Reliability Levels of Motor Competence In Youth Athletes

Ana Filipa Silva
Health Sciences and Human Development (CIDESD)

Hadi Nobari (hadi.nobari1@gmail.com)
University of Mohaghegh Ardabili

Georgian Badicu
Transilvania University of Brasov

Halil Ibrahim Ceylan
Ataturk University

Ricardo Lima
Health Sciences and Human Development (CIDESD)

Maria João Lagoa
Health Sciences and Human Development (CIDESD)

Carlos Luz
Instituto Politécnico de Lisboa

Filipe Manuel Clemente
Rua Escola Industrial e Comercial de Nun’Alvares

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Abstract

This study aimed to analyze the reliability of the tests included in the motor competence assessment (MCA) battery and compare the effects of the number of trials per test. Thirty female volleyball players (14.6±1.3 years of age) were tested. The participants performed two or three trials of each test. Intra-class correlation (ICC) was calculated, and a paired sample t-test analyzed the variations between trials (1st vs. 2nd vs. 3rd). Results revealed a significant difference between the first and the second trials for jumping sideways [t(29)=-4.108, p<0.01], standing long jump [t(29)=-3.643, p<0.01], and shuttle run [t(29)=-3.139, p<0.01]. No significant result was registered in the shifting platforms, ball throwing and kicking between the first and second trials. Hence, any difference was recorded between the second and third trial. High ICC values were registered among the three repetitions of shuttle run, ball throwing, and ball kicking, while almost perfect values were recorded for the standing long jump. Nevertheless, there seems to be a learning effect between the first and the second repetition—no differences were registered only considering the two manipulative tests. In conclusion, except for jumping sideways, the MCA tests are reliable and only need to be performed two times instead of three.

Background

Motor competence (MC), which is defined as a competence that facilitate the development of new skills in a broad range of locomotor, stability and manipulative gross motor skills [1], has been studied across the last decade. This ability that enables the person to be proficient on a wide range of motor acts or skills [2], could thus benefits sports performance. In fact, in childhood and adolescence, MC has been associated with an increase of quality of life over time, namely cardiovascular fitness, muscular endurance, strength, physical activity and perceived competence [3–9]. To reinforce the relevance of assessing the motor competence over time, is known that children increase the MC during growth, but some of them decrease their fitness level [3]. Thus, it is important to identify and support the young individuals with low performance in the MC to prevent the increase the deficit regarding physical fitness in the future [8].

Despite knowing that the MC and physical activity develops independently of each other in childhood [10], MC stills considered an important independent predictor of physical activity and fitness levels [11]. According to the facts mentioned above, were created gross motor assessment tools that could identify and evaluate motor difficulties in childhood [12]. At this respect, in a theoretical construct, MC is subdivided into three components of proficiency, such as stability (dynamic and static balance), locomotor (galloping, leaping or vertical and horizontal jump) and manipulative (catching, throwing or kicking) [13].

Regarding the components and the necessity to have valid and reliable tests to assess and quantify levels of MC, and consequently, identify skill deficiencies, and determine the effectiveness of motor skill intervention [14], Luz et al. [15] developed a quantitative model (Motor Competence Assessment - MCA) that could be applicable in research, education and clinical contexts. This developed model is represented
by six motor tasks, grouped into the three components of the MC (manipulative, locomotor and stability) and it was considered the first assessment tool designed to evaluate, at the same time and along the lifespan, the three components referred previously [16]. Accordingly, in a recent study from Rodrigues et al. [16], it was presented the MCA normative values, which allow to evaluate MC from 3 to 23 years of age according to sex and age, which realize how important is to assess the MC since young ages to adulthood as well as how linked the MC with the health related factors are [17].

Considering that MCA emerged from different, although the most used protocols and instruments in the motor development literature [15], a normalization of how many repetitions is needed to have reliable results is still missing. In fact, some protocols describe two and other three trials to perform the tests. Moreover, despite normative values represent different range of ages, researchers analyzing the MC, using the MCA battery, was made from sport context. This fact, lead us to inquire about the applicability and the reliability of the MCA in young athletes. Therefore, to answer the previous reflection, this study aimed to analyze the reliability of the tests included in the MCA battery in young athletes and compare the effects of the number of trials per test.

**Methods**

**Participants**

Thirty female volleyball youth players voluntarily participated in this study. They were included in three different levels of competition (13 initiates, 13 juniors and 4 juniors) aged between 12 and 16 (14.6±1.3) years old. All players included normally had four training sessions and one official match per week. The eligibility criteria for being considered in this study were as follow: (i) absence of injuries or illness in the last four consecutive weeks; (ii) never having experienced the MCA battery tests. In advance, parents signed an informed consent giving authorization for their daughters to participate in the study. Before the assessments, all players were informed about study procedures. The study was approved by the local University and followed the ethical standards of the Declaration of Helsinki for the study of humans.

**Motor Competence Assessment (MCA)**

The MCA battery includes six tests [15], two for each category: stability, locomotor, and manipulative. All tests are quantitative (product-oriented) motor tests without a marked developmental (age) ceiling effect, and of feasible execution. The tests were applied in the facilities where the athletes normally train. They performed all the tests in small groups (approximately 5 athletes for each task). The examiner was previously trained in administering all tests.

The calculation of the MC and the percentile was performed based on the score of the stability, manipulative, and locomotion tests in accordance with previous studies [18].

**Stability tests**
This category included lateral jumps and shifting platforms. In the first, the performer should jump sideways with two feet together over a wooden beam as fast as possible for 15s. In each correct jump a score of 1 point is attributed. In the second test, the subject should move sideways for 20s using two wooden platforms (25cm x 25cm x 2cm). Each successful transfer from one platform to the other was scored with two points (one point for each step).

**Locomotor tests**

Standing long jump and 10 m shuttle run made part of this category. In the standing long jump, the subject should jump with both feet simultaneously as far as possible. While in the 10 m shuttle run, the performer must run at maximal speed to a line placed 10 meters apart, picking up a block of wood, running back and placing it on or beyond the starting line. Then running back to retrieve the second block and carry it back across the finish line.

**Manipulative tests**

In this category the ball kicking velocity and the ball throwing velocity were included. With a ball of baseball (circumference: 22.86cm; weight: 142g), the performer must throw the ball at a maximum speed against a wall using an overarm action. Likewise, kicking velocity test implies kicking a ball of football (circumference: 64cm, weight: 350g) at maximal speed against a Wall.

**Statistical Analysis**

After checking the assumptions of normality and homogeneity of the samples, the intra-class correlation (ICC) test results were calculated, and a paired sample t-test was conducted to analyze variations between trials (1st vs. 2nd vs. 3rd). All statistical analyses were carried out using SPSS Version 27.0 (SPSS Inc., Chicago, IL, USA) and p-values of < 0.05 were considered statistically significant.

**Results**

Table 1 summarizes the descriptive statistics for each test of the MCA batterie. Significant differences were found between the first and the second trials for jumping sideways, standing long jump and shuttle run. Meanwhile, the shifting platforms presented no significant difference between the first and second trials. Also, no significant differences were found between the second and third trials in any of the tests. Finally, no significant differences between ball throwing and ball kicking in any comparison (1st vs. 2nd vs. 3rd) (p>0.05).
Table 1
Mean and standard deviation for each trial in the six MCA tests

| MCA Tests            | Trial 1     | Trial 2     | Trial 3     | p (T2-T1) | p (T3-T2) |
|----------------------|-------------|-------------|-------------|-----------|-----------|
| lateral jumps        | 16.41±6.47  | 18.47±7.32  | -           | <0.01*    | -         |
| shifting platforms   | 45.70±4.92  | 46.10±5.40  | -           | 0.57      | -         |
| standing long jump   | 1.51±0.17   | 1.56±0.15   | 1.57±0.17   | <0.01*    | 0.17      |
| 10 m shuttle run     | 11.23±0.50  | 11.59±0.82  | 11.76±0.78  | <0.05*    | 0.11      |
| ball kicking velocity| 47.13±10.12 | 48.65±11.02 | 50.90±22.38 | 0.39      | 0.05      |
| ball throwing velocity| 54.07±11.18| 54.95±8.06  | 55.30±8.08  | 0.48      | 0.74      |

Table 1 – Insert here

Regarding the reliability of the implemented tests, Table 2 presents the intraclass correlation, as well as its variation, and the coefficient of variation for each test considering each of the 3 trials.

Table 2
The mean, minimum and maximum Intra-class correlation (ICC) for each test, as well as the coefficient of variation (%CV) for each trial

| MCA Tests            | ICC  | %CV   |
|----------------------|------|-------|
|                      | Mean | Minimum | Maximum | Trial 1 | Trial 2 | Trial 3 |
| lateral jumps        | 0.987| 0.964  | 0.995    | 39.43   | 39.61   | -       |
| shifting platforms   | 0.842| 0.668  | 0.925    | 10.77   | 11.72   | -       |
| standing long jump   | 0.956| 0.919  | 0.978    | 11.19   | 9.81    | 10.56   |
| 10 m shuttle run     | 0.821| 0.672  | 0.909    | 4.47    | 7.07    | 6.66    |
| ball kicking velocity| 0.909| 0.832  | 0.953    | 21.47   | 22.66   | 22.35   |
| ball throwing velocity| 0.847| 0.719  | 0.912    | 20.68   | 14.67   | 14.62   |

Table 2 – Insert here

**Discussion**

Motor competence in fundamental motor skills is known to be positively related to youth physical activity levels, physical fitness across the childhood and adolescence, and cause the positive health outcomes throughout the lifecycle [10, 19, 20]. Further, it is very important in learning a sports motor, and performing sport-specific motor skills in team-athletes [20]. Recent study demonstrated that athletes with higher motor competence level in motor skills learned complex motor skills more easily than those with lower motor competence in motor skills [21]. Another study indicated that low motor competence in motor skills
could be a barrier to achieve additional and transitional sports skills, independent of the practice schedule [20]. Regarding the studies mentioned above, it is one of the most important purpose of our study to determine the level of motor competence of young female volleyball players through the MCA tests battery, and to determine the reliability of these tests in this population. Moreover, the number of test trials could be important to the outcome of the performance on different motor skill tests [22]. While measuring performance with too few trials does not reflect the real performance of the individual, measuring performance with too many trials may also cause fatigue [23]. Therefore, it is important to understand how many trials (minimum and the most effective one) we can take to ensure the quality, efficacy, and reliability of the results in the MCA tests battery. Based on this, the second aim of our study is to compare the effects of the number of trials for each test in the MCA battery. The present study revealed that there was a significant difference between the first and second trial of the lateral jumps, standing long jump and 10 m shuttle run tests, while there was no significant difference between the two trials in all the remaining tests (shifting platforms, ball kicking and throwing velocity). No significant difference was noted between the second and third trial in any of the six tests. Furthermore, the level of correlation between two or three trials was high in all of these tests (ICC=0.821-0.987, good-excellent), however, the CV% value was acceptable in terms of reliability in all tests except “lateral jumps”.

The use of intra-class correlation coefficients (ICCs) in reporting intra-rater, inter-rater, and test-retest reliability is considered a "gold standard" method [14]. Regarding the motor competence tests, the present study showed that ICC values of reliability range was 0.821-0.987 (good-excellent) for six tests in three sub-dimensions. This result is in line with recent study that emphasized the ICCs for tests in MCA battery in preschoolers ranged between 0.77 and 0.96, which indicates an excellent reliability [24]. It was previously stated that the ICCs between the first and second trial for the Athletic Skills Track Test was 0.881 [25]. In the study of Rodrigues et al. [3] in which they showed the normative values of MCA between the ages of 3 and 23, they observed that locomotor, stability, and manipulative tests in MCA battery had excellent reliability (>0.950). Similarly, another study found that ICC values between two trials ranged from 0.75 to 0.94 in four different motor tasks (placing and building bricks related to manual dexterity; heel to toe walking walking/running in slopes related to dynamic balance) in Motor Competence Test [26]. Additionally, Barnett et al. [27] indicated that the ICC for the object control subtest from the Test of Gross Motor Development-2 (TGMD-2) were excellent (ICC=0.93), except the “catch” which showed good reliability (ICC=0.71) between two trials in children. In current study, it was found that the results of the reliability for ICC values were similar to the studies in the literature. According to the ICC classification made by Koo et al. [28], good and excellent reliability scores were found between two or three trials for locomotor, stability, and manipulative tests in MCA battery in our study. In another study was carried out by Portney and Watkin [29] noted that the reliability coefficients ICC below 0.50 indicate poor reliability, from 0.50 to 0.75 represent moderate reliability, and values above 0.75 suggest high reliability. Accordingly, we can say that all tests in MCA battery performed in the form of two or three trials in our study showed high reliability.

The CV% (absolute reliability) analysis ensures information considering within-trial variability expressed as a percentage. i.e. it evaluates the stability of a measurement across repeated trials [30]. The coefficient
of variation explained in the mean score percentage and a CV% below 10% are considered acceptable in terms of reliability [31]. To interpret CV% in our study, we accepted the criteria developed by Atkinson and Nevill [32], the authors reported that CV% of <10% was considered excellent, 10–20% medium, implying good precision, 20–30% high, meaning low precision and >30% was considered very high, indicating very low precision. The present study revealed that shifting platforms in two trials (CV%10.77-11.72), standing long jump (CV%9.81-11.19) and 10 m shuttle run (CV%4.47-7.07) in three trials showed excellent and moderate stability. Also, lateral jumps by ICC value appear reliable, but it is important to note that there are large individual differences in lateral jumps performance variability in both the first and second trial among players in the group (CV%: 39.43-39.61). Furthermore, the current study indicated that although the CV was over 20% on all three trials for the ball kicking velocity, and only the first trial for the ball throwing velocity, it was still considered acceptable level [32]. This result was supported by a previous study that demonstrated that CV% value of the jumping hope left performance in Performance and Fitness Test Battery was found to be 21%, and this value was stated to be at an acceptable level [33].

The present study revealed that significant differences were found between the first and the second trials for lateral jumps, standing long jump and 10 m shuttle run test. Moreover, in our study, no significant differences were found in the shifting platforms, ball throwing and kicking tests between the first and second trials. These findings indicate that it is sufficient to perform MCA test battery twice instead of three times but using familiarization session is recommended to minimize the learning effect and achieve for reliability and quality results in lateral jumps, standing long jump, 10 m shuttle run test. The familiarization of the assessed participants with the test procedures is a critical factor that can affect reliability in a motor skill tests such as TGMD-2. It can be suggested that participants need to become familiar with the lateral jumps, standing long jump, 10 m shuttle run test protocols with at least one trial before the measurement starts [22, 34]. As in this study, recent studies conducted on children and adolescents showed that stability tests (lateral jumps and shifting platform) were applied two times, while locomotor and manipulative tests (standing long jump, 10 m shuttle run, ball kicking and throwing velocity) were performed three times in the MCA test battery [15, 16, 18]. In the literature, scoring of performance in standardized test batteries varied according to a wide variety of procedures. Some studies used only best out of two trials with allowing for familiarization session in some tests such as the Peabody Developmental Motor Scales [22], and Performance-Fitness (PERF-FIT) test battery [33], and other studies used at least two trials (best or sum of two trials) in tests such as Movement Assessment Battery for Children, the Test of Gross Motor Development (TGMD-2) [27, 35], and Agility and Skill Test (sum of three trials) for soccer players [36]. Wiepert and Mercer [22] also noted that the best and quality performance results for the Peabody Developmental Motor Scales was observed in three trials compared to the best of two trials. Moreover, MCA test battery and TGMD-2 have a moderately significant correlation; this indicates that the two batteries partially measure similar aspects of motor competence [24]. Our results in all six motor tests were similar to previous studies that reported that second trial was better than the first trial for object control subtest from the TGMD-2 [27], and also Athletic Skills Track test [25], the authors suggested that the use of two trials for these tests gave reliable results. Similarly, another study indicated that performing each of the 12 gross motor skills-locomotor and object control-in
the TGMD-2 test twice in Kindergarten children had good and excellent reliability. Coppens et al. [19] were tested the validity of motor competence test with KTK (Körperkoordinationstest für Kinder) in children and adolescents aged 6 to 19 years. As a result of applying the jumping sideways and moving sideways tests twice, and the balancing backwards test three times in this battery, the authors obtained the valid and reliable results. Additionally, Williams et al. [37] reported that reliability and validity (R=0.88 to 0.90) were similar for 2 and 4 four trials for CHAMPS Motor Skill Protocol in preschool children. Considering the above-mentioned studies, we can say that mostly at least two trials and in some cases two trials + practice trials were used before different motor skill tests. This is in line with the results of our study. However, the reason of the differences in the number of trials before the motor skill tests in studies in literature may be related to the motor skill test applied, the difficulty/complexity of the motor skill test, the characteristics of the tested population, and the characteristics of the sports branches.

The present study has some limitations. Firstly, this study was carried out only in female and amateur athletes. In future studies, the study can be repeated in male and elite athletes. Second, the biological maturation or menstrual cycle periods of the participants were not evaluated. Considering the relationship of physical activity to motor competence, the present study showed that reliable results were obtained in all tests in MCA battery with a small number of trials (two) in studies conducted on athletes compared to studies performed in children and adolescents. This may be related to the fact that athletes have more consistent motor control and motor performance. In future studies, the reliability, discrimination and validity of gender (male, female) and sport specific versions of the wide range of motor competence tests, including MCA battery could be evaluated in detail.

**Conclusions**

To our knowledge, this is the first study to analyze the reliability of tests in the MCA battery in volleyball players, and to compare the number of trials for each test. The present study revealed that tests in MCA battery except lateral jumps are reliable test that can be used to assess fundamental movements skills of 12 to 16-year youth volleyball players in a scientific and practical settings. Moreover, tests in MCA battery only need to be performed two times instead of three in athlete's population. However, it is recommended to use a familiarization session (only one trial) in order to minimize the learning effect and obtain more reliable results from lateral jumps, standing long jump, and 10 m shuttle run test. Lastly, MCA battery can also be preferred by coaches and practitioners as a beneficial and practical tool for longitudinal monitoring of motor skills and talent selection, especially in the sports environment.

**Abbreviations**

MCA - motor competence assessment; ICC - Intra-class correlation

**Declarations**
Ethics approval and consent to participate: The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Institutional Review Board (or Ethics Committee) of the Polytechnic Institute of Viana do Castelo School of Sport and Leisure. Informed consent was obtained from all subjects involved in the study.

Consent for publication: Not applicable.

Competing interests: The authors declare that they have no competing interests

Availability of Data and Materials: All data generated or analyzed during this study are included in this published article and its supplementary information files (https://figshare.com/articles/dataset/DATA_BMC_xlsx/19103156).

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