Sports Science

The influence of familiarization on performance testing of young soccer players

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Abstract - Aim To investigate the effects of the familiarization trials to minimize the impact of intra-subject variation on the performance evaluation of soccer athletes. **Methods:** Twenty-five players from an under-19 soccer team were submitted to three performance tests: vertical jump test, test of change-of-direction (Agility T-test) and running anaerobic sprint test (RAST). The three performance tests were repeated on three subsequent days as familiarization sessions until the fourth/last session. Familiarization sessions were performed once a day under the same conditions. For the analyses, the coefficient of variation intra-subjects was calculated for each session. For the comparison between sessions, ANOVA for repeated measures, delta percentage, intraclass correlation coefficients, standard error of measurement, and minimal difference were used. **Results:** The results demonstrated that tests with less complexity, such as the vertical jump, do not require previous familiarization sessions. In contrast, tests composed of a greater number of motor actions, such as acceleration, deceleration, and change of direction, like the agility T-test, require at least three familiarization sessions before testing. Furthermore, when maximal effort anaerobic power is tested, such as the repeated running sprint test, motivation must be considered. **Conclusion:** The familiarization process is important to determine the performance of young soccer players, especially performance activities with more complex tasks that demand greater motor organization.

Keywords: football, learning effects, athletic performance, fitness assessment, athletes.

Introduction

Speed, change of directions, and power are important components of success in soccer. Therefore, evaluations of these components are performed throughout the season to determine the athletes' physical fitness and performance condition[1]. The athletes' evaluation success is dependent on the selection of the test and on the assumption that adequate levels of reliability and validity are present[2-4]. It is also important to analyze the veracity of the data, referring to the accuracy, quality, relevance, uncertainty, reliability, and predictive values[5,6]. Intra-subject variation has been deemed one of the most important reliability measurements to be controlled, as it may influence the results and mask significant changes in performance[7]. In this regard, reducing intra-subject variation is essential for performance evaluation.

The previous execution of a motor task to reduce intra-subject variation is known as familiarization[8]. The familiarization process or previous experience with the measuring instrument can overcome the effect of learning and improve the reliability of measurements[9,10]. Authors have demonstrated that familiarization procedures minimize reliability errors when measuring muscular strength, jump power, and anaerobic capacity in several conditions[3,11-14] and constitute an important factor to be considered when testing performance[7]. Indeed, familiarization sessions allow subjects to perform practice trials to ensure that performance changes are not the result of learning effects[12]. Notably, the complexity of the motor task may significantly impact the familiarization process; specifically, the more complex the task is, more familiarization sessions are required[13]. Thus, it is important to establish the appropriate number of familiarization sessions that minimize intra-subject variation during performance testing.

Thus, this study aimed to investigate the number of familiarization sessions required to establish high degrees of test-retest reliability using specific soccer tests with different degrees of complexity for performance measurement of young soccer players. We hypothesized that, the more complex the test is, more familiarization sessions are required to reach an optimal test-retest reliability. This study is relevant considering that most of the literature and coaches do not consider the familiarization process when testing the performance of young soccer players. However, the familiarization process may ensure optimal performance testing in this population.

Methods

Study design

The study was conducted over four consecutive days. On the first day, after a comprehensive explanation of the procedures, athletes completed the performance tests. The three performance tests were repeated on subsequent days. The athletes were instructed not to exercise on the weekend prior to the testing week. Familiarization sessions were performed daily under the same conditions (same time of day and location, similar temperature, and relative humidity).

Participants

The participants in this study were 25 healthy and trained male soccer players from the under-19 category of the same football team. All players competed in the second division of the Paraná state championship in south Brazil. The mean age of the players was 16.9 ± 0.3 years, body mass 70.2 ± 9.0 kg, and height 176.0 ± 7.0 cm. The athletes were free of any musculoskeletal injuries that could disrupt the performance of the tests. The participants' training routine included two hours a day of practice in the soccer field, five to six days a week, and one hour of resistance exercise training three times a week at the gym. The athletes were evaluated during preparation season, without competitive matches that could cause physiological wear to the players. The study was approved by the local Research Ethics Board Committee (approval #1.428.377) and all volunteers signed an informed consent form prior to the start of the study procedures. None of the participants reported the use of tobacco products or the ingestion of medication or dietary supplements in the two months prior to the start of the study.

Measures

For the analysis of the familiarization, vertical jump test, agility T-test, and running anaerobic sprint test (RAST) were used.

In the vertical jump test, the players performed three jumps using the counter movement jump (CMJ) technique, which consists of standing with the lower limbs in full extension and performing a half-flexion of the knees (90 degrees), followed by a vertical jump, as described by Komi and Bosco[15], with assistance from the upper limbs as used by Moreira et al.,[16] in soccer players. The jumps were performed with a two-minute interval between each jump, and the jumping height was measured using a jump platform (Smartspeed®), calculated by the time of flight. Three attempts were performed, and the highest value was considered the performance parameter.

The agility T-test was performed as described by Guincho[17]. Four cones were placed in a T-shape with a five-meter distance between each cone. The athletes were required to travel the circuit in the shortest time possible, two attempts being made, with a two-minute interval between each attempt. The shortest time to complete the circuit was recorded and considered as the agility T-test performance parameter.

The RAST power test was performed as previously proposed by Zacharogiannis et al.,[18]. Giving the characteristic of the test, the RAST was performed only once on each day of analysis. The athletes were encouraged to complete six running attempts of a 35-meter distance, with a 10-second interval between each sprint. The time to complete each attempt was recorded. The cumulative sprint time (seconds) to complete the six runs of 35 meters was used as the anaerobic performance. For the RAST and agility T-tests, a photo cell system (Hidrofit®) was used. The sensors were aligned to the start and finish lines and positioned one meter above the ground. The recovery time were five minutes between the CMJ and the agility T-test and 15 min between the agility T-test and the RAST.

In all tests, the procedures, routes, and guidance were carried out by means of demonstration and explanation (verbal instruction) of the process in advance. All tests were performed during four consecutive days, with a 24-h interval between them. Even though the tests were always performed in the same sequence (*i.e.*, CMJ, Agility T-test, and RAST), the order of the athletes to perform each test was randomly chosen over the four days of testing. The participants were allowed to ingest water *ad libitum* during the tests and performed a standardized warmup of approximately 15 min, consisting of stretching and light jogging. The athletes maintained their preparation season training routine, after the tests, during the study period, which consisted of a reduced load intensity, prioritizing technical and tactical field training.

Statistical analysis

Data is presented as mean ± standard deviation. The normality of data was tested using the Shapiro-Wilk test. The coefficient of variation (CV) intra-subject (*i.e.*, variation between attempts in the same test) was calculated for vertical jump and agility T-test for each day through the ratio of the standard deviation to the mean, considered small when < 10%[19]. The comparisons between the different assessment sessions were performed through one-way analysis of variance (ANOVA) for repeated measures. The Bonferroni post-hoc test was used to identify the specific differences at the moments when the F values were found to be higher than the established statistical significance criterion ($P < 0.05$). The delta percentage (Δ%) between different assessment sessions was calculated using Δ% = A − B/A x 100. The eta partial squared was calculated as the effect size.

The reliability statistics were calculated between consecutive testing sessions. The estimation of the intraclass correlation coefficient (ICC) agreement model 2,1 and their respective confidence intervals (95% CI) were calculated. ICC values lower than 0.50 were considered as low reproducibility, values between 0.50 and 0.75 as moderate reproducibility, values between 0.75 and 0.90 as good reproducibility, and values above 0.90 as excellent reproducibility[20]. The measurement errors were estimated as the standard error of the measurement (SEM)[21], absolute values calculated by the square root of the mean square error term from the ANOVA e relative values calculated by ratio between SEM and average result between sessions. SEM results lower than 5% have been suggested and classified as good (SEM ≤ 5%), moderate (SEM = 5.0-9.9%), or poor (SEM ≥ 10%)[5]. Using the SEM, the minimal difference (MD) was calculated using $MD = 1.96 \pm \sqrt{2} \times SEM$. MD reflects the magnitude of change necessary to provide confidence that a change is not the result of random variation or measurement error. For MD no reference values were found in the literature.

The bias and limit of agreement between the evaluation sessions were analyzed through the procedures proposed by Bland and Altman[22]. Data were tabulated and analyzed in the GraphPad Prism 6 and SPSS 22.0 statistical packages.

The athletes' familiarization with each performance test was considered when low intra-subject variation was detected using the following criteria: 1) no significant changes in subsequent performance were detected using ANOVA followed by Bonferroni post-hoc test; 2) the ICC was higher than 0.75 (good and excellent reproducibility); and 3) the Bland-Altman plot demonstrated low or no bias. The SEM, MD, Delta percentage values and the effect size were also analyzed in the comparison between sessions.

Results

The results of effect size, SEM, MD and ICC (IC 95%) between sessions are presented in Table 1.

Jump performance tests over the familiarization days are presented in Figure 1. The mean intra-subject coefficient of variation was less than 5% in all session (Session 1 = 2.5 ± 1.9%; session 2 = 2.04 ± 1.33%; session 3 = 2.54 ± 1.44%; session 4 = 2.53 ± 1.9%). The effect size, and MD values were considered small between sessions, the SEM values were moderate between session 1-2 and small between sessions 2-3 and sessions 3-4 (Table 1). ANOVA demonstrated no significant differences among any familiarization sessions. Delta percentage (Figure 1) and intraclass correlation coefficients (Table 1) presented a minimal range: 0.72 and 0.93 (CI 95% from 0.84 to 0.96) between familiarization sessions 1-2, respectively. Therefore, the results demonstrated no need for familiarization sessions when testing vertical jumping. The Bland-Altman plot confirmed low bias for jumping test performance (Figure 1).

For the agility T-test, the mean intra-subject coefficient of variation was less than 5% in all session (Session 1 = 3.19 ± 2.95 %; session 2 = 2.80 ± 2.7 %; session 3 = 2.0 ± 1.53 %; session 4 = 2.0 ± 1.53 %).

Table 1 - Results of effect size, standard error of measurement (SEM), minimum difference (MD), intraclass correlation coefficient (ICC) between sessions.

	Effect size (partial eta squared)	SEM absolute (relative %)	MD	ICC (IC 95%)
Vertical Jump (cm)				
Session 1-2	0.100	2.162 (5.0%)	5.99	0.93 (0.84-0.96)
Session 2-3	0.141	1.399 (3.2%)	3.88	0.96 (0.92-0.98)
Session 3-4	0.006	1.790 (4.0%)	4.96	0.80 (0.89-0.97)
Agility T-Test (sec)				
Session 1-2	0.506	0.721 (7.5%)	2.00	0.68 (-0.31-0.88)
Session 2-3	0.461	0.173 (1.8%)	0.48	0.88 (0.43-0.96)
Session 3-4	0.001	0.217 (2.3%)	0.60	0.89 (0.77-0.95)
RAST (sec)				
Session 1-2	0.770	0.497 (1.5%)	1.38	0.83 (-0.17-0.92)
Session 2-3	0.005	0.764 (2.3%)	2.12	0.92 (0.82-0.96)
Session 3-4	0.530	0.582 (1.7%)	1.61	0.92 (0.49-0.97)

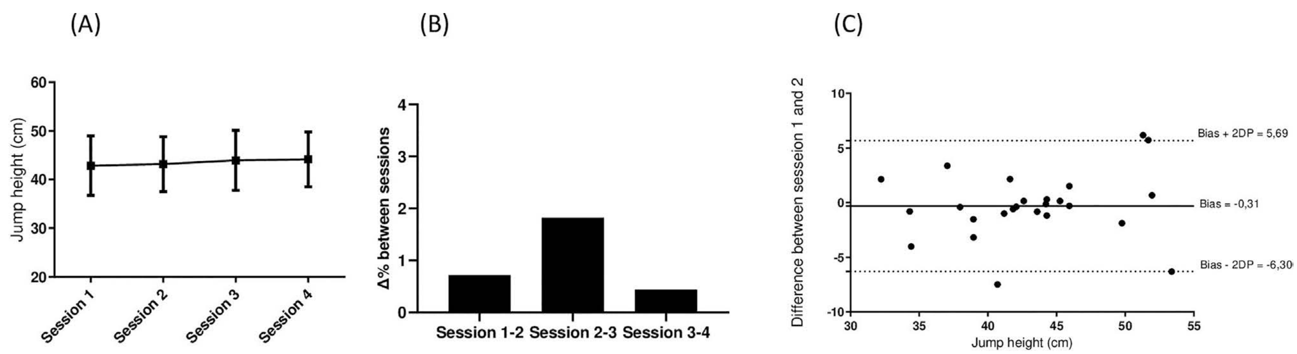

Figure 1 - Vertical jumping performance over the familiarization week (A); delta percentage between familiarization sessions (B) and *Bland-Altman* plot of familiarization sessions one and two, when minimal intra-subject variation occurred (C).

The effect size was considered moderate between sessions 1-2 and sessions 2-3 and small between sessions 3-4; SEM was moderate between sessions 1-2, and small between sessions 2-3 and sessions 3-4, the MD was considered small between the sessions (Table 1). Statistical analysis performed by ANOVA demonstrated a significant elevation in change-of-direction performance (reduced time to complete the test) from familiarization sessions one to three, with no significant differences between familiarization sessions three and four. The two first familiarization sessions also demonstrated a slightly elevated delta percentage (-3.3%) and a moderate intraclass correlation coefficient (0.68, CI 95% from -0.03 to 0.88). In contrast, change-of-direction performance demonstrated a small delta percentage (0.1%) and good reproducibility (intraclass correlation coefficient of 0.87, CI 95% from 0.45 a 0.95) between the third and fourth familiarization sessions. Therefore, we may affirm that, despite the variation between the first two familiarization sessions, change-of-direction performance stabilized between the final two. The Bland-Altman plot demonstrated low bias for the agility T-test test performance between familiarization sessions (Figure 2).

The RAST performance is presented in Figure 3. The effect size was moderate between sessions 1-2, small between sessions 2-3 and moderate between session 3-4, the SEM and MD was small between the sessions (Table 1). ANOVA demonstrated a smaller cumulative time for the RAST during the second and third familiarization sessions when compared to the first; RAST performance returned to basal levels after four familiarization sessions. RAST also demonstrated a small delta percentage between the second and third (-0.22%) familiarization sessions, however, it was elevated between both sessions one and two (-3.76%) and three and four (2.67%). In addition, RAST demonstrated a good to excellent intraclass correlation coefficient (sessions one and two 0.83 CI 95% from -0.17 to 0.92; sessions two and three 0.92 CI 95% from 0.82 to 0.96; sessions three and four 0.92 CI 95% from 0.49 to 0.97).

Discussion

Based on our results, our main finding is that tests with less complexity, such as the vertical jump, do not seem to require familiarization before testing. In contrast, tests that require a greater number of motor actions, such

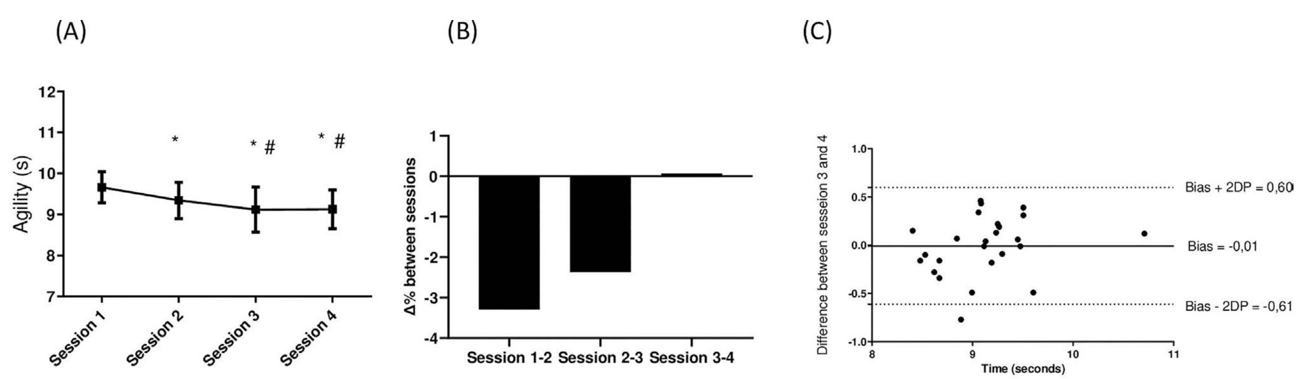

Figure 2 - Agility T test performance over the familiarization week (A); delta percentage between familiarization sessions (B) and *Bland-Altman* plot of familiarization sessions three and four, when minimal intra-subject variation occurred (C). *Indicates significant difference from session one, # Indicates significant difference from session two by ANOVA followed by Bonferroni post-hoc test $P < 0.05$.

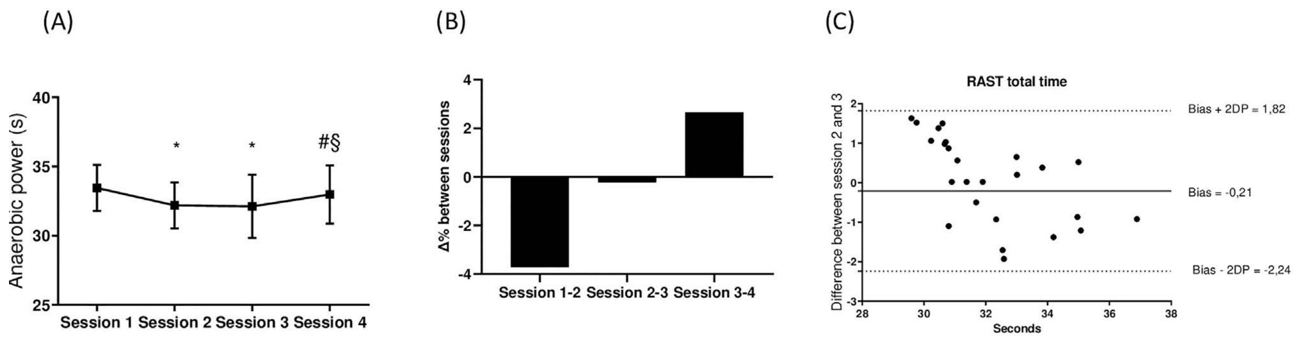

Figure 3 - Running anaerobic performance over the familiarization week (A); delta percentage between familiarization sessions (B) and *Bland-Altman* plot of familiarization sessions two and three, when minimal intra-subject variation occurred (C). *Indicates significant difference from session one, # Indicates significant difference from session two, § Indicates significant difference from session three by ANOVA followed by Bonferroni post-hoc test $P < 0.05$.

as running multiple sprints and those that require greater complexity and organization (acceleration, deceleration, and change of direction), such as in the agility T-test, require familiarization sessions before testing. Taking all the results together, the need for familiarization is evident when the task to be tested reaches a certain degree of complexity.

The vertical jump is a commonly used movement in numerous sports modalities, including soccer[16,23]. For this reason, several authors have tested the validity and reliability of instruments that evaluate jump height[24,25]. Our results demonstrated no significant vertical jump performance with coefficient of variations and intraclass correlation coefficient presented a minimal range, as well, Bland Altman plot confirmed low bias for jumping test performed. Studies conducted by Moir et al.[12,26] and Loturco et al.[27] demonstrated similar results to ours, as a small intra-variation between vertical jump trials was observed. Arteaga et al.[28] also demonstrated no need for familiarization sessions when testing vertical jumping, having used six separate test sessions. Thus, there seems to be no need for previous familiarization sessions to determine jumping power in young soccer players. The lack of necessity for familiarization sessions in the jump test can be attributed to the lack of complexity in the motor execution of the movement[28].

Considering that the familiarization process is associated with the level of complexity of the execution techniques and number of motor actions involved[29], it seems paradoxical that the agility T-test needed more familiarization sessions than the RAST performance test. RAST is composed of a one-direction multiple sprints running test, with no directional changes or fast decisions needed. On the other hand, the agility T-test involves acceleration, deceleration, and change of direction, a greater number of motor movements that make the agility T-test more susceptible to learning effects than the RAST test. Thus, we would expect that a more complex task, such as the agility T-test, would require a greater number of familiarization sessions when compared to the RAST test.

Familiarization effects in multiple sprint tests have previously been studied[30-32]. These studies demonstrated the need for one to three familiarization sessions before anaerobic power determination; Although good intraclass correlation coefficients were demonstrated, our study revealed that running performance changed from the first to the fourth test evaluated, which makes us believe that more than four familiarization sessions are needed when running anaerobic performance is tested. These results are different from those presented in the literature. Although we could say that the protocols used for the running power evaluation were different among the studies cited above and ours, which may contribute to the discrepancy, the difference can be better explained by the fact that the repeated sprint test may be greatly influenced by motivation, especially as anaerobic abilities are tested[33,34]. Maximal anaerobic performance can cause discomfort and pain, which can make the test demotivating[34]. According to Geron and Inbar[33], motivation stimuli based on emotional factors, such as rewards and sanctions, are more effective to improve Wingate anaerobic power when compared to cognitive information, such as verbal motivation that may promote little or no effect on anaerobic performance. Although verbal encouragement and feedback were given during the RAST test in our study, the athletes lost performance in the final test session compared to sessions two and three. We expected no changes in anaerobic running performance after three sessions of familiarization. Thus, binomial motivation and learning effects must be considered when maximal effort anaerobic power is tested.

When the agility T-test was evaluated, the absence of variation occurred only after three tests; a progressive reduction in the time to complete the trial was observed from trials one to three, with no subsequent changes in the fourth trial. Therefore, three to four familiarization sessions are needed when using the agility T-test. No studies had comparing performance in change-of-direction tests on subsequent days as the present study; however, the study by Beekhuizen et al.[35] assessed familiarization achievements in the hexagonal agility test and observed a plateau in the second test session, which was performed two hours after the first, with no difference for the third session realize 48 h later. Thus, according to Katic et al.[36], the greater the complexity of the task, the more important repetition is for familiarization; consequently, more sessions are necessary for performance stabilization.

Conclusions

In conclusion, the findings of the present study demonstrate that the familiarization process may influence motor performance tests in soccer players, especially for tests that consist of more complex tasks and demand greater motor organization, such as the agility T-test. In addition, when maximal effort anaerobic power is tested, such as the repeated running sprint test, motivation and learning effect must be considered.

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