Testing the peak running speed in analytical and contextual-based scenarios: applied research in young adult soccer players

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Abstract

The primary aim was to compare the peak running speed (PRS) attained in the 40-m linear sprint test, in an analytical-based soccer drill, in the 5-0-5 test, and a training match scenario. The secondary aim of the study was to evaluate the differences between the three assessment sessions and identify how the tests can vary from session to session. Additionally, we aimed to investigate the within-test variability to understand how consistent the performance is within each test format across the different sessions. Forty male under-19 players competing at the national level participated in this study. A training session was observed for each of the three study weeks in which the following tests/scenarios were monitored using a GPS. The 40-m linear sprint test and the analytical-based soccer drill presented the smallest within-subject coefficients of variation between the sessions. A large correlation (r=0.742) was found between the PRS during the 40-m linear sprint test and the analytical-based soccer drill. The 40-m linear sprint test was the best method of those examined for measuring PRS. The analytical drill provides a reliable method for measuring PRS, although it differs from the 40-meter linear sprint test.

Keywords: football; athletic performance; running; speed tests.

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Introduction

A substantial amount of time is spent executing low-to-moderate effort activities in soccer match play, however, near-to-maximum and maximum intensity actions, such as sprinting, are an essential element of successful performance (16,45). Previous research revealed that straight-line sprinting is the most frequent action that precedes a goal-scoring opportunity in open play, thus underlining the influence of such an activity on successful performance within games (17).

The prevalence of sprinting has increased in some competitive leagues such as the English Premier League, with some reports indicating an increase of around 50% between the 2006-07 and 2012-12 seasons (10). Depending on contextual factors and playing position, professional soccer players may accumulate up to ~350 meters per match as has been shown for the fullback position in previous research (10). In the UEFA Europa League, the average number of sprints per game is 11.2±5.3 per player and in most cases, these sprints are shorter than five seconds in duration (4). In relation to the peak speed attained in such sprints, a recent study revealed that highly ranked German professional players can achieve velocities of between 9.2 and 9.4 m/s (33.1 to 33.8 km/h) (13).

Because sprinting is a key performance indicator in soccer, testing batteries recommended for soccer typically include sprinting tests to determine players' ability in this domain (7,46,48). Across different distances, the typical test distances used for soccer players are between 30 and 40 m. However, some authors suggest that 20 and 30 m appears to be long enough distance to guarantee a reliable estimate of peak running speed (PRS) (9). Usually, the sprint test employed is linear in direction, a characteristic that offers very good intra-day and inter-day reliability (3). Although sprint time is a fairly easy metric to evaluate (since common apparatus such as photocells and smartphones can measure it), another important piece of information to extract from a sprint test is the PRS which can be used to standardize sprint training and determine the anaerobic speed reserve (8,25). Despite this, PRS is more complicated to measure as it requires either a gold-standard radar gun, a Global Positioning System (GPS) (6,43) or photocells with a split at each 5-m interval (49).

Considering that undertaking physical fitness tests is usually challenging in professional football due to scheduling and time constraints, some approaches argue that PRS can be measured in other scenarios, such as during matches or drill-based games (e.g., small and large-sided games). Despite these assertions, recent comparisons between small-sided games, soccer matches, and 40-m linear sprint tests, reveal that only the latter can accurately estimate PRS (29). This is underlined by the fact that the inherent variability and dynamic conditions of match play may not present players with opportunities to perform linear sprints at PRS (29). Additionally, the different positional demands of soccer may enable only some players to achieve PRS in a match scenario. The findings suggesting the non-possibility of a match being used as a scenario for estimating the PRS, although this is contradicted by a study that found PRS was higher in a match than it was in a 40-m linear sprint test (32).

Given the above-described dilemma, there may exist an intermediate test that incorporates the characteristics of both match play and the 40-m linear sprint test, thus allowing coaches to test PRS more regularly while integrating some specificity to the task at hand. For example, technical drills involving the execution of crossing and shooting, often used in soccer training, may present players with the necessary space (between 30- and 40-m) to achieve PRS whilst also minimizing the potentially disruptive effects posed by opponent players. Indeed, increasing the pitch size in environmental situations, such as large-sided games with large fields, may lead to more sprints in players (12). However, it is essential to consider the contextual effects on within and between-player variability (19), which can still persist even in such scenarios, similar to what occurs in a match. While it is important to use training drills that ensure the perception-action coupling and the dynamics of the game, ecological drills for assessment purposes may not guarantee that all players achieve the same maximum performance at the same time, thus increasing time consumption.

While linear sprinting may not be the most frequent action in a game, it is crucial to acknowledge that the mechanical load of such activity is of paramount importance in adjusting the training process. This includes preventing injuries and preparing players for the occurrence of such activities during the game (31). Moreover, despite most sprinting actions occurring in curvilinear trajectories (20), linear sprinting is highly related to those actions and provides a practical means to measure PRS.

An additional alternative worth considering for PRS is the classical 5-0-5 change-of-direction test. This particular test evaluates change-of-direction performance, and it presents an opportunity to investigate whether the 15-meter linear sprint trajectory within the test can provide meaningful data for PRS evaluation in soccer players. Previous research has indicated a nearly perfect correlation between change-of-direction time and linear speed (44), which raises the possibility of exploring whether PRS can be reliably assessed during this test. If such a relationship is found to exist, it would offer the advantage of obtaining two crucial measures from a single test, simplifying the assessment process and saving valuable time during player evaluations.

Based on the above information, it is necessary to determine time-efficient, alternative approaches to measuring PRS that conform to the specific characteristics of a soccer match. Although PRS can be monitored in official matches, not all players are selected to partake in these matches with a rotational squad system highly recommended, particularly during fixture congestion during the season (21). Moreover, within-player variability within matches is an essential factor that may influence the evaluation of PRS. Accordingly, building analytical drills to test PRS and conform to the specificity of a match may decrease such variability and provide coaches with an opportunity to deploy regularly in training sessions. Considering the pertinence of examining more ecological approaches to testing PRS, this study has two purposes: the primary aim is to compare the PRS attained in the 5-0-5 and 40-m linear sprint tests, an analytical-based soccer drill and during a training match scenario. A secondary aim is to evaluate the within-test variation of PRS over three consecutive weeks. This analysis will focus on assessing the variability within each test and comparing the results between different days and trials to understand if the observed differences are meaningful. The aim is to ensure that the test consistently provides similar information over time, allowing for reliable and meaningful data to be obtained. Based on our objectives, we hypothesize that the change-of-direction test will not yield the same PRS results as the linear speed test. Additionally, we speculate that there may be slight differences in PRS between the linear speed test and the analytical-based drill or the match scenario. Regarding the second aim of the study, we anticipate that the match scenario will exhibit higher within-player variability, while the linear speed test will show smaller variability within the participants.

Methods

Experimental approach to the problem

This applied research study adopted a repeated measures design conducted over three consecutive weeks of a soccer season. Forty players from two teams were tested to evaluate their PRS in the 5-0-5, 40-m linear sprint, analytical-based soccer drill, and match scenarios. The players underwent measurements once per week for three consecutive weeks. This specific time frame was chosen to allow for repeated measures, which would enable the evaluation of within-player variability. Additionally, the duration of the study was kept as short as possible to accommodate the team's training schedule efficiently. The assessments always occurred during the equivalent training session and day of the week, aiming to preserve similarity of conditions. Over the observation period, the teams undertook four training sessions per week (Monday, Wednesday, Thursday and Friday) and had one official match (Sunday). The tests were implemented in session two of the training week (i.e., Wednesday), which occurred 72 h after the most recent match. This session corresponded to the first session after the players had recovered from the match. The research team suggested this timing to ensure that the players were in the most suitable condition for the test. On Monday (the day after the match), the training session was primarily dedicated to recovery, with a focus on low-to-moderate training intensity, and more emphasis on tactics and strategy. On Wednesday, the players began the session with the experimental approach and later transitioned to a match scenario. On Thursday and Friday, the players were typically engaged in aerobic-based and agility-based training sessions, respectively. The environmental conditions recorded on the testing days were as follows: an average temperature of 16.0±1.7ºC, with a coefficient of variation of 10.8%, and a relative humidity level of 65.0±5.6%, with a coefficient of variation of 8.6%. The assessments occurred outdoors on dry synthetic turf and with no rain falling.

Participants

The sample size was determined using G*Power software (version 3.1.9.6). To achieve a small effect size in Cohen's d of 0.41, a power of 0.8, and a significance level of 0.05 (for the two dependent means while accounting for a two-tailed effect), a total sample size of 50 participants was recommended. The effect size was calculated based on the means and standard deviations of two trials of a 20-meter sprint test (2.50±0.09 and 2.52±0.12) for soccer players, as previously published. The correlation level was set at 0.93, determined using the intra-class correlation coefficient (ICC) reported in the referenced article (36).

Given the unavailability of literature reporting three sessions of sprint tests for reference in the ANOVA analysis, we employed match-to-match variation in peak speed as a reference point, which yielded a minimal partial eta squared of 0.14 (50). Utilizing this reference, for an ANOVA repeated measures test with within factors, an effect size of 0.4 (calculated from the eta squared), a power of 0.8, and three measurements, assuming a correlation of 0.5, we estimated a required sample size of 12.

Two teams were selected to participate in this study through convenience sampling, as the researchers aimed to integrate the experimental approaches into their regular routines. The teams were chosen because they exhibited similar patterns regarding the number of training sessions per day and the days when the experimental approach would be implemented. The only observed variation was in the training time, as one team started their sessions after the other team. Participants were enrolled by convenience sampling and were selected to the study based on the following eligibility criteria: (i) they do not miss any of the observations; (ii) they participate in all training sessions occurring during the three weeks corresponding to the period of the observation; (iii) they have not been injured in the previous four weeks before the study was initiated and were being injured during the period of the observation; and (iv) they play in an outfield position (i.e., no goalkeepers were included in this study). Out of the total of 45 players recruited, 5 players were excluded from the analysis since they were acting as goalkeepers. Forty male soccer players (18.5±0.5 years old; 6.0±1.5 years of experience) from under-18 and under-19 soccer teams competing at the national level voluntarily participated. No dropouts or missing data were recorded in the study. The competitive level corresponded to tier 3 (highly trained/national level) of the Participant Classification Framework (33). The participants were informed about the study design, risks, and benefits prior to their participation. After verbal agreement, they signed a study consent form. The study followed the ethical standards for researching humans set out by the Declaration of Helsinki. The ethical committee of the University of XXXX, XXXX, XXXX approved the research.

Procedures

For each day of the assessments, the following sequence was employed: (i) standardized warm-up protocol following the FIFA 11+ warm-up protocol (2) ; (ii) 5-0-5 test; (iii) 40-m linear sprint test; (iii) analytical-based soccer drill incorporating the skills of passing, crossing and shooting; and (iv) match scenario. The sequence was maintained consistently to ensure similar conditions, which was crucial for conducting the within-player analysis. There was a 5-minute rest period between each of these tests. Each test was executed twice, with a 3-minute rest period between each trial. This approach aimed to ensure consistent performance during the training session, as relying on only one attempt might not provide sufficient data to establish a reliable and representative measure of performance. The participant wore the team's official training uniform, consisting of a shirt and shorts, and used the same pair of soccer boots for the field tests.

The players used a Global Positioning System (GPS) Polar Team Pro (10 Hz, Finland) to measure PRS in each test. A body-worn sensor was positioned in the center of the chest and was held in place by an elastic band. To decrease inter-unit variability, players wore the same units in each testing session. The GPS system was previously tested for its concurrent validity against radar guns and was also confirmed for its intra- and inter-unit reliability in measuring PRS (43). In this particular case, the GPS Polar Team Pro was compared with a radar gun, and the overall coefficient of correlation for maximum sprint speed was found to be extremely high ($r = 0.938$, $p < 0.001$) (43). Additionally, good inter-unit reliability between the Polar Team Pro GPS units was observed for maximum sprint speed, with low coefficients of variation (5%–6%) and low smallest worthwhile changes (0.4 for all systems) (43). To ensure optimal data collection, a standard protocol was followed in which all devices were powered on 15 to 30 minutes prior to commencing data collection. This timeframe allowed the devices to establish a connection with multiple satellites, synchronize their clocks with the satellite's atomic clock (30), and achieve a horizontal dilution of precision (HDOP) of less than 5, as indicated in the manufacturer's specifications. The player’s data were objectively recorded using Polar Team Pro hardware and software. Afterward, the collected data were processed through the device's web platform and exported in accordance with RFC 4180 standards, which specify a comma-separated values (CSV) text format.

40-m linear sprint test

Players started in a staggered stance position. The players always started with the same preferred leg in front and after a count (i.e., ‘3, 2, 1, go’), they executed the sprint with maximal intent. For each session, the players performed two trials, interspaced by three minutes of rest. In each trial, the players wore the GPS unit to measure PRS. This PRS was used in further statistical analysis.

5-0-5 test

The original version (42) of the 5-0-5 test was used. While it may not be expected to observe PRS as in the case of a linear sprint test, previous studies suggest that the results of change of direction tests are often highly correlated with linear sprint performance (44). Considering that soccer players typically achieve maximum speed earlier than sprint athletes (9), we aimed to investigate whether this change of direction test could provide similar information to a properly designed linear sprint test. By doing so, we aimed to exclude the possibility of obtaining redundant or duplicate information from both tests. The test consisted of sprinting a distance of 15 meters, before turning 180º and performing a five-meter sprint to the finish line. The players started in a staggered stance with the same preferred leg in a forward position. Braking was also performed with the same preferred leg. Two trials were executed and were interspaced by a 3-minute rest period. The players wore a GPS unit during the trials. The PRS attained in each trial was collected and used in further statistical analysis.

Analytical-Based Soccer Drill

A standard crossing and shooting drill, typically performed as part of a regular training session, was also used to estimate RPS (Figure 1). Accordingly, players were familiarized with the utilized format. The drill began with players standing 40-m away from the goal. A row of three players was positioned with one of each on the left, at the center, and on right of the field. The player in the center had possession of the ball. Following the coach's instruction, this player performed a long pass aiming for the furthest 10-meter portion of the pitch (i.e., 30+ metres away) on the left or right sides. The player that was positioned on the side that this pass was directed to sprinted maximally in an attempt to collect the ball. Once the sprinting player gained possession of the ball, the original passing player from the center, and the player from the opposite side to which the pass was directed, sprinted maximally to enter the goal area. The player who had received the original pass then ran with the ball before performing a cross pass to his teammates in the goal area, who would then attempt to shoot to the target. The target was the regularly-sized goal with a goalkeeper utilized as per a match scenario. The goalkeeper was instructed not to leave the goal and not to constrain the players in possession of the ball. Thus, goalkeepers were only allowed to perform a shot save in the line of goal.

The players were asked to sprint with maximal intent. The players rotated between the center (for passing and shooting) and each of the side positions (for crossing). They adopted the same positions and sequencing in all three of the observed training weeks. The players performed two trials and were monitored for PRS with the GPS unit. The trials were interspaced by ~3-minutes of active recovery (jogging back to the next position). The PRS attained in each trial was collected for statistical analysis.

< FIGURE 1 NEAR HERE

Match Scenario

Players were grouped into two teams. The traditional 11 vs. 11 format of play (10 outfield players and a goalkeeper) was implemented in two repetitions of 5-minutes duration (interspaced by 3-minutes of rest). The soccer pitch was 105 × 68 meters. The players were grouped with their regular playing positions taken into consideration. The coach selected the teams based on his perception of players' individual abilities, aiming to provide two equally competitive sides. It is important to mention that each team consisted of an equal distribution of typical starters and non-starters, carefully balanced across the defensive, midfield, and attacking zones. This composition was maintained consistently throughout the three observed sessions, ensuring the stability and consistency of the experimental setup. The players wore the GPS units to measure the PRS achieved during these match scenarios. The PRS attained during each repetition was collected and treated further for statistical analysis.

Statistical procedures

Preliminary inspection of the normality and homogeneity of the data was carried out using the Shapiro-Wilk and Levene's tests, respectively. Results indicated the accomplishment of assumptions of normality and homogeneity ($p>0.05$). Within-session variability was tested using the data median across the three-week trial. The coefficient of variation (expressed as a percentage) and the intra-class correlation test (two-way random, absolute agreement, and average measures) was used to determine reliability. On the other hand, the paired t-test was used to evaluate potential variations in performance between Trial 1 and Trial 2. Cohen's *d* was used as the effect size measure and was calculated using the sample standard deviation of the mean difference adjusted by the correlation between measures. The effect size magnitude followed Cohen's own classifications (18): 0.0-0.2, trivial effect size; 0.41-1.14, recommended minimum effect size; 1.15-2.69, moderate effect size; >2.70, strong effect size. Furthermore, within-session comparisons were conducted by generating Bland-Altman plots for each test, incorporating 95% confidence intervals.

To calculate between-session variability, the coefficient of variation and the intra-class correlation (two-way random, absolute agreement, and average measures), the highest PRS in each session was used. Repeated measures ANOVA was used to compare the variations between the observed training weeks with the Bonferroni adjustment used post-hoc analysis. Comparisons between the best scores in each test and drill scenario were performed using a repeated measures ANOVA. Finally, a Pearson's product-moment correlation test was performed to test the relationships between the PRS attained in each test and scenario. The correlation magnitude was classified as: 0.0-0.1, trivial; 0.1-0.3, small; 0.3-0.5, medium; 0.5-1.0, large (14). All the statistical procedures were executed in the SPSS software (version 28.0.0.0, IBM, Chicago, USA) for a $p<0.05$.

Results

Table 1 displays the within-session analysis, evaluating the variability of Trial 1 and Trial 2 across three different training sessions. Trial 1 represents the results of the first repetition performed for each test, while Trial 2 shows the results of the second repetition for the same test. Table 1 presents the variability within-trial, the differences between means, and the intraclass correlation test. It was possible to observe that the variability between trials (within-session) was acceptable (below 3.3%) except for the match (8.0% coefficient of variation). Significant differences were also found between trials 1 and 2 in the match scenario (2.5 km/h of difference; $p<0.001$; $d=1.021$). Furthermore, Figure 2 presents the Bland-Altman plots, which illustrate the limits of agreement and facilitate the analysis of agreement between trials for each conducted test. Specifically, for the 5-0-5 test, the average difference was 0.3, with lower and upper 95% confidence interval limits of –2.5 and 2.0, respectively. In the case of the 40-meter test, the average difference was 0.1, with lower and upper 95% confidence interval limits of –2.0 and 2.1, respectively. For the analytical-based soccer drill, the average difference was –0.2, with lower and upper 95% confidence interval limits of –3.3 and 2.9, respectively.

Finally, in the match scenario, the average difference was 2.5, with lower and upper 95% confidence interval limits of –0.1 and 5.2, respectively.

<TABLE 1 NEAR HERE

<FIGURE 2 NEAR HERE

The between-session analysis can be found in table 2. The 40-m linear sprint test and the analytical-based soccer drill presented the smallest coefficient of variations within-subject between the sessions (3.3±2.5 and 3.6±2.3%, respectively). Repeated measures ANOVA revealed significant differences in PRS between training sessions on the 5-0-5 test (p=0.007; η_p^2=0.119) and match scenario (p=0.005; η_p^2=0.145). No significant differences were found between sessions regarding the 40-m linear sprint test (p=0.337; η_p^2=0.027) and analytical-based soccer drill (p=0.186; η_p^2=0.044).

Overall (the three sessions pooled), the intra-class correlation test (for absolute agreement) revealed that the PRS attained in the 5-0-5 (ICC=0.536, [95%CI: 0.236;0.735]), 40-m linear sprint test (ICC=0.693, [95%CI: 0.483;0.827]), and analytical-based soccer drill (ICC=0.593, [95%CI: 0.318;0.770]). Smaller ICC values were found for the match scenario (ICC=0.013, [95%CI: –0.538;0.413]).

<TABLE 2 NEAR HERE

Table 3 presents the comparisons of the best PRS attained during the three weeks for each of the tests and scenarios. The highest speed was found in the 40-m linear sprint test (30.6±1.5 km/h), followed by the analytical-based soccer drill (30.1±1.1 km/h). The repeated measures ANOVA executed to test the variations of the best values attained during the three weeks between tests and scenarios revealed significant differences between them ($p<0.001$; $\eta_p^2=0.913$).

< TABLE 3 NEAR HERE

Pearson's product-moment correlation test was executed to test the relationships of the best PRS between tests and scenarios. Large correlations were found between the 40-m linear sprint test and the analytical-based soccer drill (r=0.742 [95%CI: 0.554; 0.853]; $p<0.001$). Moderate correlations were found between the 5-0-5 test and the 40-m linear sprint test (r=0.442 [95%CI: 0.146; 0.659]; p=0.004), the 5-0-5 and the analytical-based soccer drill (r=0.346 [95%CI: 0.034; 0.591]; p=0.029) and the analytical-based soccer drill and match scenario (r=0.355 [95%CI: 0.044; 0.597]; p=0.025). The remaining relationships were trivial to small. Figure 3 presents the scatterplot of the best PRS attained during the three weeks for each test and scenario.

<FIGURE 3 NEAR HERE

Discussion

The primary aim of the current study was to compare the PRS attained in the 40-m linear sprint test with the 5-0-5 test, an analytical-based soccer drill, and match format scenarios. By analyzing the PRS results from these different test formats, we sought to gain insights into the relationships and potential differences between the tests, which could provide valuable information for coaches and practitioners in the field of soccer training and assessment. Additionally, we also aimed to analyze differences between training sessions and identify how the tests can vary from session to session, while also investigating the within-test variability.

The results of the study suggest that: (1) PRS presents low within-session and between-session variability in the 5-0-5 test and 40-m linear sprint tests as well as in a analytical-based soccer drill, but presents a high level of variability in match scenarios; (2) measured PRS is significantly greater in the 40-m linear sprint test than in the remaining tests and scenarios, although the percentage of difference in the analytical-based soccer drill is 1.6% and the magnitude of the effect size is small; (3) there is a significantly large correlation between PRS in the 40-m linear sprint test and the analytical-based soccer drill.

The variability of the four tests and scenarios applied was tested within- and between sessions. The coefficient of variation for within-session variability (two trials) revealed that the 5-0-5, 40-m linear sprint and analytical-based soccer drill had a within-subject coefficient of variation below 3.3% compared to 8.0% in match scenarios. Utilizing the Bland-Altman method to assess within-test agreement between trial 1 and trial 2 (Figure 2), our analysis reveals variations in agreement levels among the four tests examined. Specifically, the 5-0-5 and 40-m linear sprint tests exhibit lower levels of agreement, with an average difference of approximately 0 and confidence intervals spanning approximately 2. In contrast, the analytical drill shows a similar average difference of approximately 0 but wider confidence intervals, ranging around 3. The match scenario, conversely, presents the most substantial average difference of approximately 2.5.

This significant mean difference may stem from several factors. Firstly, the intricate and dynamic nature of a soccer match (24), often influenced by various contextual and tactical factors, can lead to scenario-dependent variations in player movements and behaviors (23,39). Consequently, this complexity increases the likelihood of variability in test outcomes across similar scenarios. Additionally, the choice of measurement instruments may contribute, as GPS devices at peak speeds are known to exhibit lower reliability and greater variability (43). However, this particular issue was less pronounced in the remaining tests (5-0-5, 40-m, and analytical-based drill).

In light of these findings, it is important for coaches to recognize that the dynamic nature of soccer matches may not consistently provide ideal conditions for achieving consistent test outcomes (29). These outcomes are intricately linked to the ever-changing contextual and dynamic elements inherent in the inherently chaotic nature of dynamic systems (24).

Regarding between-session variability, it was found that only the 40-m linear sprint and the analytical-based soccer drill had a coefficient of variation of between 3.3 and 3.6%, with the 5-0-5 tests demonstrating 5.6% and the match scenario 13.2%. These results suggest that the 40-m linear sprint test and the analytical-based soccer drill offer the smallest within- and between-session variability when measuring PRS. The results for the 40-m linear sprint were expected given that the coefficient of variation for this measure is typically < 3% (3). Additionally, the ICCs for within- and between-session measures normally exceed 0.75 (22,35,41) an observation that was confirmed in our study with an ICC of 0.832 observed. However, despite this, the between-session ICC for this measure in our study was 0.693 indicating a lower degree of agreement over a more extended period of time during the season.

Interestingly, the analytical-based soccer drill presented small within- and between-session variability (ICC), which suggests that this exercise can provide coaches with good repeatability in a scenario which closely replicates the demands and characteristics of soccer play. That both the 40-m linear sprint and the analytical-based soccer drill presented lower variability and higher reliability can potentially be attributed to the linear nature of the exercises in terms of the running demands placed on the athlete. Previous studies (15,37,47) suggest that the measurement reliability of a sprint test is correlated to the distance that an individual traverses in a given test. Considering that the analytical-based soccer drill required participants to cover a 40-m distance, lower variability and greater reliability might reasonably have been expected in this test relative to the 5-0-5 test. Although not presenting the same levels of reliability as the 40-m linear sprint, the analytical-based soccer drill does require participants to demonstrate soccer-specific skills in addition to sprinting, thus providing coaches with a viable and more sport-relevant alternative to precisely measure PRS. On the other hand, the ecological alternative of the match scenario revealed greater within and between-session variability and a poor level of reliability thus calling into question its usefulness as a measure of in-season PRS. The positional demands of a soccer match as well as the contextual factors associated with that match may mean that only some players are required to reach PRS on a repeated basis. This is confirmed by the greater between-match variability reported in previous studies (23,28) which can be attributed to the tactical and technical constraints and collective behaviors within a given match (5).

In addition to the match scenario being a less reliable method to determine PRS, it presents a 14.1% difference in PRS when compared to that captured in the 40-m linear sprint test and 12.6% when compared to that observed in the analytical-based soccer drill. While the PRS was 21.2 km/h in the 5-0-5 test and 26.3 km/h in the match scenario, players achieved velocities of 30.1 km/h in the analytical-based soccer drill and 30.6 km/h in the 40-m linear sprint. The magnitude of difference was large between the 5-0-5 test and match scenario compared to the analytical-based soccer drill and the 40-m linear sprint. However, the magnitude of difference between the analytical-based soccer drill and the 40-m linear sprint was small, although statistically significant.

A match scenario did not appear to offer the requisite conditions to detect PRS in a previous study that compared small-sided games, match scenarios and linear sprinting to determine maximum velocity (29). The explanation for such a result can be attributed to the limited space to execute longer sprints in a soccer match (40) restriction imposed by playing position constraints which prevent players from running over extended distances and reducing the possibility of achieving maximum speed. A previous study comparing the maximum velocity attained in a 40-m linear sprint and match scenarios revealed that none of the players achieved the maximum velocity in the match and that the playing position had a vital role in determining those that did (34).

While the match scenario may not guarantee the optimal conditions to achieve PRS as a linear speed test, coaches often raise concerns about the specificity of certain tests, leading to their limited use. To address this, we proposed an analytical-drill based task to offer coaches an alternative option that may not have as much within and between player variability in terms of PRS as a match scenario, but it can provide some degree of specificity compared to traditional linear speed tests. By having this option available, coaches may be more inclined to use the tests more frequently, allowing sports scientists and strength and conditioning coaches to monitor the training stimulus provided to players and identify potential adaptations over longer periods of observation. Furthermore, this approach ensures that the tests can easily fit into the regular training schedule of the coach, facilitating its practical implementation.

In the current study, the 5-0-5 test also significantly underestimated PRS in comparison to the 40-m linear sprint and the analytical-based soccer drill. This is explainable due to the 5-0-5 test only allowing a player to run linearly for 15-m before decelerating and changing direction. Considering that soccer players often require distances of up to 30-m to achieve the maximum velocity (9), it could be argued that the 5-0-5 test is not an appropriate way to measure PRS. However, it may offer an opportunity to measure accelerative abilities in soccer players.

The additional analysis of relationships between PRS in the various tests and scenarios also confirmed that only the 40-m linear sprint test and the analytical-based soccer drill shared a correlation of large magnitude (r=0.742 [95%CI: 0.554; 0.853]). These results confirm that among the tests and scenarios utilized in this study, the analytic-based soccer drill holds meaningful relationships with the demands of the 40-m linear sprint test, which is considered the gold standard for measuring PRS. From a skill execution perspective, that the analytical-based soccer drill only implicated a pass, a cross and a shot without the impediment of opponents reduced the variability of a match scenario while adding some specificity to the task compared to the 40-m linear sprint. Although this analytical drill may not fully replicate the complexity of small-sided games or match scenarios, it is a common practice in shooting and finalization training. The main purpose of testing this drill was to provide coaches with a focused approach to improve shooting skills and finalization techniques while also exploring the possibility of measuring PRS.

This study does have some limitations worth noting. Firstly, the sample size, while consisting of forty participants, aligns with the typical sample sizes seen in recent sports science research focused on testing the reliability of sprint tests in soccer (20). However, it's important to highlight that the a priori sample size estimation suggested that the sample size fell below the required level. This discrepancy could potentially introduce bias into the final interpretation of the results, as previously discussed (1). Consequently, the statistical findings may be somewhat compromised, and generalizations should be made cautiously. Moreover, the match scenario was analyzed in training sessions and not in an official match which may constrain players' maximal efforts differently at various junctures, for example, late in the game when fatigue is present. Additionally, the duration of the match scenario was limited to two repetitions of 5 minutes each. While this allowed for controlled testing conditions, it may not provide the necessary ecological validity to fully capture the demands of an actual game and attain accurate PRS. Longer match scenarios or multiple repetitions may be necessary to better simulate real-game situations and gather more comprehensive data on players' performance.

Moreover, it is important to note that the tests and scenarios were conducted in a predetermined order rather than randomly (i.e., 5-0-5, 40-m linear sprint, analytical-based soccer drill, and match). This sequential approach introduces the possibility of interference from fatigue effects. For example, we cannot definitively ensure that match performance was not significantly influenced by the preceding test performances. It is worth mentioning that adopting a random order for the tests would have circumvented such an issue. However, it is also fair to acknowledge that soccer players frequently execute peak efforts in various periods throughout a 90-minute match. For instance, a recent study revealed that maximum speed actions are distributed across different intervals of the first and second halves, with around 22.7% occurring in the first 15 minutes and 21.9% between the 45th and 60th minutes (38). Additionally, 10 to 15% of maximum speed actions were observed in the second and third thirds of the match (38). This suggests that even after periods of recovery, players are still capable of delivering peak efforts over extended durations.

In our study, the match scenario was limited to 10 minutes, interspersed with 3 minutes of rest (5+5 minutes in total). These timings align with when players often prepare to engage in peak-speed actions during actual game scenarios. It's worth mentioning that before the match scenario commenced, there was a 5-minute (i.e., 300-second) rest period. In real soccer matches, players, on average, recover for 139±43 seconds between high-intensity actions (11), which is notably less than the rest periods provided in our study design. It is also important to note that in maximal velocity training, recovery times between maximal sprints typically range from 4 to 15 minutes (26). However, these longer rest intervals are commonly recommended for elite sprinters, who engage in 30 to 40 sprints (26), a stark contrast to soccer players who perform shorter sprints covering less than 20 meters and achieve lower speeds compared to elite sprinters (27).

Therefore, while it is a recognized fact that randomizing the test order would be the ideal methodological design, we should also emphasize that the rest periods between tests may not necessarily compromise player performance. This potential bias should be acknowledged by coaches and the scientific community when interpreting the present results.

Additionally, the three-week period could be considered a limitation of the study, as a longer duration might provide more sensitivity to capture potential seasonal changes and accurately determine the actual changes in sprint ability. A more extended study period could help account for variations that occur over the course of a season, thus providing a more comprehensive and robust assessment of the players' sprinting capabilities. Despite these limitations, the fact that the study has been conducted over three consecutive weeks and in a relatively large group of over forty players from two teams offers a solid practical application of the findings.

It is important to acknowledge that the current analytical-based soccer drill employed in this study may not fully replicate the environmental demands of actual game situations. This is because all players, regardless of their typical playing positions, are required to perform the same actions. Ideally, future drills should be designed to respect the playing positions and better approximate the training scenario to the reality of the game.

Since the current analytical-based drill lacks playing position-based training scenarios, coaches may find it less practical or relevant to incorporate it into their training routines. Thus, future studies should explore alternative skill-based scenarios that allow coaches to regularly assess players while maintaining specificity to the sport without introducing biases to the assessment. It is essential to respect the playing-position specificity to ensure the drill's effectiveness in evaluating players' skills and performance accurately.

Practical applications

While acknowledging the potential methodological biases previously discussed in this article, it is important to note that among the within-session comparisons, the PRS demonstrated the smallest mean difference (0.1; –2.0-2.1, 95% CI) in the 40-m linear sprint condition, according to the Bland-Altman analysis. Additionally, it exhibited the lowest coefficient of variation (2.1±1.5%) and did not show a significant difference in the paired test (p=0.730), accompanied by a trivial effect size in the pairwise comparison (d=0.038).

Practically speaking, the 40-m linear sprint test emerged as the most reliable and stable condition for measuring PRS in the soccer players who participated in this study. In contrast, the analytical training drill scenario, involving passing, crossing, and shooting, exhibited an average difference of –0.2 (–3.3 and 2.9 95% CI), a coefficient of variation (3.0±2.7%), no significant difference (p=0.215), and a small effect size (d=–0.140).

In practice, this implies that the 40-m linear sprint is the least variable condition identified in the current study. However, the analytical-based condition also demonstrated the potential for reproducibility, albeit without achieving the desired PRS, which is the primary objective when testing players.

Furthermore, when comparing the best PRS, the 40-m linear sprint test and the analytical drill-based test did not significantly differ from each other (p=0.029). Nevertheless, there was a medium magnitude of difference (d=0.339) and a mean percentage of difference of 1.6% between them. Based on these findings, it is not recommended to use these tests interchangeably, as they exhibit deviations that can ultimately influence coaches' assessments and interpretations.

Therefore, it is advisable for coaches not to generalize the results and, if feasible, to incorporate both tests into their assessments. Alternatively, they should be mindful that while these tests may share some similarities, they provide distinct information and insights regarding players' abilities. Recognizing these differences will empower coaches to make more informed decisions when evaluating player performance and designing tailored training programs.

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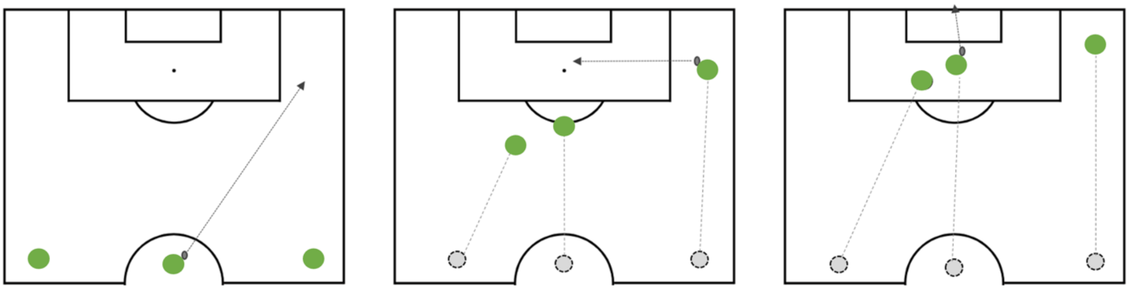

Figure 1. The sequence of actions during the analytical-based soccer drill.

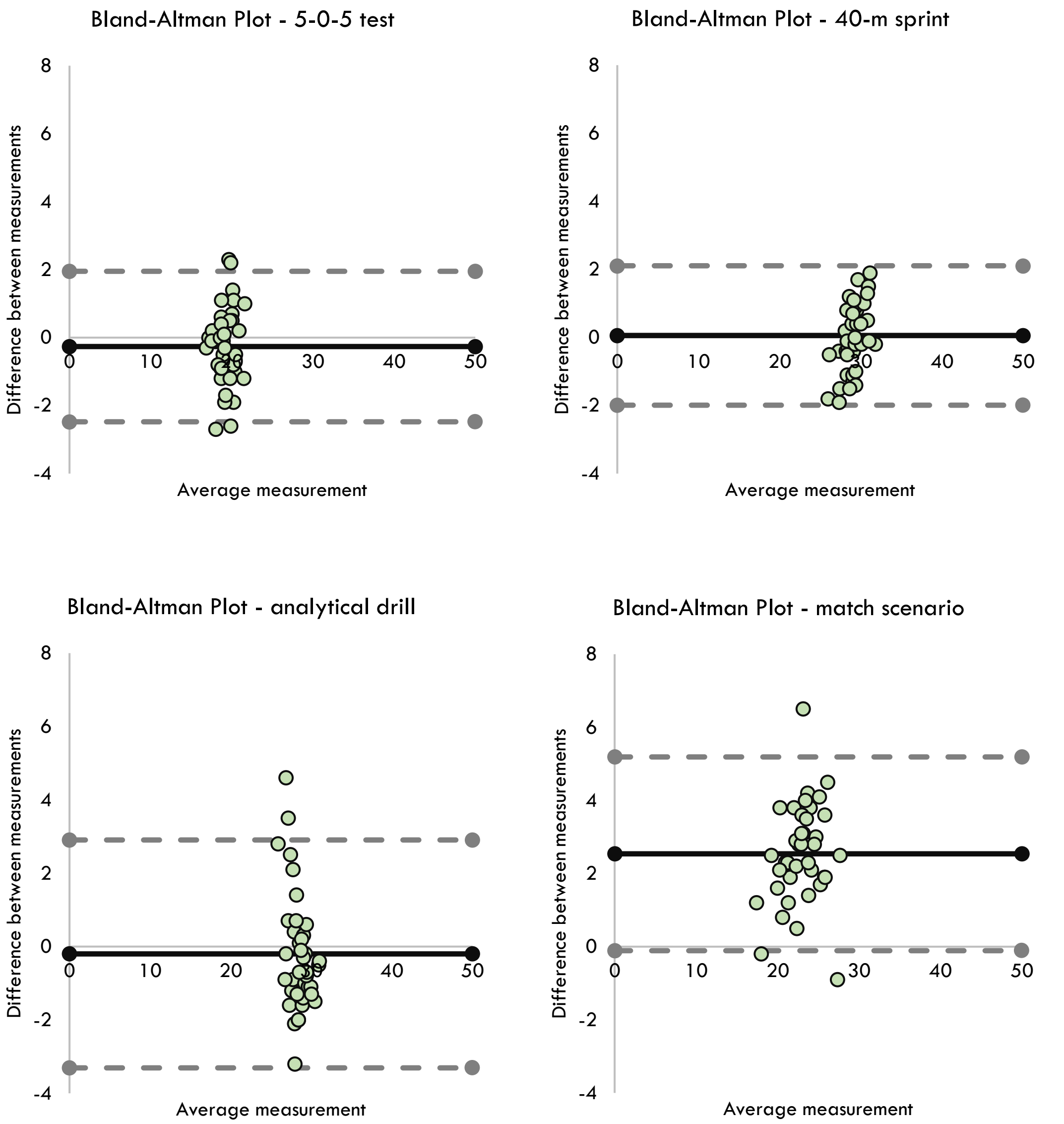

Figure 2. Bland-Altman plots depicting the limits of agreement (95% confidence interval) when comparing trial 1 and trial 2 for the four distinct tests analyzed in the study.

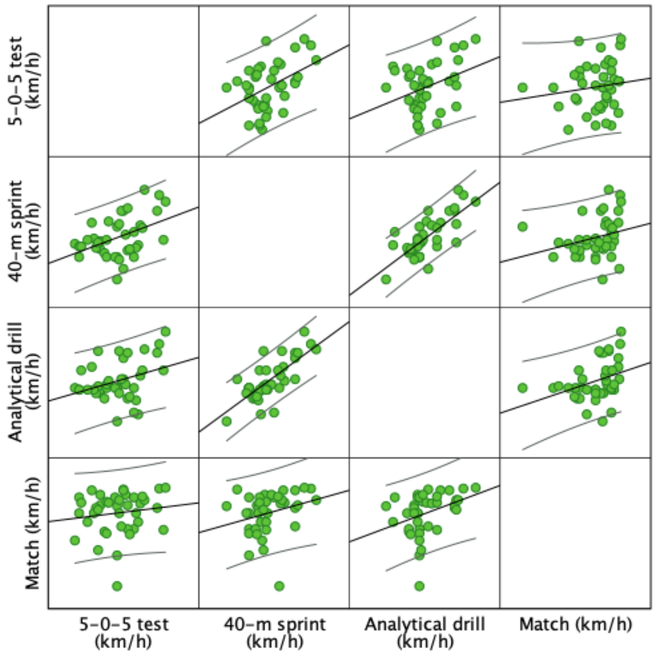

Figure 3. Scatterplot of the best PRS attained during the three weeks for each test and scenario.

Table 1. Within-session analysis (trial one vs. trial 2) for the four tests used to estimate running peak speed.

	T1	T2	%CV between trials	Difference (T1 vs. T2)	ICC* [95%CI]	p	d (T1–T2) [95%CI]
5-0-5 (km/h)	19.2±1.3	19.5±1.2	3.3±2.6	0.3 km/h | 1.4%	0.727 [0.490;0.855]	0.150	–0.213 [–0.509; 0.084]
40-m sprint (km/h)	29.1±1.6	29.0±1.1	2.1±1.5	0.1 km/h | 0.2%	0.832 [0.681;0.911]	0.730	0.038 [–0.185; 0.262]
Drill (km/h)	28.4±1.1	28.6±1.6	3.0±2.7	0.2 km/h | 0.7%	0.523 [0.098;0.748]	0.215	–0.140 [–0.497; 0.217]
Match (km/h)	24.1±2.6	21.6±2.3	8.0±3.7	2.5 km/h | 10.5%	0.710 [–0.193; 0.915]	<0.001	1.021 [0.730;1.313]

T: trial; d: Cohen-d value; CI: confidence interval; ICC: intraclass correlation test; *two-way random; absolute agreement; average measures; drill: analytical-based soccer drill

Table 2. Between-session analysis for the four tests used to estimate running peak speed.

	W1	W2	W3	%CV between sessions	Pairwise Difference (%)	Pairwise comparison (ICC*)	Pairwise comparison (p-value)	Pairwise comparison (d)
5-0-5 (km/h)	19.6±1.5	20.1±1.4	20.5±1.4	5.6±2.9	W1 vs. W2: 2.6% W1 vs. W3: 4.6% W2 vs. W3: 2.0%	W1 vs. W2: 0.643 W1 vs. W3: 0.189 W2 vs. W3: 0.434	W1 vs. W2: 0.188 W1 vs. W3: 0.021* W2 vs. W3: 0.340	W1 vs. W2: 0.306 W1 vs. W3: 0.596 W2 vs. W3: 0.306
40-m sprint (km/h)	29.7±1.7	29.4±1.4	29.8±1.8	3.3±2.5	W1 vs. W2: –1.0% W1 vs. W3: 0.3% W2 vs. W3: 1.4%	W1 vs. W2: 0.659 W1 vs. W3: 0.569 W2 vs. W3: 0.582	W1 vs. W2: 0.842 W1 vs. W3: >0.999 W2 vs. W3: 0.448	W1 vs. W2: 0.172 W1 vs. W3: –0.075 W2 vs. W3: –0.248
Drill (km/h)	28.9±2.1	29.3±1.0	29.3±1.1	3.6±2.3	W1 vs. W2: 1.4% W1 vs. W3: 1.4% W2 vs. W3: 0.0%	W1 vs. W2: 0.484 W1 vs. W3: 0.441 W2 vs. W3: 0.638	W1 vs. W2: 0.434 W1 vs. W3: 0.538 W2 vs. W3: >0.999	W1 vs. W2: –0.253 W1 vs. W3: –0.245 W2 vs. W3: 0.019
Match (km/h)	22.2±3.9	24.5±3.1	24.5±2.7	13.2±6.6	W1 vs. W2: 10.4% W1 vs. W3: 10.4% W2 vs. W3: 0.0%	W1 vs. W2: –0.299 W1 vs. W3: –0.258 W2 vs. W3: 0.611	W1 vs. W2: 0.028* W1 vs. W3: 0.021* W2 vs. W3: >0.999	W1 vs. W2: –0.658 W1 vs. W3: –0.682 W2 vs. W3: 0.017

W: week; d: Cohen-d value; CI: confidence interval; ICC: intraclass correlation test; *two-way random; absolute agreement; average measures; drill: analytical-based soccer drill; *: significant different (p<0.05).

Table 3. Comparisons between the best PRS attained during the three weeks for each test and scenario.

	5-0-5[a] (km/h)	40-m sprint[b] (km/h)	Drill[c] (km/h)	Match[d] (km/h)	Pairwise Difference (%)	Pairwise comparison (p-value)	Pairwise comparison (d)
Best	21.2±1.1	30.6±1.5	30.1±1.1	26.3±2.4	a vs. b: 44.3% a vs. c: 42.0% a vs. d: 24.1% b vs. c: –1.6% b vs. d: –14.1% c vs. d: –12.6%	a vs. b: <0.001 a vs. c: <0.001 a vs. d: <0.001 b vs. c: 0.029 b vs. d: <0.001 c vs. d: <0.001	a vs. b: –6.863 a vs. c: –7.868 a vs. d: –2.685 b vs. c: 0.339 b vs. d: 2.094 c vs. d: 1.910

Drill: analytical-based soccer drill