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Convergent Validity Between Two Fundamental Movement Skills Assessment Tools: The Test of Gross Motor Development-3 and the Canadian Agility and Movement Skill Assessment

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Abstract

Background: In response to China's recent educational policies mandating a focus on fundamental movement skills (FMS) in school physical education, this study investigated the convergent validity between two widely used FMS assessment tools: the Test of Gross Motor Development-3 (TGMD-3) and the Canadian Agility and Movement Skill Assessment (CAMSA). Methods: A random sample of 134 9–10-year-old children were tested with both the CAMSA and the TGMD-3. Results: The outcomes from both the TGMD-3 and the CAMSA revealed a superiority in object-control skills among boys compared to girls, with a significant correlation between the two (r = 0.265–0.482, $p < 0.01$). Additionally, the Kappa correlation coefficient between the CAMSA and the TGMD-3 was 0.395, while the Kappa correlation coefficient between the CAMSA total skill and the TGMD-3 was 0.654. Conclusions: Both assessment tools effectively identified gender disparities in FMS, demonstrating correlation and consistency within acceptable ranges. Considering the slight variations in scoring methods, it is recommended to employ a variety of assessment tools in future evaluations of children's FMS to enhance the overall comprehensiveness of the assessment.

Keywords: convergent validity; TGMD-3; CAMSA; fundamental movement skills; assessment tools

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1. Introduction

Fundamental movement skills (FMS) are considered motor patterns that are typically developed between the ages of 4 and 7, which serve as building blocks to more complex movement patterns and lifelong PA (Gallahue et al., 2019). They encompass locomotor, object-control, and stability skills (Barnett et al., 2016). Childhood plays a crucial role in FMS development with early acquisition of FMS (in particular object-control skills) enabling future development of advanced motor skills, which typically correspond with greater levels of PA across one's lifespan (Gallahue et al., 2019; He et al., 2024; Barnett et al., 2024). As development and identification of FMS abilities in childhood is relevant for establishing longer-term PA and health outcomes, FMS assessment is extensively employed to

evaluate the overall growth and development of children and adolescents (Makaruk et al., 2023). Multiple internationally recognized FMS assessment tools exist, which can be categorized as process assessment or outcome assessment based on their evaluation methods (Bardid et al., 2019). Process evaluation primarily emphasizes the quality of movement and its performance component elements, e.g., body posture, fluidity of movement, while outcome evaluation centers on the product of the movement, i.e., outcome measures commonly measured in speed, or number of successful completed attempts (Greg et al., 2008; Logan et al., 2018). The choice of assessment instrument depends on factors such as the range of skills that the assessors (i.e., clinicians, educators, research scientists) wish to measure (i.e., motor, fine motor, object-control, etc.), ease of administration and assessment, as well as time and logistical constraints (i.e., number of assessors required, space, etc.) (Bardid et al., 2019). A range of tools exist for assessing children's FMS, with some designed primarily for clinical identification of motor difficulties (e.g., the Movement Assessment Battery for Children) and others intended for educational settings to inform teaching and physical literacy development (e.g., the TGMD-3 and CAMSA) (Cools et al., 2009). Recent research in the UK has similarly explored school-based FMS assessments among children of comparable ages (Lawson et al., 2021), highlighting the international relevance of this work.

A cross-sectional survey of 11,480 Chinese children aged 3–10 years using the TGMD-3 found that the development of FMS in Chinese children was lagging, with fewer and poorer movements being mastered, which reflects global trends of decline in FMS abilities (Bolger et al., 2021; Xu et al., 2023). In light of these poor FMS abilities, curriculum changed ensued. The development of students' FMS abilities has become a key strategic priority. In 2021, the China's General Office of the Ministry of Education (GO-MOE) systematically proposed that the quality of school physical education should improve, with a diligent focus on effective teaching, and the development of "health knowledge + fundamental movement skills + specialized sports skills" at the core of future policy (GO-MOE, 2021). In 2022, the MOE issued the Physical Education and Health Curriculum Standards (PEHCS), which, for the first time in a national-level curriculum document, explicitly stipulates curricular content and teaching objectives related to FMS for students, marking the formal integration of FMS development into the national curriculum system as a core component of teaching and evaluation (GO-MOE, 2022).

However, the effective implementation of these Chinese policy goals hinges on the availability of scientifically sound and practically feasible assessment tools for FMS. China currently employs predominantly foreign-imported tools for FMS assessment, with the Test of Gross Motor Development-2/3 (TGMD) series (Ulrich, 2000, 2013) being the most widely utilized among them. Traditional assessment tools such as the TGMD-2 face limitations in school environments due to factors such as time consumption, the need for multiple assessors, in addition to needing specialized equipment and a high volume of space (Tompsett et al., 2017). The Canadian Agility and Movement Skill Assessment (CAMSA) (Francis et al., 2016) specifically addresses the aforementioned limitations, focusing on evaluating the fundamental, comprehensive, and intricate movement skills of children aged 8–12 in a more dynamic environment with less space and assessors required (Francis et al., 2016).

As the CAMSA was developed following the TGMD-2, with both toolkits designed originally for children in North American sporting and physical activity culture, these two assessment tools share some similarities. Regarding the test components, the CAMSA incorporates seven assessment items; these seven assessment items are also part of the 13 tests included in the TGMD-3. In terms of scoring methodology, the CAMSA integrates both process and outcome assessments, whereas the TGMD-3 primarily emphasizes process evaluation (Nagy et al., 2023; Ulrich, 2013). With regard to scoring criteria, eight out

of the CAMSA's 14-skill assessment standards (i.e., the process criteria) bear resemblance to those assessment standards within the TGMD-3. In terms of the testing environment, the CAMSA is more dynamic, requiring the performance of multiple different skills one after another in a course-like format, making the assessment more reflective of a sport or physical activity (PA) environment, in addition to significantly reducing the testing time (HALO, 2017). By contrast, the TGMD-2/3 environment is relatively static and performed in isolation (Ulrich, 2013; Longmuir et al., 2017).

It is evident that, even though the TGMD-3 and the CAMSA have slightly different measurement objectives and testing environments, they exhibit numerous overlaps in terms of the applicable age range, test components, scoring methods, and criteria, which provides a basis for the comparison of the two assessment tools. However, there has been no research exploring the distinctions and connections between the CAMSA and other assessment tools in terms of assessment outcomes within the Asian, and specifically Chinese, context. This study represents the first investigation of the CAMSA's convergent validity in Asia by assessing 134 children aged 9–10 using both the TGMD-3 and the CAMSA to compare and analyze the differences and similarities in their scoring results (across gender and skill ability levels). Understanding how these tools perform in diverse educational contexts, including in China, is essential for informing evidence-based physical education practice. The prior utilization of the TGMD 2/3 within Chinese contexts made its selection a natural choice for evaluating motor competence abilities, as its implementation is accepted within the region. This study marks the first time the CAMSA has been implemented for use in China; however, the new curriculum standards indicate a greater need to develop FMS abilities (with a corresponding need to assess said abilities) among students. The CAMSA is noted for its more efficient and less labour-intensive collection protocols (Francis et al., 2016). A combination of assessment measures can provide a more thorough understanding of a child's FMS levels, while indicating if the CAMSA may be feasible for school populations where staffing and resources to accommodate assessment are limited (O'Brien et al., 2021; Philpott et al., 2023). This work will contribute to evaluating the efficacy of the newly implemented national curriculum standards, by specifically assessing FMS abilities in childhood and youth, which is a targeted measure of the newly enacted policy. It may serve as a proxy evaluation of physical education teaching quality and the efficacy of teachers in enacting said policies. Furthermore, this will provide guidance for future researchers on the value of utilizing multiple tools to understand children's FMS levels.

2. Materials and Methods

2.1. Subjects

Following approval from the Jinan Municipal Education Bureau (Jinan, China) to obtain permission to conduct the study in primary schools, a random sampling procedure was implemented to select participating schools. Specifically, two primary schools were randomly selected from all primary schools in Jinan using a computer-generated random number sequence, and school administrators were then invited to approve participation. Once two schools agreed to partake, informed consent was sought from all parents and guardians of potential study participants. Study participants were required to complete their own assent form in addition to parental or guardian consent. Participants were entitled to withdraw from the study at any time in agreement with principles from the Helsinki declaration, and ultimately 180 children aged 9–10 years (all Asian) from these two schools were recruited to participate. After excluding 46 children who did not complete the CAMSA and the TGMD-3 due to ill-health, voluntary withdrawal, or other school-related absence, a total of 134 children (age: 10.42 $\pm$ 0.33 years, height: 157.41 $\pm$ 7.04 cm, weight: 47.42 $\pm$ 10.43 kg) were included. It is generally accepted that the number of sub-

jects for validity assessment is in the range of 50–200, so the number of subjects in this study meets the requirements (Crawford et al., 2001; Cools et al., 2010; Menescardi et al., 2022). Out of these, 61 were boys and 73 were girls, as indicated in Table 1. All the included participants had no significant movement disorders or sports injuries within the past year, nor had they engaged in high-intensity sports 24 h prior to testing. The study received approval from the Ethics Committee of Shandong Normal University in 2020, with approval number SDNUTY20200312.

Table 1. Basic information of subjects.

Gender	*N*	Age (Year)	Height (cm)	Weight (kg)	BMI (kg/m^2)
Boy	61	10.42 ± 0.33	157.60 ± 7.97	49.19 ± 12.16	19.69 ± 3.97
Girl	73	10.42 ± 0.32	157.26 ± 6.31	46.10 ± 8.76	18.56 ± 2.99
All	134	10.42 ± 0.35	157.41 ± 7.04	47.42 ± 10.43	19.05 ± 3.48

2.2. Measurements

2.2.1. TGMD-3

The TGMD-3 is a process assessment tool used to measure the motor development of gross muscle groups in typically developing children (Ulrich, 2000, 2013). It has gained widespread adoption among clinicians and educators due to its high reliability and validity (Cools et al., 2009; Rey et al., 2020). A previous study in Italy (n = 5210; mean age female = 8.38 ± 1.97 years; 2709 male; mean age = 8.38 ± 1.97 years) supported the strength of a two-factor model (locomotor and object-control) of the TGMD-3 through acceptable confirmatory factor analysis loadings across both subsets (range of values 0.584 to 0.675 across 13 skills), while the test–retest reliability measures across all locomotor, object-control and overall skills illustrated excellent consistency (locomotor sub-scale 0.996; object-control sub-scale: 0.997), as well as the TGMD-3 total scores (0.996) (Magistro et al., 2020). A German study (n = 189; 99 male; mean age 7.15 ± 2.02 years) of the TGMD-3 prompted further strong evidence of the assessment tool's validity and reliability (Wagner et al., 2017). Confirmatory factor analysis supported a two-model fit of locomotor and object-control skills (Wagner et al., 2017). Interrater and intra-rater reliability across the TGMD-3 subscales in the aforementioned German study, in addition to American and Finnish studies, was cited as excellent (USA and Germany) and good-to-excellent (Finland), respectively (Maeng et al., 2017; Rintala et al., 2017; Wagner et al., 2017).

The TGMD-3 consists of 13 test items: run, gallop, one-legged hop, skip, jump, slide, two-handed strike, one-handed strike, catch, kick, dribble, overhand throw, and underhand throw, with the first 6 items for locomotor skills and the last 7 items for object-control skills, and the test can be completed in about 15–20 min. During the test, participants are instructed to perform one practice trial followed by two formal trials, and participants can earn points once they meet the task criteria components for each skill, the total scores for the TGMD-3 were the sum of the scores from the two formal trials (K. E. Cohen et al., 2015).

2.2.2. CAMSA

The CAMSA plays a crucial role in the Canadian Assessment of Physical Literacy (CAPL) (HALO, 2017), which is a new assessment tool that integrates process and outcome-based assessment (Cools et al., 2009). It comprises seven motor skills, and participants can earn points once they meet the criteria for each task, with time taken to complete the circuit of skills also factored into performance. The goal of the time score is to complete the test as quickly as possible, and a shorter completion time results in a higher time score. The completion time recorded is converted into a time score which is derived from examples laid out in the CAMSA scoring procedures, e.g., a time of between 20 and 21 s to complete

the course is given a time score of 7, and a time of between 21 and 22 is given a score of 6 (Longmuir et al., 2017).

In this study, the motor skills were further classified into locomotor skills (2-foot jumping, sliding, skipping, one-foot hopping) and object-control skills (catching, throwing, kicking) (Guo, 2020). The CAMSA total score is a combination sum of the seven motor skill scores and the time score (a faster speed to complete circuit is viewed as a better score, indicating higher competence). Notably, the time score contributes approximately 50% to the final CAMSA total score. The test can be completed within approximately 1–2 min. The test includes one practice attempt followed by two formal trials, and the best performance from the two formal trials is taken into account as the final CAMSA score (HALO, 2017, pp. 42–56), as shown in Table 2.

Table 2. Comparison of TGMD-3 and CAMSA.

Items	TGMD-3	CAMSA
Types of evaluation	Process-based	Process and outcome-based
Year of development	2013 (3rd edition)	2015
Suitable age (years)	3–10	8–12
Number of items	13	8
Duration of test (min)	15–20	1–2
Test administration	1 practice, 2 trials	1 practice, 2 trials

2.3. Grading of Assessment Results

Converting scores into more comparable levels is a prerequisite for conducting convergent validity analysis (Cools et al., 2010). Since the CAMSA instruction manual (Francis et al., 2016) provides grade classification indexes, while the TGMD-3 does not, this study established a unified classification standard by categorizing the total TGMD-3 scores, the total CAMSA scores, and the CAMSA total skill scores into grades based on the final scores. To establish rankings, the 15th percentile was chosen as the threshold, where scores $\leq$ 15th percentile were categorized as rank 1 and scores > 15th percentile were categorized as rank 2 in accordance with prior studied protocol. The 15th percentile is a widely accepted cutoff in motor development research for identifying children at risk of motor difficulties, making it a clinically meaningful threshold for classifying performance in this study (Van Waelvelde et al., 2007; Cools et al., 2010).

2.4. Procedure

The test was conducted in an indoor gymnasium to minimize external influences, and the children were instructed to wear sportswear for testing. The gymnasium was equipped with standard indoor lighting to ensure clear visibility of all movement performances. The testers were three trained physical education graduates, with no affiliation or prior connection to the study participants. Following an explanation of the experimental requirements by the testers, the children proceeded to practice and undertake the test. The test was divided into two phases, with the CAMSA test performed in the first phase and the TGMD-3 test performed in the second phase, with the two phases spaced one week apart to mitigate the fatigue and loss of concentration from continuous testing (Logan et al., 2011). The entire test session was video-recorded using an iQOO Z3 device (vivo Mobile Communications Co., Ltd., Guangdong, China) and a Honor 90 device (Honor Device Co., Ltd., Shenzhen, Guangdong, China) to facilitate subsequent scoring, one camera positioned frontally and one sagittally (at a 90-degree angle) to capture both planes of movement. The cameras recorded at 1080p resolution with a frame rate of 60 frames per second (fps) to ensure sufficient detail for analyzing dynamic movements. In this study, two graduate students majoring in physical education, who had prior assessment experience, served as raters. The raters underwent an additional three-day training session (approximately 6 h in total)

led by an expert in the field before this evaluation. To assess inter-rater reliability prior to formal scoring, both raters independently scored 60 children's videos as part of their training. During scoring, raters used slow-motion playback to carefully evaluate skill execution according to the criteria. The Pearson correlation coefficient between the two raters' total scores was 0.91 ($p < 0.01$), indicating a high level of linear consistency before any discussion. Discrepancies between raters were resolved through consensus to ensure aligned perspective prior to raters completing their scoring. Subsequently, each test was independently assessed by 2 raters based on the raw scoring criteria, with any discrepancies resolved through consensus. All scores were reported as raw scores in this manuscript, with the exception of the ranking data for the CAMSA and the TGMD-3, where ranking measures were utilized as outlined above.

2.5. Statistical Analyses

In this study, the data and the results were analyzed using SPSS 25.0 (IBM Corp., Armonk, NY, USA). Gender differences in FMS indicators were assessed using independent samples *t*-tests, and correlations between the CAMSA and the TGMD-3 indicators were examined using Pearson correlation analyses, where an r value of 0.10–0.29 was considered as low correlation, 0.30–0.49 as moderate correlation, and more than 0.50 as strong correlation (J. Cohen, 1988). Difficulty indices, referring to the likelihood of a participant correctly completing the test, were calculated as the "mean/total score". Given the large number of pairwise correlations (28 for each subgroup: boys, girls, and overall; totaling 84 comparisons), a Bonferroni correction was applied to adjust for multiple testing, and the p value was set at $p = 0.0006$ across the tests deployed. Since correlations do not indicate the agreement strength between assessment instruments (Liu et al., 2016), the Kappa consistency test was implemented to explore the consistency between the CAMSA skill scores and the TGMD-3 total scores, as well as between the CAMSA total scores and the TGMD-3 total scores, in line with prior assessment protocol (Van Waelvelde et al., 2007; Cools et al., 2010). To complete the Kappa analysis, the original continuous variables of the two tools were converted into categorical variables. Since both tools were used to assess the same group of participants, they can be regarded as "two sources of measurement" classifying the same subjects.

3. Results

3.1. Gender Differences in FMS Indicators

This section aims to explore the similarities in results between the CAMSA and the TGMD-3 in identifying gender differences in FMS indicators. On the CAMSA test, boys scored significantly higher than girls on three indicators: object-control skills scores, time scores, and total scores ($p < 0.0006$). On the TGMD-3 test, boys scored higher than girls on the object-control skills scores and the total scores, but the differences did not reach significance after Bonferroni correction ($p > 0.0006$). There were no significant differences in the locomotor skills scores between boys and girls in both the CAMSA and TGMD-3 tests, as shown in Table 3.

Table 3. Gender differences in FMS.

Tools	Items	Boy	Girl	All
CAMSA	Locomotor	5.93 ± 1.46	5.89 ± 1.71	5.91 ± 1.60
	Object-control	3.74 ± 0.81 #	2.77 ± 1.02	3.21 ± 1.05
	Time	8.00 ± 2.32 #	6.16 ± 1.83	7.00 ± 2.25
	Total skills	9.67 ± 1.64	8.66 ± 2.16	9.12 ± 2.00
	Total CAMSA	17.64 ± 2.99 #	14.84 ± 3.05	16.11 ± 3.32
TGMD-3	Locomotor	35.46 ± 3.91	34.51 ± 4.18	34.94 ± 4.08
	Object-control	35.80 ± 6.22	33.12 ± 6.52	34.34 ± 6.50
	Total TGMD-3	71.26 ± 8.66	67.63 ± 9.01	69.28 ± 9.00

# indicates significance remains after Bonferroni correction (adjusted $p < 0.0006$ across 84 comparisons).

3.2. Skill-Level Profiles

Individual skill scores were converted to percentages of the maximum possible score to enable comparison across skills (see Table 4). For the CAMSA, two-foot jumping (81%) and sliding (77%) showed the highest relative scores, while one-foot hopping (44%) and skipping (54%) were the lowest. For the TGMD-3, sliding (81%) and running (80%) were the highest, whereas overhand throwing (38%) and skipping (57%) were most challenging.

Table 4. Descriptive statistics for individual skills.

Tools	Items	Raw Score	Difficulty
CAMSA	2-foot jumping	1.61 ± 0.5	0.81 ± 0.25
	Sliding	2.32 ± 0.86	0.77 ± 0.29
	Catching and throwing	1.84 ± 0.75	0.61 ± 0.25
	Skipping	1.08 ± 0.76	0.54 ± 0.38
	One-foot hopping	0.87 ± 0.57	0.44 ± 0.28
	Kicking	1.38 ± 0.63	0.69 ± 0.32
	Time	7.01 ± 2.23	0.50 ± 0.16
TGMD-3	Kicking	4.93 ± 1.48	0.62 ± 0.19
	Catching	4.39 ± 1.38	0.73 ± 0.23
	Overhand throwing	3.03 ± 2.85	0.38 ± 0.36
	Underhand throwing	6.00 ± 1.45	0.75 ± 0.18
	One-handed striking	4.81 ± 2.30	0.60 ± 0.29
	Dribbling	4.64 ± 1.50	0.58 ± 0.19
	Two-handed striking	6.30 ± 2.00	0.63 ± 0.2
	Running	6.41 ± 1.08	0.80 ± 0.14
	Galloping	5.82 ± 1.06	0.73 ± 0.13
	Hopping	5.41 ± 1.09	0.68 ± 0.14
	Skipping	4.55 ± 1.19	0.57 ± 0.15
	Jumping	6.30 ± 1.18	0.79 ± 0.15
	Sliding	6.45 ± 1.10	0.81 ± 0.14

3.3. Correlation Between FMS Indicators

In the boys' cohort, no statistically significant correlations remained between the CAMSA and the TGMD-3 following the Bonferroni adjustment. In the girls' cohort, there was a moderate correlation between the TGMD-3 locomotor skills scores and the total skills scores (r = 0.479), and the total scores (r = 0.479) of the CAMSA, which were, respectively, all at $p < 0.0006$. The girls' TGMD-3 object-control skills scores presented a moderate correlation with the total skills scores (r = 0.443) and total scores (r = 0.444) of the CAMSA, which were, respectively, all at $p < 0.0006$; the TGMD-3 total scores had a moderate to strong correlation with the locomotor skills scores (r = 0.429), the object-control skills scores (r = 0.427), the total skills scores (r = 0.543) and the total scores (r = 0.544) from the CAMSA, which were, respectively, all at $p < 0.0006$.

When looking at overall values (boys and girls values combined) there was a moderate correlation between the TGMD-3's locomotor skills scores and the locomotor skills scores (r = 0.339), the object-control skills scores (r = 0.306), the total skills scores (r = 0.431) and the total scores (r = 0.431) of the CAMSA, which were, respectively, all at $p < 0.0006$. The TGMD-3 object-control skills scores presented a moderate correlation with the locomotor skills scores (r = 0.322), the total skills scores (r = 0.397) and the total scores (r = 0.326) of the CAMSA, which were, respectively, all at $p < 0.0006$; the TGMD-3 total scores showed a moderate correlation with the locomotor skills scores (r = 0.386), the object-control skills scores (r = 0.330), the total skills scores (r = 0.482) and the total scores (r = 0.430) from the CAMSA, which were, respectively, all at $p < 0.0006$, as shown in Table 5.

Table 5. Correlation between TGMD-3 and CAMSA.

Gender	Items	1	2	3	4	5	6	7
Boy	1. CAMSA locomotor							
	2. CAMSA object-control	−0.043						
	3. CAMSA time	−0.005	0.230					
	4. Total CAMSA skills	0.868 #	0.458 #	0.110				
	5. Total CAMSA	0.452 #	0.432	0.843 #	0.617 #			
	6. TGMD-3 locomotor	0.277	0.153	0.252	0.322	0.353		
	7. TGMD-3 object-control	0.296	−0.050	−0.123	0.239	0.044	0.431	
	8. Total TGMD-3	0.338	0.034	0.026	0.317	0.191	0.762 #	0.913 #
Girl	1. CAMSA locomotor							
	2. CAMSA object-control	0.192						
	3. CAMSA time	0.054	0.243					
	4. Total CAMSA skills	0.885 #	0.626 #	0.159				
	5. Total CAMSA	0.660 #	0.590 #	0.711 #	0.804 #			
	6. TGMD-3 locomotor	0.382	0.369	0.242	0.479 #	0.479 #		
	7. TGMD-3 object-control	0.347	0.353	0.228	0.443 #	0.444 #	0.387	
	8. Total TGMD-3	0.429 #	0.427 #	0.278	0.543 #	0.544 #	0.745 #	0.904 #
All	1. CAMSA locomotor							
	2. CAMSA object-control	0.101						
	3. CAMSA time	0.029	0.375 #					
	4. Total CAMSA skills	0.853 #	0.606 #	0.221				
	5. Total CAMSA	0.525 #	0.617 #	0.811 #	0.744 #			
	6. TGMD-3 locomotor	0.339 #	0.306 #	0.269	0.431 #	0.431 #		
	7. TGMD-3 object-control	0.322 #	0.265	0.130	0.397 #	0.326 #	0.418 #	
	8. Total TGMD-3	0.386 #	0.330 #	0.216	0.482 #	0.430 #	0.755 #	0.912 #

# indicates significance remains after Bonferroni correction (adjusted $p < 0.0006$ across 84 comparisons).

3.4. CAMSA and TGMD-3 Classification Consistency

The classification criteria indicate that out of the children, 25 had a CAMSA total skills score ranked as 1 and 109 ranked as 2. Similarly, 20 had a TGMD-3 total score ranked as 1 and 114 ranked as 2. There were 16 children ranked 1 by both the CAMSA total skills scores and the TGMD-3 total scores, while 105 children were ranked as 2 by both assessments. The rank assessment showed agreement among 90.30% of the children, with a Kappa coefficient of 0.654, indicating fairly consistent results according to the Fleiss scale, as shown in Table 6.

Table 6. Grading based on CAMSA total skills scores versus total TGMD-3 scores.

		Total TGMD-3 Scores		
		Rank 1	**Rank 2**	**All**
CAMSA skills scores	Rank 1	16	9	25
	Rank 2	4	105	109
	All	20	114	134

Based on the classification criteria, 21 children had total CAMSA scores ranked as 1, while 113 had scores ranked as 2. Out of the total CAMSA and TGMD-3 scores, 10 children were ranked as 1, and 103 children were jointly ranked as 2. The level assessment exhibited agreement among 84.33% of the children, with a Kappa coefficient of 0.397. According to the Fleiss scale, this value indicates a general level of agreement, as shown in Table 7.

Table 7. Grading based on total CAMSA scores versus total TGMD-3 scores.

		Total TGMD-3 Scores		
		Rank 1	**Rank 2**	**All**
Total CAMSA scores	Rank 1	10	11	21
	Rank 2	10	103	113
	All	20	114	134

4. Discussion

4.1. Identification of Gender Differences

Regarding gender differences, both the TGMD-3 and CAMSA tests yielded similar results. Specifically, the results from both assessments demonstrated that boys outperformed girls in object-control skills (significant differences in CAMSA, but not TGMD-3) and total scores in both measures (differences were significant in CAMSA only), with significantly faster times in the CAMSA performance, while no gender differences were observed in locomotor skills across both measures. These results echo prior results reported in Chinese studies with more than 10,000 children, which further support the need to address FMS in Chinese PE contexts, as proficiency levels remain quite low (Li, 2021; Xu et al., 2023).

This gender difference also exists in European countries such as Ireland (Philpott et al., 2023) and the UK (Lawson et al., 2021), as well as within Australian research (Barnett et al., 2024). According to prior research, there is a general consensus that proficiency in catching and throwing skills is contingent on experience (Latash & Turvey, 1999). Although both boys and girls in China are uniformly taught both locomotor and object-control skills in school, and the same PE curriculum targets established for both boys and girls, boys record higher levels of PA and are more prone to participating in object-control forms of sport outside school than girls, which may contribute to the difference in levels of object-control skills evident in this study (K. E. Cohen et al., 2014; Bolger et al., 2021). Accordingly, the two tools demonstrate similar trends in sex differences rather than definitively identifying them. The differential sensitivity to gender differences after correlation reflects their distinct measurement approaches. The CAMSA's inclusion of a time component—where boys scored significantly higher—appears to amplify gender disparities, as boys' tendency to prioritize speed enhances their total scores. In contrast, the TGMD-3's exclusive focus on movement process captures underlying skill quality that is less influenced by such behavioural tendencies. This interpretation is supported by the boys' correlation patterns: before correction, boys showed low-to-moderate correlations between the CAMSA and the TGMD-3 ($r = 0.277–0.452$, $p < 0.05$), suggesting that the time component in the CAMSA introduces variance related to speed-oriented performance that is distinct from the process-oriented skills measured by the TGMD-3. They can reliably measure and authentically reflect the assessed characteristics. However, the current scores across boys and girls being subpar across both FMS assessment tools indicates an implementation gap between the issuance of current policy directives and measurable improvements in Chinese children's FMS performance (Li, 2021; Xu et al., 2023). Several challenges persist in cultivating FMS among Chinese children. While the PEHCS outlines general requirements for FMS instruction, specific pedagogical designs tailored to different regions, ages, and genders remain undefined. In addition, the majority of physical education teachers have not yet received specialized training in FMS pedagogy, which inevitably constrains teaching effectiveness. Both adequate teacher training and supportive pedagogical approaches are essential components of developing FMS abilities within the school context, as motor development must be promoted and supported for children at an age and developmentally appropriate context (Tompsett et al., 2017; Lai et al., 2014). Crucially, effective implementa-

tion in schools depends not only on policy directives but also on teacher knowledge, time, and practical supports for assessment and instruction. Without targeted professional learning and streamlined assessment tools, gains in FMS proficiency may remain limited despite favourable policy intentions.

4.2. Correlation

The correlation analysis between the total TGMD-3 scores and the total CAMSA scores across the sample demonstrated a moderate correlation ($r = 0.431$, $p < 0.0006$). However, the correlation observed in our study was slightly lower compared to previous findings on other assessment tools (Cools et al., 2010; Logan et al., 2011; O'Brien et al., 2021). For instance, previous studies have reported a moderate to good correlation between the TGMD-2 and the Movement Assessment Battery for Children (M-ABC) ($r = 0.52$, $p < 0.01$) (Logan et al., 2011), as well as between the M-ABC and the MOT 4-6 ($r = -0.68$, $p < 0.01$) (Cools et al., 2010). The slightly lower correlation can be explained by three factors. Firstly, there is a difference in the focus of process and outcome assessment (Stodden et al., 2008). The TGMD-3 is designed as a process assessment, but the CAMSA includes a mix of process and outcome measures. Secondly, the two assessment tools differ in the scoring proportion for each skill. The skill distribution for the TGMD-3's object-control skills and locomotor skills are more balanced (i.e., seven locomotor, and six object-control) whereas the CAMSA assigns a greater proportion of scores to locomotor skills (four skills) and time (with quick completion necessitating a high level of locomotor proficiency), with time scores accounting for 50% of the total scores (Longmuir et al., 2017). Because CAMSA assigns approximately 50% of points to completion time, children may prioritize speed over skill execution—a speed–form trade-off—which can attenuate correlations with the process-oriented TGMD-3. This structural difference diminishes the advantage of children with strong object-control skills and contributes to variations in total scores. Interestingly, when excluding the time scores, the correlation between the CAMSA skill scores and the TGMD-3 skill scores ($r = 0.482$, $p < 0.0006$) increased, further supporting the inference of this study. The absence of significant correlations in boys after correction is a notable finding that highlights how the two tools capture different dimensions of performance across genders. Thirdly, gender appears to be another factor influencing the correlation. The results showed no significant correlation between the total TGMD-3 scores and the total CAMSA scores among boys, whereas a strong correlation was observed among girls ($r = 0.544$, $p < 0.0006$). Boys may show greater interest in the CAMSA test, tending to prioritize speed over skill execution, perhaps due to competitive instincts and an interest in challenging their peers. This likely results in their improved timing score (i.e., the derived time score from the CAMSA guidebook generated from time in seconds to complete the course) contributing disproportionately to the boys' total CAMSA scores, thereby weakening the correlation with the total TGMD-3 scores. Conversely, girls for whom greater locomotor performance and locomotor PA habits are more commonly observed may benefit from the greater focus of the CAMSA test on locomotor skills (Bolger et al., 2021). This inference is supported by Table 3, which shows that boys' time scores were significantly higher than those of girls.

A moderate correlation ($r = 0.339$, $p < 0.0006$) was observed between the locomotor skills of the CAMSA and the TGMD-3 across both boys and girls. This result can be attributed to not only the aforementioned differences in assessment methods but also the percentage of balance skills in the respective tests. Previous studies have emphasized that the proportion of balance skills significantly influences test outcomes (Geuze, 2003). Several locomotor skills (e.g., one-legged hopping, two-legged jumping, running) involve the element of dynamic balance (Logan et al., 2011). As mentioned earlier, the CAMSA test

is designed with a focus on safety and multiple transitions between skill types, aiming to enhance the balance and complexity of skill execution to simulate real-life motor experiences (Longmuir et al., 2017), requiring more dynamic balance skills than the TGMD-3; the capacity for multiple transitions between different skills is reflected in the time score. Despite both the CAMSA and the TGMD-3 showing a consistent pattern of gender disparity in object-control skills (see Table 3), the correlation between the two tests on this specific subscale was not significant (r = 0.265, $p > 0.0006$). Two factors were assumed to contribute to this observation. Firstly, the CAMSA encompasses only three items related to object-control skills, which is less comprehensive compared to the TGMD-3 (Ulrich, 2013; Francis et al., 2016). Secondly, while in recent years China has placed greater emphasis on developing children's skills in basketball, football, and table tennis (which are recommended for teaching in physical education in China), a number of items within the TGMD-3 reflect skills pertinent to performance in tennis and baseball, neither of which are popular in China (GO-MOE, 2022). Object-control proficiency is often informed by prior personal experience and vicarious experience, and children would be less exposed to particular skills when they are not a part of the movement culture of Chinese sport and PA, thus affecting the final assessment results (Cools et al., 2009). Though these toolkits may not fully capture essential elements of Chinese movement culture, and there is a need for assessments reflective of this culture, comparing Chinese findings with international and global standards provides strong insight on the enactment of policy, and such global insights on movement proficiency are sorely needed as research evidence (Bolger et al., 2021; Bardid et al., 2019). Unlike clinical tools such as the M-ABC, school-appropriate instruments like the TGMD-3 and the CAMSA are designed to inform teaching, and the present findings align with UK research demonstrating their practical utility in educational settings (Lawson et al., 2021). Additionally, it is important to highlight that time scores in the CAMSA, although indicative of children's dynamic balance and agility, do not exhibit correlation with locomotor skills. This study postulates that this discrepancy may arise due to the CAMSA's requirement for children to strike a balance between speed and skill during performance (Francis et al., 2016), potentially resulting in a situation where children compromise their motor performance to achieve faster times.

4.3. Consistency

Due to the consideration of chance agreement, the kappa coefficient is generally regarded as a more reliable measure of consistency than simple percentage agreement (Strijbos et al., 2006). In this study, the kappa coefficient between the total scores of the CAMSA and the TGMD-3 was 0.395, indicating a relatively low level of agreement between the two assessment tools, suggesting the tools have different utility. Previous studies have also shown substantial variations in the level of agreement between different assessment tools. For example, the kappa value between the Motor Proficiency Test 4-6 (MOT4-6) and M-ABC was 0.67 (Cools et al., 2010), between BOT and M-ABC was 0.71 (Riggen et al., 1990), while the kappa coefficient between Peabody Developmental Motor Scales-2 (PDMS-2) and M-ABC was only 0.29 (Van Waelvelde et al., 2007). This suggests that the results of one assessment tool are difficult to compare with another (Strijbos et al., 2006), thus using only a single assessment tool for motor skill diagnosis would make the results less comprehensive (Logan et al., 2011; O'Brien et al., 2021; Philpott et al., 2023). Upon excluding the time scores, the Kappa correlation coefficient between the CAMSA skills scores and the total TGMD-3 scores was determined to be 0.654, indicating a higher level of consistency. This finding suggests that, apart from the differences arising from variations in assessment methods and content proportions, the time scores significantly influence the consistency between the two assessment tools. The marked difference in Kappa values—0.395 for the CAMSA

total scores versus 0.654 for the CAMSA skill scores—directly illustrates this point: the time component, which contributes approximately 50% to the total CAMSA score, reduces concordance with the process-oriented TGMD-3, whereas the skill-based components of the two tools align reasonably well. Therefore, the present study assumed that the agreement level between the CAMSA without time constraints and the TGMD-3 would be further improved. Notably, achieving faster completion times and superior skill performance appear challenging to reconcile during actual testing, with one element often sacrificed for the betterment of the other (i.e., better time score resulting in lower skill performance or vice versa). However, the influence of time and pressure in the context of skill performance remains worthy of evaluation, as both these elements serve as key task constraints reflective of authentic sporting environments (O'Sullivan et al., 2022). This integrated scoring approach combining process and product (i.e., time constraints) aligns with the recent trend in FMS assessment tools toward dynamic, real-world evaluations. It acknowledges that movement is frequently influenced by environment, task, and other constraints (e.g., physical or mental) with completion time representing one aspect of task constraints which are pertinent to everyday movement capabilities (O'Sullivan et al., 2020; Thelen, 2005).

The results showed that both the total CAMSA scores and the total TGMD-3 scores demonstrate similar capabilities in identifying children with poorer FMS, with 21 and 20 children identified, respectively. However, as previously mentioned, the consistency between the total scores of the CAMSA and the TGMD-3 was not high, as only 10 children were jointly classified as having poor FMS. Notably, the CAMSA skills scores appears to have a greater tendency to categorize children at the poorer FMS level, identifying a total of 25 children as having poor FMS. Among these, 16 children were jointly recognized as having poor FMS by both the CAMSA skill scores and the TGMD-3 total scores. This could be attributed to the CAMSA skills component, which entails transitions between multiple motor skills and poses greater challenges compared to simple time scores. While some inconsistency between the two assessment tools in identifying children with poor FMS is evident, with factors such as performance environment and task demands impacting on categorization of FMS ability, assessment of FMS is vital. Children with poor FMS may exhibit more pronounced motor difficulties if these deficits are not addressed, in addition to issues such as higher weight status and low levels of PA (O'Brien et al., 2021). The skill-level profiles revealed in this study highlight the importance of moving beyond total scores in practice. Identifying specific weaknesses—such as one-foot hopping and overhand throwing—enables teachers to design targeted interventions rather than generic FMS programmes.

4.4. Limitations

This study represents the first exploration of the convergent validity between the TGMD-3 and the CAMSA among an Asian populace, establishing a basis for employing a diverse range of assessment tools to evaluate FMS. However, certain limitations should be acknowledged. Firstly, the sample was confined to children aged 9–10 years from Jinan, which limits the generalizability of the findings. Future research should include broader age ranges and diverse geographical regions to further investigate assessment variability. Secondly, the stringent Bonferroni correction applied in this study, while controlling for Type I errors, may have increased the risk of Type II errors, potentially masking existing gender differences or correlations—particularly the absence of significant correlations in boys after correction. Future studies with larger samples are needed to verify these findings. Thirdly, the CAMSA total score incorporates both skill execution and completion time, with time contributing approximately 50% to the final score. This weighting may

have attenuated its agreement with the process-oriented TGMD-3, suggesting that the time component should be considered when interpreting the convergent validity between these two instruments. Additionally, inter-rater reliability was assessed using Pearson correlation (r = 0.94); however, future studies should employ intraclass correlation coefficients (ICC) to better account for absolute agreement between raters.

5. Conclusions

This study compares the results of the TGMD-3 and the CAMSA in 9–10-year-old children and shows that the two instruments accurately identify gender differences in children and that the correlations and consistencies between the instruments are within reasonable limits. In addition, the differences in assessment methods allowed the two instruments to provide different information. Therefore, it is recommended that multiple instruments be used in future assessments of children's FMS to ensure a comprehensive depiction of an individual's movement abilities is provided. These findings assist in evaluating current physical education teaching policy to promote health, FMS, and sports skills, with current findings across male and female participants suggesting students are not yet reaching expectations of FMS performance as laid out in the curriculum. Further support for educators in terms of guidelines for teaching practice and guidance on optimal assessment methods for children in the Chinese region are paramount to supporting and achieving these curricular targets.

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Abbreviations

The following abbreviations are used in this manuscript:

FMS	Fundamental movement skills
TGMD-3	Test of Gross Motor Development-3
CAMSA	Canadian Agility and Movement Skill Assessment
PEHCS	the Physical Education and Health Curriculum Standards
PA	Physical activity
HALO	Healthy Active Living and Obesity Research Group
GO-MOE	General Office of the Ministry of Education of the People's Republic of China

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