessments. The mean error score (solid horizontal line) and 95% confidence intervals above and below (broken horizontal line).



**Fig. 2.** Bland-Altman plot showing error scores across Test 1 and Test 2 of the Victorian FMS Assessment against the average of the two assessments. The mean error score (solid horizontal line) and the 95% confidence intervals above and below (broken horizontal line) shown on plot.

als [(Trial 2 + Test 1)/2] indicated no evidence of proportional bias between the two trials of the CAMSA ( $r = 0.02$ ,  $p = 0.89$ ), nor the two measures of the Victorian FMS Assessment instrument ( $r = -0.12$ ,  $p = 0.49$ ).

Spearman's Rho rank order analysis using a two-tailed test of significance indicated a strong positive correlation between the finishing position of students in the CAMSA using their total CAMSA score and Victorian FMS Assessment in Test 1 ( $r_s = 0.68$ ,  $p < 0.05$ ). When isolating the skill score of the CAMSA, with the total skill score of the Victorian FMS Assessment, the correlation was slightly weaker, but still considered strong ( $r_s = 0.60$ ,  $p < 0.05$ ).

## 4. Discussion

This study examined the test-retest reliability and the concurrent validity of the CAMSA and the Victorian FMS Assessment, among a sample of female Year 7 students, in a junior high school setting. The CAMSA provided reliable estimates of students' FMS proficiency. Indeed, the test-retest reliability of the CAMSA was stronger than the Victorian FMS Assessment; which was still highly reliable.<sup>29</sup> In addition, the concurrent validity between the CAMSA and the Victorian FMS Assessment instrument was strong.

The isolated *time* score reliability for the CAMSA (7 days: ICC=0.80) was the same as that of the Canadian study (8 to 14 days: ICC=0.80). When isolating the *skill* score component of the CAMSA, reliability was slightly stronger (ICC=0.85) in the current study, and even more so than skill reliability in the Canadian study, which was moderate over a short (2–4 days) interval (ICC=0.46), but strong over a long (8–14 days) interval (ICC=0.74).<sup>21</sup> The lower test-retest reliability correlations across the shorter intervals in the Canadian study were explained by a possible learning effect due to participants remembering the CAMSA over the shorter period, and thus improving their performance.<sup>21</sup> However, the learning effect was not apparent in the longer test-retest interval of the Canadian study, nor in the current study. Therefore, when assessing reliability, a minimum of a 7-day test-retest interval is recommended.

From a research and educative perspective, there is a trade-off between the number of performance criteria required for adequate analysis, and the burden on time for both students and teachers. The CAMSA took significantly less time to administer than the Victorian FMS Assessment. The administration time was reduced as the CAMSA requires only a small space (20 m), for all seven skills to be performed, so potentially more courses can be set up, and more students assessed. In addition, several skills (seven) are performed in succession, and are analysed live (in-field); resulting in a mean completion time, and thus analysis time, of 15 s per student. This is in contrast to the Victorian FMS Assessment instrument, which took over a minute to complete, and other common FMS assessments which can take 20–60 min per child.<sup>20</sup> This reduces administration and assessment burdens, which are two major barriers for teachers in PE.<sup>17</sup> Subsequently, there is more class time available for targeted instruction, delivery of appropriate learning tasks, and ultimately skill improvement.

Furthermore, findings demonstrated no evidence of proportional bias in either assessment. This is important, as other reliability assessments in this field have found some evidence of proportional differences.<sup>30</sup> This finding is also encouraging in relation to the potential use of the CAMSA to extend beyond research to be used as an educative assessment instrument within a school setting. Particularly promising is the potential for the CAMSA to be integrated as a teaching tool, whereby the instrument is conducted on multiple occasions across a curriculum unit to monitor progress, with the intention to advance and promote teaching, and improve learning outcomes.

Based on the current study, the CAMSA appears to have strong concurrent validity when compared with the Victorian FMS Assessment instrument, meaning that the instruments are ranking the girls in a similar order in terms of their FMS proficiency. Although the latter cannot be considered the 'gold standard' of assessment in adolescents, the validity and reliability of the Victorian assessment has been previously established in children,<sup>23</sup> and the instrument has been used in a number of previous FMS studies in children of a similar age.<sup>24,25</sup> Therefore, these findings in regards to the strong concurrent validity between the CAMSA and the Victorian FMS Assessment are positive.

Both assessment instruments in this study involve a process-based assessment of skill. When aiming to assess FMS improvement, process-oriented instruments such as the Test of Gross Motor

Development-2 (TGMD-2)<sup>2</sup> are recommended, as they are effective in identifying skill deficits.<sup>17</sup> Indeed, the CAMSA skill criteria was drawn from the TGMD-2 skill criteria.<sup>21</sup> The CAMSA, however, has an additional advantage of including a product-oriented assessment as well. As there is some evidence that process and product oriented assessments are capturing slightly different constructs,<sup>10</sup> an assessment that combines both aspects of product and process assessment is likely to give a more complete picture of motor competence level.

The CAMSA has only been tested before in children aged up to age 12. Although the girls in this study were at the upper end of this age group (i.e., mean age of 12.6 years) they predominantly performed in the lower two standards (i.e., *beginning or progressing*), and no student was considered to be at 'mastery' or 'near mastery'<sup>28</sup> in the Victorian FMS Assessment. The results of the current study are congruent with several other studies highlighting lower than expected movement skill proficiency in girls.<sup>11,21</sup>

There were some limitations of this study. Although the skills and movements required by the CAMSA were selected to represent a more authentic picture of the students' movement capacity, other aspects of agility and movement skill (e.g., bilateral coordination, twisting) may not be assessed by the CAMSA.<sup>21</sup> However, the Delphi panel used in the CAMSA, supported the choice of movement skills in the protocol as being reflective of the skills that children should acquire through school PE.<sup>21</sup> Also, the skills, although well matched, were not identical in the two assessment instruments; however, this does not appear to have reduced the concurrent validity between the two instruments. In addition, it should be acknowledged that other aspects of validity and reliability remain unverified (e.g., construct and convergent validity, and inter-rater reliability). In the interest of promoting use of the instrument in school setting, further investigation into the reliability and validity of the CAMSA is important. Furthermore, the generalisability of the findings may be limited due to the relatively small, homogenous, girls-only sample. Therefore, future research may seek to investigate the reliability and validity of the CAMSA further in boys and also, larger, diverse samples.

## 5. Conclusion

The results demonstrate excellent test-retest reliability for both FMS instruments, and strong concurrent validity between them. In addition, the CAMSA required less time to administer, is a more authentic measure of movement skill proficiency,<sup>21</sup> and is feasible for use in Australian schools.<sup>19</sup> FMS assessment should be an integral part of the teaching and learning process within PE. Not only does the assessment need to be valid and reliable, but also authentic, meaningful, and relevant to the students' age and development.<sup>19,21</sup> In addition, the assessment must be feasible for teachers to integrate within PE, to enable the assessment process to facilitate more informed teaching, thus more effective FMS programs. Therefore, the CAMSA may be an attractive alternative, for use by teachers of early adolescent girls, to the more traditional forms of FMS assessments.

## Practical implications

- There is a lack of valid and reliable instruments for early adolescent and adolescent fundamental movement skill assessment.
- Both the Victorian FMS Assessment and the CAMSA are highly reliable.
- The CAMSA may be an attractive alternative as it was comparable to the Victorian FMS Assessment, involved less time to administer and has higher authenticity than traditional FMS assessments.



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## Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <http://dx.doi.org/10.1016/j.jsams.2016.11.007>.

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