# Associations of process- and hybrid-oriented motor competence assessment in spanish adolescents

*Asociaciones de la evaluación de la competencia motriz orientada al proceso e híbrida en adolescentes españoles*


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## Abstract

Introduction: despite the discrepancies between process and product-oriented motor assessments, some hybrid tests exist in the literature that provide a more comprehensive approach.
Objective: the study explored the associations between process and hybrid-oriented motor assessments in Spanish adolescents to test possible overlapping motor competence (MC) constructs.
Methodology: a sample of 82 Spanish public high school students underwent assessments using the Test of Gross Motor Development – 3rd edition (TGMD-3) and the Canadian Agility and Movement Skill Assessment (CAMSA) on separate days within the same week.
Results: in boys, all variables showed significant associations, with a moderate correlation observed between TGMD-3 manipulative skills score (TGMD-3-MS) and CAMSA skill score (CAMSA-SS) (r = 0.30-0.49). For other variables, correlations were classified as high (r ≥ 0.50). Among girls, significant associations were found between TGMD-3-MS and CAMSA-SS, TGMD-3-MS and CAMSA total score (CAMSA-T), TGMD-3 loco-motor skills score (TGMD-3-LS) and CAMSA-T, TGMD-3 total score (TGMD-3-T) and CAMSA-SS, and TGMD-3-T and CAMSA-T. All associations for girls were moderate (r = 0.30-0.49). Boys exhibited statistically significant higher means in height (effect size [ES] = 0.65), TGMD-3-MS (ES = 1.74), TGMD-3-T (ES = 1.07), CAMSA time score (ES = 1.09), and CAMSA-T (ES = 0.97).
Discussion: the significant associations found between tests align with the established patterns observed in other hybrid and process-oriented tests in the literature.
Conclusions: these results suggest that both tests may measure similar MC constructs. However, caution should be exercised in Spanish adolescent girls, where fewer correlations were observed between tests and the associations were weaker.



## Keywords

Adolescents; fundamental motor skills; motor assessment; motor competence; motor development.



## Resumen

Introducción: a pesar de las discrepancias entre las evaluaciones motrices orientadas al proceso y al producto, existen en la literatura propuestas híbridas con enfoques más completos.
Objetivo: el estudio exploró las asociaciones entre evaluaciones motrices orientadas al proceso e híbridas en adolescentes españoles para comprobar posibles constructos de competencia motriz (MC) superpuestos.
Metodología: 82 estudiantes españoles de educación secundaria pública se sometieron a evaluaciones utilizando el Test of Gross Motor Development – 3rd edition (TGMD-3) y el Canadian Agility and Movement Skill Assessment (CAMSA).
Resultados: para los chicos, todas las variables mostraron asociaciones significativas, con correlaciones entre moderadas (r = 0.30-0.49) y altas (r ≥ 0.50). Para las chicas, se encontraron asociaciones significativas entre la puntuación de habilidades manipulativas del TGMD-3 (TGMD-3-MS) y la puntuación de habilidades del CAMSA (CAMSA-SS), TGMD-3-MS y puntuación total CAMSA (CAMSA-T), puntuación de habilidades loco-motoras TGMD-3 (TGMD-3-LS) y CAMSA-T, puntuación total del TGMD-3 (TGMD-3-T)" y CAMSA-SS, y TGMD-3-T y CAMSA-T. Todas estas asociaciones fueron moderadas (r = 0.30-0.49). Los chicos mostraron medias estadísticamente superiores en estatura (tamaño del efecto [ES] = 0.65), TGMD-3-MS (ES = 1.74), TGMD-3-T (ES = 1.07), puntuación de tiempo del CAMSA (ES = 1.09) y CAMSA-T (ES = 0.97).
Discusión: las asociaciones significativas encontradas entre los test se alinean con los patrones observados entre otros test híbridos y orientados al proceso en la literatura.
Conclusiones: estos resultados sugieren que ambas pruebas pueden medir constructos de MC similares. Sin embargo, debe tenerse precaución en las adolescentes españolas, donde se observaron menos correlaciones y más débiles.



## Palabras clave

Adolescentes; competencia motriz; desarrollo motor; evaluación motriz; habilidades motrices básicas.

## Introduction

Fundamental Motor Skills (FMS) can be considered the building blocks (the most basic task level) of more advanced and complex movements, usually needed for sports, play, and specific contexts of physical activity (PA) (Logan et al., 2017b; Newell, 2020). There is wide evidence of the huge important relationship that FMS has with positive developmental trajectories of health for children and adolescents, sedentary behaviors, health-related physical fitness, weight status, and PA (bidirectional relationship) (Bolger et al., 2021; Jones et al., 2020; Logan et al., 2012; Robinson et al., 2015; Tompsett et al., 2017; Webster et al., 2019; Lubans et al., 2010). FMS are also connected with psychological outcomes, academic and cognitive performance, and the existence of a proficiency barrier for the development of more complex skills (dos Santos et al., 2022; Haapala, 2013; Lubans et al., 2010).

Despite these, evidence shows that the current situation should be improved, since the competence of the youth in FMS tends to be poor (Bolger et al., 2021; Hardy et al., 2013), and the "below desirable" levels of PA can have a role on that (Bolger et al., 2021; van Sluijs et al., 2021; Weaver et al., 2021). This leads to a large potential for development (Bolger et al., 2021) that cannot occur "naturally", since organized and planned motor interventions are needed for improving FMS (Logan et al., 2012; Ritonga et al., 2024; Tompsett et al., 2017). In this regard, for evaluating the effectiveness of the FMS interventions, assessment tools are vital in the field of motor development and physical education (PE), as well as for tracking motor competence (MC), making comparisons across ages, identifying skill deficiencies, and understanding the potential impact of MC with health-related constructs (Hulteen et al., 2020; Hulteen et al., 2023; Logan et al., 2017a; Logan et al., 2012).

Typically, motor assessments occur through process or product-oriented measures (Rey et al., 2020). The first one assesses the quality of movements performed during a skill execution, or "how" they were performed (demonstration of a component of a skill, behavioral criteria, etc.), while the second one focuses on the outcomes of skills (velocity, distance, etc.) (Logan et al., 2012; Logan et al., 2017b). Both measures seem to assess different aspects of MC, showing their strengths and limitations (Hulteen et al., 2023; Logan et al., 2017a). A hybrid approach that could possibly include both, will provide one assessment that measures FMS more comprehensively and feasibly (Cao et al., 2020; Hulteen et al., 2020; Palmer et al., 2021; Robinson et al., 2015; Webster et al., 2019).

The Canadian Agility Movement Skill Assessment (CAMSA) is an example of that (Longmuir et al., 2017). CAMSA represents a more enjoyable and similar to real sport hybrid tool since it is performed in an agility course format (Chang et al., 2021; Longmuir et al., 2017). It is considered feasible, accurate, reliable, and an alternative assessment of motor proficiency in fundamental, complex, and combined movement skills (Chang et al., 2021; Longmuir et al., 2017). However, process-oriented tests are still the most common in the literature (Logan et al., 2017b), and despite there is no such thing as a gold standard in motor assessment (Hulteen et al., 2020; Hulteen et al., 2023), the Test of Gross Motor Development (TGMD) and its variants are the most common ones (Hulteen et al., 2020; Logan et al., 2017b), being one of the most reliable, valid, robust, and suitable tools for evaluating a wide range of FMS (Hulteen et al., 2020; Hulteen et al., 2023; Rey et al., 2020).

The main efforts of the research should focus on the already existing tests, as well as on the relationships between process and product-oriented measures, and hybrid approaches (Hulteen et al., 2020; Hulteen et al., 2023; Logan et al., 2017a; Logan et al., 2017b). TGMD has been compared with product-oriented tests, showing varying degrees of correlation, different ability for motor delay classification, and inequal sensitivity to motor improvements after intervention, suggesting that different constructs of MC are assessed (Hulteen et al., 2020; Logan et al., 2017a; Palmer et al., 2021; Re et al., 2018; Webster et al., 2019).

In the case of CAMSA, associations with product (Cao et al., 2020; Menescardi et al., 2022) and process-oriented assessments (Stearns et al., 2019) have been shown in the literature. However, to the best of our knowledge, no study has compared CAMSA and TGMD between them, until today, even though skill criteria of the CAMSA was initially drawn from the TGMD (Longmuir et al., 2017). So, this study aims to establish potential associations between the CAMSA and the latest version of the TGMD, the third edition (TGMD-3), testing possible overlapping MC constructs.

## Method

### *Participants*

A sample of Spanish public high school students, consisting of 82 individuals (39 boys and 43 girls) between the ages of 12 and 15 years, participated in this study. Their mean age was 12.43±0.77 years, and their mean height, weight, and body mass index (BMI) were recorded as 158.57±7.97 cm, 54.77±13.18 kg, and 21.64±4.19 $kg \cdot m^{-2}$, respectively. All participants volunteered for the study and provided written consent from their parents or guardians. Verbal consent was also obtained from the participants. Participants were required to attend school physical education classes and demonstrate the ability to perform all tests and skills without any movement limitations (injuries, pain, etc.). This study adhered to the ethical principles of the Helsinki Convention and was approved by the Ethics Committee.

### *Procedure*

All the tests were carried out in a sports hall during the regular school day and always in the presence of at least one teacher from the school. The tests were administered on two separate days of the same week, with a 48-hour rest period in between. On the first day, the participants completed the TGMD-3 test, and on the second day, they completed the CAMSA test. Prior to the TGMD-3 test, the participants received an explanation of each skill and were shown a video recording demonstrating the correct performance of each skill at normal speed and in slow motion. To test their skills, participants underwent three trials for each skill. The first trial served as practice to ensure that they understood what to do, while the other two were recorded as test trials (Carballo-Fazanes et al., 2021; Ulrich, 2019). For CAMSA, a researcher performed a full trial of the circuit and skills with verbal description and cueing at a slow but correct pace. A second demonstration was then performed by the researcher, this time at a fast and accurate pace. Subjects then underwent two trials, and the punctuation used for analysis was the best one. Verbal cues were given before each skill during the assessment to remind the participants of the next task, reducing the impact of memory on task sequence and completion time (Longmuir et al., 2017; Menescardi et al., 2022).

### *Instruments*

The TGMD-3 is a process-oriented assessment of gross motor skills in children. It consists of two subscales: locomotor skills (TGMD-3-LS) (including running, galloping, one-legged hopping, skipping, jumping, and sliding) and manipulative ball skills (TGMD-3-MS) (including two-hand striking, one-hand striking, catching, kicking, dribbling, overhand throwing, and underhand throwing) (Carballo-Fazanes et al., 2021; Ulrich, 2019). The test comprises 50 motor criteria, with each skill consisting of three to six criteria. Each criterion is scored as either '0' or '1', depending on its absence or presence, respectively (Carballo-Fazanes et al., 2023; Valentini et al., 2022). Motor performance in each skill was assessed through video recordings analyzed after the intervention (camera Nikon D5300), as this is also considered a consistent and reliable way of assessment (Carballo-Fazanes et al., 2021; Rey et al., 2020). Individual performances were individually recorded. The total test score (TGMD-3-T) is calculated by adding the scores for each skill and subtest, with a maximum score of 100.

CAMSA is a hybrid approach that measures both process and product-oriented performances in an agility and movement skill course format (Longmuir et al., 2017). Test components consist of performance time, time score (CAMSA-TS), skill score (CAMSA-SS), and total score (CAMSA-T). CAMSA-TS is converted from performance time to a 14-point score, with higher scores representing shorter performance time on the course. CAMSA-SS consists of 14 criterion points in seven movement skills. Each criterion point is scored as either '0' or '1' depending on whether it is absent or present. The maximum possible score for CAMSA-T is 28 points (Menescardi et al., 2022). The components used for statistical analyses were CAMSA-TS, CAMSA-SS, and CAMSA-T. The movement skills performed by the subjects were two-foot jumping, sliding, catching, throwing, skipping, one-foot hopping, and kicking a soccer ball, in that order. Motor performance of each skill was assessed by videotaping the entire course. Timing began with the 'go' command and ended when the participant kicked the soccer ball (Cao et al., 2020; Longmuir et al., 2017). Time was recorded to the nearest 0.1s using a manual chronometer and compared to the video recording. All examiners were previously trained to administer the CAMSA and used the official test manual.

### *Data analysis*

Data are presented as mean and standard deviation (SD). All statistical analyses were conducted using the IBM Statistical Package for the Social Sciences, v. 26.0 (IBMSPSS Inc., Chicago, IL, USA). Statistical significance was set at $p < 0.05$. Independent samples t-tests were used to calculate sex differences within the measured variables. Two Pearson's bivariate correlations were calculated to determine the strength of association between TGMD-3 and CAMSA (total and test subcomponents) for boys and girls scores. Correlations were categorized as low ($r$ = 0.10-0.29), moderate ($r$ = 0.30-0.49), and high ($r \geq$ 0.50) (Cohen, 1988).

## Results

Table 1 displays the descriptive results (mean and standard deviation) for all the measured variables divided by gender groups (boys or girls) and the $p$-value of the $t$ test. There are no significant differences between boys and girls for age, weight, BMI, TGMD-3-LS and CAMSA-SS. However, statistically significant higher means are found for boys in height ($d$ = 0.65), TGMD-3-MS ($d$ = 1.74), TGMD-3-T ($d$ = 1.07), CAMSA-TS ($d$ = 1.09), and CAMSA-T ($d$ = 0.97).

Table 1. Descriptive data of the measured variables according to sex group.

| Variables | Group | Mean ± SD | *p* value |
|---|---|---|---|
| Age (years) | Boys | 12.36 ± 0.71 | 0.451 |
| | Girls | 12,49 ± 0.83 | |
| Height (m) | Boys | 1.61 ± 0.09 | 0.041 |
| | Girls | 1.57 ± 0,06 | |
| Weight (kg) | Boys | 57.54 ± 14,17 | 0.069 |
| | Girls | 52.25 ± 11.82 | |
| BMI (kg/m$^2$) | Boys | 22.24 ± 4.51 | 0.216 |
| | Girls | 21.09 ± 3.85 | |
| TGMD-3-MS (score) | Boys | 23.56 ± 2.26 | <0.001 |
| | Girls | 19.63 ± 2.27 | |
| TGMD-3-LS (score) | Boys | 19.59 ± 2.35 | 0.632 |
| | Girls | 19.35 ± 2.19 | |
| TGMD-3-T (score) | Boys | 43.15 ± 3.99 | <0.001 |
| | Girls | 38.98 ± 3.81 | |
| CAMSA-SS (score) | Boys | 11.44 ± 2.34 | 0.067 |
| | Girls | 10.49 ± 2.28 | |
| CAMSA-TS (score) | Boys | 11.18 ± 2.06 | <0.001 |
| | Girls | 8.86 ± 2.18 | |
| CAMSA-T (score) | Boys | 22.62 ± 3.68 | <0.001 |
| | Girls | 19.35 ± 3.05 | |

TGMD-3-MS = Test of Gross Motor Development-3-Manipulative Skills subcomponent; TGMD-3-LS = Test of Gross Motor Development-3-Locomotor Skills subcomponent; TGMD-3-T = Test of Gross Motor Development-3-Total Score; CAMSA-SS = Canadian Agility and Movement Skill Assessment-Skills subcomponent; CAMSA-TS = Canadian Agility and Movement Skill Assessment-Time Score subcomponent; CAMSA-T = Canadian Agility and Movement Skill Assessment-Total Score.

Table 2 shows the Pearson correlation coefficient between the two tests (total and subcomponents) by sex. In boys, all variables show significant associations, with a moderate correlation between TGMD-3-MS and CAMSA-SS ($r$ = 0.30-0.49). For the remaining variables, all correlations are classified as high ($r \geq$ 0.50). Among girls, significant associations are found between TGMD-3-MS and CAMSA-SS, TGMD-3-MS and CAMSA-T, TGMD-3-LS and CAMSA-T, TGMD-3-T and CAMSA-SS, and TGMD-3-T and CAMSA-T. All the associations for girls are classified as moderate ($r$= 0.30-0.49).

Table 2. Pearson correlation coefficients (r) among performances on TGMD-3 and its subtests and CAMSA and its subtests, by sex.

| | CAMSA-SS | CAMSA-TS | CAMSA-T |
|---|---|---|---|
| Boys | | | |
| TGMD-3-MS | 0.326* | 0.543** | 0.511** |
| TGMD-3-LS | 0.614** | 0.564** | 0.706** |
| TGMD-3-T | 0.546** | 0.639** | 0.704** |
| Girls | | | |
| TGMD-3-MS | 0.39** | 0.23 | 0.456** |
| TGMD-3-LS | 0.236 | 0.230 | 0.341* |
| TGMD-3-T | 0.368* | 0.27 | 0.468** |

TGMD-3-MS = Test of Gross Motor Development-3-Manipulative Skills subcomponent; TGMD-3-LS = Test of Gross Motor Development-3-Locomotor Skills subcomponent; TGMD-3-T = Test of Gross Motor Development-3-Total Score; CAMSA-SS = Canadian Agility and Movement Skill Assessment-Skills subcomponent; CAMSA-TS = Canadian Agility and Movement Skill Assessment-Time Score subcomponent; CAMSA-T = Canadian Agility and Movement Skill Assessment-Total Score; * = correlation is significant at the 0.05 level; ** = correlation is significant at the 0.01 level.

## Discussion

This study aimed to test associations between the CAMSA and the TGMD-3. To the best of our knowledge, this is the first study to compare any TMGD test and the CAMSA, and to assess FMS in a high school sample of adolescents using the TGMD-3 test. For boys, all variables (including test totals and subcomponents) showed significant associations with each other with a high correlation, except for the TGMD-3-MS and CAMSA-SS, where the correlation was moderate. Significant associations were found between TGMD-3-T and CAMSA-T scores for both girls (moderate) and boys (high). Boys had a significantly higher mean for TGMD-3-MS, TGMD-3-T, CAMSA-TS, and CAMSA-T.

Boys and girls showed a significant correlation between TGMD-3-T and CAMSA-SS. This is one of the main findings of the study, as this correlation may indicate a similar construct of MC for the process-oriented subcomponent of the CAMSA and the TGMD-3 test (Menescardi et al., 2022; O'Brien et al., 2023). This is consistent with previous research in which the TGMD-3 was associated with other process-oriented tests, such as the Child FIRST (Jimenez-García et al., 2024), or the TGMD second edition (TGMD-2) was correlated with the performance criteria of two other process-oriented tests, the Get Skilled-Get Active and the Developmental Sequences, in a sample of children aged 4 to 11 years (Logan et al., 2017a). Similarly, O'Brien et al. (2023) found that when the combination of some FMS assessments criteria was compared with 7 process-oriented functional movement patterns, the latter movements were associated with the locomotor skills of the mixed FMS battery, suggesting that they may measure somewhat overlapping MC constructs. Finally, this correlation may be due to the motor skills and performance criteria of the CAMSA-SS, which are derived from the TGMD (Longmuir et al., 2017).

While both TGMD-3-MS and TGMD-3-LS were also associated with CAMSA-SS in boys, only TGMD-3-MS was associated with CAMSA-SS in girls, which may indicate a low parallelism between the locomotor skills assessed in both tests in this population. This may be due to the fact that although the skills were well matched, they are not identical in terms of the number of locomotor skills assessed and the performance criteria of the two test instruments (Lander et al., 2017). This may indicate a different locomotor construct in the girl sample. It should also be noted that there were no differences in the TGMD-3-LS means between boys and girls. It can be suggested that if a complete picture of the locomotor performance of Spanish high school girls is needed, it might be better to administer both the TGMD-3-LS subcomponent and the CAMSA circuit. However, as the TGMD-3-T correlated with the CAMSA-SS in both girls and boys, this shows that the CAMSA circuit can be a valid tool for assessing general process-oriented motor performance and FMS in Spanish high school girls (Menescardi et al., 2022), overlapping with the MC construct assessed in the TGMD-3.

Regarding TGMD-3-T and CAMSA-TS, there was a significant high correlation between both tools in the boys' sample, with TGMD-3-LS and TGMD-3-MS also being highly associated. In the literature, a significant and acceptable correlation has been shown between the TGMD-3-T and a product-oriented test such as the "Körperkoordinationstest für Kinder" (KTK) in a sample of 9 to 10 years-old Chinese boys and girls (Li et al., 2023). Logan et al. (2017a) also found that a combination of process-oriented FMS (standing long jump, hop, and throw) had a significant moderate to strong correlation with the product-oriented scores of these FMS. One possible explanation for this correlation may be the existing associations between physical fitness and motor competence (Carballo-Fazanes et al., 2022; Wu et al., 2021), where speed and agility have been shown to be related to FMS in adolescents, such that greater speed and agility performance is synonymous with better motor competence (Burton et al., 2023). In this regard, the CAMSA-TS is considered useful in assessing an individual's agility capacity due to its strong relationship with other well-stablished agility tools such as the Illinois Agility Test (Cao et al., 2020).

Conversely, in the girl's sample, the TGMD-3-T did not correlate with the CAMSA-TS, nor with any of the TGMD-3 subcomponents. This means that in this Spanish high school girls sample motor competence in FMS, as assessed by the TGMD-3, is not associated with performance on the product-oriented subtest of the CAMSA. Similarly, a study of 7 to 10 years-old girls from Iran found only weak to moderate correlations between the TGMD-3 and KTK (Khodaverdi et al., 2020). The study concluded that these low associations may indicate that different constructs of MC are being measured, possibly due to the fact that the TGMD-3 measures skills related to typical sports play while the KTK measures movement skills. The difference in associations between boys and girls may also be explained by the absence of an

FMS domain in the TGMD-3, the stability subcomponent (Logan et al., 2017b). Even though the CAMSA instrument does not reflect stability skills in the FMS being assessed, it is thought to be influenced by them, as the body control and balance required to perform the circuit correctly changes from one skill to another (Longmuir et al., 2017; Menescardi et al., 2022). Girls have been shown to better correlate their stability domain with the performance of other functional movement patterns related to human movement (O'Brien et al., 2023), and to have lower scores in the manipulative skills (Hardy et al., 2013; Longmuir et al., 2017; O'Brien et al., 2023), which was the case in this study with a significant lower performance in this last domain by girls. However, stability skills could not be measured in the TGMD-3. Thus, this may be an answer to the lack of a correlation between TGMD-3-T and CAMSA-TS for this sample, regardless of the existing association between motor competence in FMS and agility (Burton et al., 2023). The TGMD-3 may not provide a complete picture of all FMS. Future studies should assess whether the addition of the stability domain of the FMS can better correlate with performance on the CAMSA-TS for teenage girls.

Another major finding of this study is the association between TGMD-3 (total score, locomotor score, and manipulative skills score) and CAMSA-T, for both girls (moderate) and boys (high). This suggests that these tests may assess similar or overlapping MC constructs, and that total scores from both instruments may provide a similar measure of FMS. In the same vein, Stearns et al. (2019) found that CAMSA had moderate to large correlation with other process-oriented tools, the PLAYfun and PLAYbasic tests, in a similar sample of 8 to 14 years-old subjects, suggesting similar MC assessments. In addition, Lander et al. (2017) showed a strong concurrent validity between CAMSA and the Victorian FMS (process-oriented) in a sample of 34 girls with a mean age of 12.6 years old. According to all these results, and even though the purpose of the study was not to determine which test is better (only to analyze correlations), it can be suggested that CAMSA could be implemented over TGMD-3. This is due to the possible overlapping MC constructs, the influence of the TGMD on CAMSA skills and criteria leading to some similar FMS (Longmuir et al., 2017), the associations presented in this study, the combination of both process- and product-oriented measures, being less time-consuming, indirectly assessing skills that are not included in the TGMD, and being more feasible and realistic to sport and play due to its dynamic nature (Chang et al.,2021; Lander et al., 2017; Longmuir et al., 2017; Menescardi et al., 2022).

There were significant different means favoring boys for height, TGMD-3-MS, TGMD-3-T, CAMSA-TS, and CAMSA-T scores. In the case of the TGMD-3-MS, similar results have been exhibited in the literature where a global tendency towards boys' superiority in manipulative skills is being documented throughout childhood and adolescence. The main reason for this situation is typically explained by sociological factors of gender influencing motor experience in play and sports activities, and the skills assessed being related to sports play, biasing some MC assessments towards more experienced boys in sports involving ball and object control and manipulation (Hardy et al., 2012; Hardy et al., 2013; Khodaverdi et al., 2020; Longmuir et al., 2017; O'Brien et al., 2023; Philpott et al., 2023). The TGMD-3-T is then influenced by a significantly higher score on the TGMD-MS, as the TGMD-LS did not differ between samples, and the sum of both subcomponents results in a higher TGMD-3-T for boys. Again, the sports and activities experienced by boys may create this imbalance in MC (Hardy et al., 2013). CAMSA-TS also showed higher means for boys, as in other product-oriented assessments for youth (Li et al., 2023). There is also evidence of better CAMSA-TS performance in Spanish boys compared to girls (Menescardi et al., 2022). Considering the age range of this sample (12 to 15 years old), it is likely that this product-oriented difference occurred due to the biological changes experienced near peak height velocity (PHV), which favor boys in some physical performances (Hardy et al., 2012; Li et al., 2023; Lloyd et al., 2014). Finally, CAMSA-T, similar to TGMD-3-T, shows greater performance for boys. The already higher score in CAMSA-TS makes the sum of both CAMSA subcomponents unbalanced towards boys. Evidence for a better CAMSA total score for boys has also been described in the literature (Longmuir et al., 2017; Menescardi et al., 2022).

Finally, although it was not the main objective of the study, the MC results presented in both instruments and sexes are worrying when compared with other values in the literature, showing mean scores below the 50th percentile for 12 years old in CAMSA (Longmuir et al., 2017), and with the TGMD-3 having the worst MC results (Webster and Ulrich, 2017). In general, these below desirable MC scores are in line with international trends for FMS in children and adolescents, suggesting that huge efforts are still

needed to reverse this situation for the benefit of population health and well-being (Bolger et al., 2021; Hardy et al., 2013; Lubans et al., 2010).

This study is not without limitations. First of all, the sample enrolled was composed of typically developing children in whom any assessment of biological maturity was made. These 82 Spanish high school students, with a mean age of 12.43±0.77 years, may not be the most representative of the 12- to 15-year-old population. Also, if we compare the sample size with other studies, it may not be large enough to represent a heterogenous population, which could explain some conflicting results between the girls' and boys' differences in tests associations. Also, even though CAMSA may have some strengths over TGMD-3 for overall MC assessment (hybrid-oriented), the tool lacks measuring other aspects and skills that influence MC. As mentioned above, comparing the ability of both instruments to classify subjects in terms of their motor competence was not an aim of this study; future projects could compare the sensitivity of these instruments to classify MC. Although studies can be found in the literature for older age groups than those for which the tools were originally designed, it is important to note that TGMD-3 is mainly for 3 to 10-11 years old (Carballo-Fazanes et al., 2021; Ulrich, 2019), and CAMSA for 8 to 12 years old (Longmuir et al., 2017).

## Conclusions

The main findings of the study were: (I) for boys, all variables (including test scores and subcomponents) showed significant associations with each other with a high correlation, except for the TGMD-3-MS and CAMSA-SS, where the correlation was moderate, (II) significant associations were found between TGMD-3-T and CAMSA-T scores for both girls (moderate) and boys (high), indicating a correlation between the instruments that suggests an overlapping MC construct, and (III) boys had a significantly higher mean on some subcomponents (TGMD-3-MS, CAMSA-TS) and both tests total scores (TGMD-3-T, CAMSA-T). Concluding, significant associations were found for both boys and girls, being less present and weaker for the last ones, and the significant associations found between test total scores suggest that both may measure similar MC constructs. Due to the strengths of CAMSA over TGMD-3 mentioned before, authors suggest that CAMSA could be implemented over TGMD-3. The limitations and results of this study advocate caution when using the CAMSA test to assess specific FMS domains in Spanish teenage girls.

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