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Measurement Properties and Feasibility of the Loughborough Soccer Passing Test: A Systematic Review

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Abstract

Since the Loughborough Soccer Passing Test (LSPT) is a widely applied tool to assess soccer skill, the purpose of this paper was to systematically review the literature and examine the research methodological quality, measurement properties and feasibility of the LSPT. PubMed, Scopus, SPORTDiscus, and Web of Science databases were searched up to June 2017. Twenty five studies fulfilled the eligibility criteria: six for reliability, nine for validity and 16 for responsiveness. The main methodological limitations of the included studies were the small sample size and the lack of information on participants and eligibility criteria. The results showed that test-retest reliability of the LSPT was moderate to excellent (correlation: r = 0.43-0.99, intraclass correlation coefficient: ICC = 0.42-0.93). Good discriminative validity was found between playing levels and ages. The LSPT was positively correlated with sprint, dribbling, and agility test (r = 0.49-0.75); however, a weak correlation (r = 0.30-0.47) was established with in-game performance. Test responsiveness (an ability to detect change over time) to some external interventions was observed in studies. Adjusted Cronbach's alpha (α = 0.67), smallest worthwhile change (SWC = 0.8-3.8) and minimal detectable change (MDC_{50} = 1.9-11.3) were calculated based on the available data. The findings indicate that the LSPT has acceptable test-retest reliability and discriminative validity. However, it may not be a feasible and effective way to interpret the intra-individual change of skill performance in practice due to the large measurement error. Future work should be carried out to focus on more measurement properties of LSPT, and to improve its practical feasibility.

Keywords: Football; LSPT; passing; reliability; validity

Introduction

Competitive soccer performance depends on many factors that include physical, physiological, mental, technical and tactical areas (Stolen, Chamari, Castagna, & Wisloff, 2005). Among these factors, technical skill is under intensive focus as it is crucial for successful match play (Carling, Bloomfield, Nelsen, & Reilly, 2008). Consequently, various tests have been employed to measure the isolated soccer skills, such as dribbling, passing, and shooting (Haaland and Hoff, 2003; Hoare and Warr, 2000; Reilly and Holmes, 1983; Rosch et al., 2000; Rostgaard, Iaia, Simonsen, & Bangsbo, 2008; Russell, Benton, & Kingsley, 2010). However, the ecological validity and sensitivity of the tests have been questioned (A. Ali, 2011). Elite soccer requires high levels of cognitive, perceptual, and motor skills in a rapidly changing environment (Russell, Rees, Benton, & Kingsley, 2011), and therefore, a multi-faceted test evaluating these abilities simultaneously is preferable (A. Ali, 2011).

The Loughborough Soccer Passing Test (LSPT), developed by Ali et al. (A. Ali et al., 2007) is a testing protocol designed for assessing a number of aspects of soccer techniques including passing, dribbling, control, and decision making. Briefly, the LSPT requires players to complete 16 passes against coloured targets as quickly as possible, while making the fewest mistakes. One examiner calls out the order of the passes while a second examiner records the test scores including movement time (time taken to complete each trial), penalty time (time added for errors, inaccurate passes and slow performance), and total performance time (the sum of movement

time and penalty time). Previous evidence has demonstrated an acceptable level of reliability and validity for the LSPT in adult male (A. Ali, et al., 2007; Andrade-Souza, Bertuzzi, de Araujo, Bishop, & Lima-Silva, 2015; McDermott, Burnett, Robertson, Chia, & Jenkins, 2015; Naser and Ali, 2016), female (A. Ali, Foskett, & Gant, 2008) and youth (Benounis et al., 2013; Huijgen, Elferink-Gemser, Ali, & Visscher, 2013; Le Moal et al., 2014; McDermott, et al., 2015; O'Regan, Ali, & Wilson, 2007) players. Accordingly, the LSPT has been applied widely in the field as a useful tool for monitoring the technical progress of individuals, discriminating players of different competitive levels, and assessing whether a player has the potential to become elite performers in talent identification conditions (Huijgen, et al., 2013; McDermott, et al., 2015). The test has also been used in research to assess the effects of various external interventions such as learning strategies (H. M. Ali et al., 2016), training methods (Impellizzeri et al., 2008; Zago, Giuriola, & Sforza, 2016), warm-up (Zois, Bishop, Fairweather, Ball, & Aughey, 2013), fluid ingestion (A. Ali, Gardiner, Foskett, & Gant, 2011; A. Ali and Williams, 2009; Andrade-Souza, et al., 2015; Foskett, Ali, & Gant, 2009; Gant, Ali, & Foskett, 2010; Owen, Kehoe, & Oliver, 2013) and fatigue (Draganidis et al., 2013; Impellizzeri, et al., 2008; Jacobson, 2011; Lyons, Al-Nakeeb, & Nevill, 2006; Rampinini et al., 2008; Sinclair and Artis, 2013; Smith et al., 2016). However, a recent study (Serpiello, Cox, Oppici, Hopkins, & Varley, 2017), investigating the criterion validity of the LSPT in elite youth players demonstrated a poor correlation between the LSPT scores and in-game passing

performance thereby indicating the impracticality of the test for assessing the in-game passing performance. Notwithstanding the inherent limitations of their study design, the result encouraged reconsideration of the measurement properties and feasibility of the LSPT in order to inform further applications and scientific research.

The importance of ensuring that a designed test displays an adequate level of measurement quality including measurement properties (reliability, validity, and responsiveness) and feasibility (interpretability) is well-established (Currell and Jeukendrup, 2008; Robertson, Burnett, & Cochrane, 2014; Robertson, Kremer, Aisbett, Tran, & Cerin, 2017). Regardless of research or practical purposes, a field test possessing adequate measurement properties can provide more accurate, stable, and true information about the capacity of an individual. Moreover, the ability of a test to achieve feasibility of use and to well interpret difference or change in the exercise and sport science is also considered essential (Beaton, 2000; Robertson, et al., 2014). Previous reviews have examined the strengths and limitations of methods used to measure soccer skill performance (A. Ali, 2011; Russell and Kingsley, 2011); however to date, there has been no specific review addressing the LSPT. Considering its prevalence of use in both the field and research, such a review is required. The aim of this study is to systematically review the measurement properties and feasibility of the LSPT, as well as to evaluate the methodological quality of the reported literature.

Method

This systematic review was conducted according to the "Preferred Reporting Items for Systematic Reviews and Meta-Analyses" (PRISMA) guidelines (Moher, Liberati, Tetzlaff, Altman, & Group, 2009) and a published criteria checklist (Robertson, et al., 2017) that was developed to aid in assessing the measurement properties and feasibility of performance tests for exercise and sport sciences. The checklist consists of nineteen items which are divided into 2 levels. Ten level 1 items (re-test reliability, content validity, responsiveness, etc.) are considered essential under any circumstances, whereas nine level 2 items (stability, predictive validity, concurrent validity, etc.) are considered to be more context-specific in their application.

Search Strategy

Four electronic databases (PubMed, Scopus, SPORTDiscus, and Web of Science) were searched systematically for studies published before June 2017. The initial search terms included "Loughborough Soccer Passing Test" OR "LSPT" OR "passing test" OR "skill test". The second search terms included "reliab*" OR "reproducib*" OR "valid*" OR "respons*" OR "sensit*" OR "feasib*" OR "measurement properties" OR "measure*" OR "time" OR "scor*" OR "second". The third search terms included "football" OR "soccer". Finally, theses three search terms were combined using the operator "AND". Additional articles were identified by checking the reference lists of the included articles and related reviews.

Eligibility Criteria

Eligibility assessments were performed by two independent reviewers (DZW and BHS), and any disagreements were resolved by focused discussion or mediated by an additional investigator (HCC). The inclusion criteria to identify the studies were as follows: (1) studies with football participants irrespective of age, sex, or level; (2) studies in which the soccer skill was measured using the LSPT; (3) the LSPT total performance time (TT) were reported or could be obtained by the sum of movement time (MT) and penalty time (PT); (4) studies must report at least one aspect of reliability, validity, or responsiveness relating to the LSPT. Studies were excluded if they met the following criteria: (1) studies not reporting any valuable information on the measurement properties of LSPT; (2) studies were not original research, for instance reviews; (3) studies were not reported in the English language.

Data Extraction and Quality Assessment

The extraction and assessment of the included studies consisted of three steps: (1) Summary of the study characteristics; (2) Assessment of methodological quality; (3) Evaluation of measurement quality (measurement properties and feasibility). For the first step, we extracted the study characteristics containing author, year of publication, sample size, participant details, and the baseline mean MT, PT, and TT of the LSPT scores.

To assess methodological quality, we used a six-item spreadsheet based on the assessment criteria in a previous review on sport-related skill test (Robertson, et al., 2014). These six criteria encompassed (1) sample size; (2) participant details (sex, age, playing level); (3) inclusion/exclusion criteria; (4) a familiarization session (yes / no); (5) information relating to the stability of testing and participant conditions between testing sessions; (6) the amount of time between assessments, if applicable.

In the final step, we extracted the reliability, validity, responsiveness, and interpretability results from each article for assessing the measurement properties and feasibility. Reliability, including test-retest reliability, inter/intra-rater reliability and internal consistency reliability, was defined as the degree to which measurement is free from error (Baumgartner and Jackson, 1998). The correlation coefficient (*r*) or intraclass correlation coefficient (ICC) values of < 0.4, ≥ 0.4 to < 0.8 and ≥ 0.8 were rated as poor, moderate, and excellent, respectively (Helmerhorst, Brage, Warren, Besson, & Ekelund, 2012; Streiner, Norman, & Cairney, 2014). Validity is the degree to which a test measures the construct it claims to measure; it consists of content validity, construct validity (discriminative and convergent) and criterion validity (concurrent and predictive) (Portney and Watkins, 2009). The responsiveness reflects the ability of an instrument to detect change over time and is generally estimated by testing the statistical significance of the mean change scores. However, two important but often overlooked properties, smallest worthwhile change (SWC) calculated by 0.2 of the between-participants standard deviation (Hopkins, 2004), and

minimal detectable change (MDC) estimated as measurement error with a given level of confidence (Beaton, 2000), are often considered more practically meaningful for the evaluation of responsiveness; both useful indicators overcome the limitations of the “statistically significant difference” (Beaton, 2000; Copay, Subach, Glassman, Polly, & Schuler, 2007). Therefore, we further calculated the values of SWC and MDC according to a previous recommendation regarding the interpretation of changes in an athletic performance test (Hopkins, 2004). Only when a relevant change exceeds the SWC or MDC (when MDC $>$ SWC), the investigator can be confident that it is a real change most of the time and not just the measurement error (Hopkins, 2004). With respect to feasibility, we primarily focused on the interpretability (Mokkink et al., 2010) of the SWC or MDC (when MDC $>$ SWC) for use in discriminating the performers of different constructs (such as playing levels), and detecting a change in performance caused by an external intervention. Besides, we also paid attention to whether a test is easy to perform and administer. It is only when a test can be undertaken without excessive costs (e.g. long duration, a lot of examiners requirements, expensive high-end equipment or complex process) that it can be easily applied in practical environments such as teams and clubs.

Results

The initial database search identified 368 articles and a further eight were found via reference searching. After excluding the duplicates, 305 articles were retained for the

examination of the titles and abstracts. Of these, 41 were selected for full-text review and assessed according to the eligibility criteria. Finally, a total of 25 articles were included in the systematic review (Figure 1). Of these, 9 studies (A. Ali, et al., 2008; A. Ali, et al., 2007; Andrade-Souza, et al., 2015; Benounis, et al., 2013; Huijgen, et al., 2013; Le Moal, et al., 2014; McDermott, et al., 2015; Naser and Ali, 2016; O'Regan, et al., 2007; Serpiello, et al., 2017) focused on reliability and validity, and 15 studies (A. Ali, et al., 2011; A. Ali and Williams, 2009; H. M. Ali, et al., 2016; Andrade-Souza, et al., 2015; Draganidis, et al., 2013; Foskett, et al., 2009; Gant, et al., 2010; Impellizzeri, et al., 2008; Jacobson, 2011; Lyons, et al., 2006; Owen, et al., 2013; Rampinini, et al., 2008; Sinclair and Artis, 2013; Smith, et al., 2016; Zago, et al., 2016; Zois, et al., 2013) reported the responsiveness to some external interventions, plus one study (Andrade-Souza, et al., 2015) that assessed both domains. Table 1 summarized the characteristics of the included studies, and the baseline LSPT scores from each study group are sorted in an ascending order (relating to time) in Figure 2.

Study Methodological Quality

Table 2 shows the methodological quality of the included studies. The majority of the studies (84%) provided adequate details of the participants, with 16% missing at least one characteristic (such as sex and playing level). Only 24% of the studies reported both inclusion and exclusion criteria, while a majority of the remaining studies did not

report whether the goalkeepers were excluded. Sample sizes of the included studies varied greatly (n = 8-319); only 16% utilized a sample size $>$ 50, whereas 72% had $<$ 30. All studies required their participants to attend at least one familiarisation session prior to main testing, except one conference abstract (O'Regan, et al., 2007) that did not provide this information. A total of 84% of the studies reported the stability of conditions adequately, whereas the remaining 16% of the studies did not or partially reported. The amount of time between the two assessments was also reported in 84% of the studies, whereas it was either not report or not available in the reminding 16%.

Reliability

Six studies (A. Ali, et al., 2008; A. Ali, et al., 2007; Andrade-Souza, et al., 2015; Benounis, et al., 2013; Le Moal, et al., 2014; McDermott, et al., 2015) examined the test-retest reliability of the LSPT scores (MT, PT and TT) without addressing either inter-rater reliability or internal consistency reliability (Table 3). The most commonly reported statistical approaches were r coefficient (A. Ali, et al., 2008; A. Ali, et al., 2007; Le Moal, et al., 2014), ICC (A. Ali, et al., 2007; Andrade-Souza, et al., 2015; Benounis, et al., 2013; McDermott, et al., 2015), coefficient of variation (CV%) (A. Ali, et al., 2008; A. Ali, et al., 2007; Le Moal, et al., 2014), and 95% limits of agreement (LoA) (A. Ali, et al., 2008; A. Ali, et al., 2007; Le Moal, et al., 2014; McDermott, et al., 2015). Overall, for the MT and TT to perform the LSPT, the

correlation between the test and retest was moderate to excellent (MT: r = 0.50-0.81, ICC = 0.63-0.92; TT: r = 0.43-0.99, ICC = 0.42-0.93). However, the PT for inaccurate passing and poor control during testing showed widely varied levels of reliability with low to excellent correlation between the tests (r = 0.22-0.86, ICC = 0.26-0.89). Table 4 shows the standard error of measurement (SEM) of LSPT in different populations, with test data obtained from three comparable included studies (A. Ali, et al., 2008; A. Ali, et al., 2007; McDermott, et al., 2015).

None of the included 25 studies assessed the internal consistency reliability. Thus we extracted and tabulated the baseline MT and PT data from the included studies (a total of 32 groups from 22/25 studies), and calculated the Pearson's correlation coefficient (r = 0.50), as shown in Figure 3. Then, the r coefficient was converted to adjusted Cronbach's alpha (α = 0.67) using the Spearman–Brown formula (Eisinga, Grotenhuis, & Pelzer, 2013).

Validity

The content validity, which was defined as how well a specific test measures what it intends to measure (Robertson, et al., 2014), can only be deduced from a simple description in Ali et al. study (A. Ali, et al., 2007). The authors stated that the LSPT was developed by their expert panel (consisting of Ajmol Ali, Clyde Williams, Mark Hulse, Anthony Strudwick, Jonathan Reddin, Lee Howarth, John Eldred, Matthew Hirst and Steve McGregor) in order to "assess the multi-faceted aspects of soccer

skill, including passing, dribbling, control, and decision making within the match-play".

The construct validity was assessed in eight studies (A. Ali, et al., 2008; A. Ali, et al., 2007; Huijgen, et al., 2013; Le Moal, et al., 2014; McDermott, et al., 2015; Naser and Ali, 2016; O'Regan, et al., 2007) (Table 3). 7/8 studies used three different statistical analyses (*t*-tests, ANOVA, or multilevel model) to detect the statistical significance. The LSPT was demonstrated to exhibit good discriminative validity while examining the individual differences between the playing levels (A. Ali, et al., 2008; A. Ali, et al., 2007; Le Moal, et al., 2014; Naser and Ali, 2016; O'Regan, et al., 2007) and ages (Huijgen, et al., 2013; McDermott, et al., 2015). Only one study (Benounis, et al., 2013) investigated the convergent validity for a variety of associated measures, and demonstrated that the LSPT TT was positively correlated to the sprint tests (r = 0.49-0.60), 15 m agility run (r = 0.75), 15 m ball dribbling (r = 0.71) and the Illinois agility test (r = 0.72).

Four studies assessed the criterion validity of the LSPT. (Table 3) Of these, three studies (A. Ali, et al., 2008; A. Ali, et al., 2007; Huijgen, et al., 2013) investigated the concurrent validity utilizing the median-split analysis or *t*-tests, and displayed a strong association between the LSPT scores and concurrent expected participant rankings. However, the remaining study (Serpiello, et al., 2017) examined the predictive validity of the LSPT in elite youth players and demonstrated a poor

correlation (r = 0.30-0.47) of the test scores with passing performance during subsequent competitive games.

Responsiveness

The ability of the LSPT to detect changes or differences in the individual was explored in 16 studies utilizing various statistical methods including ANOVA, general linear model, and *t*-tests. (Table 5) Six studies (A. Ali, et al., 2011; A. Ali and Williams, 2009; Andrade-Souza, et al., 2015; Foskett, et al., 2009; Gant, et al., 2010; Owen, et al., 2013) investigated the effect of fluid ingestion on LSPT performance after a 90-min intermittent exercise; except one (Foskett, et al., 2009), all the studies reported no improvement in LSPT scores when different fluid intake protocols were used. Seven studies (Draganidis, et al., 2013; Impellizzeri, et al., 2008; Jacobson, 2011; Lyons, et al., 2006; Rampinini, et al., 2008; Sinclair and Artis, 2013; Smith, et al., 2016) reported the impact of physical, mental or mixed match-related fatigue on the LSPT performance, all studies, except one (Jacobson, 2011), demonstrated an impairment in at least one of the three LSPT outcomes (MT, PT, or TT). In the remaining three studies, different learning (H. M. Ali, et al., 2016), training (Zago, et al., 2016), and warm-up (Zois, et al., 2013) strategies were considered to be beneficial effects on the LSPT performance.

Owing to the absence of SWC or MDC values in the included studies, we calculated these two indicators for the LSPT based on the between-athlete standard

deviation (SD) and SEM derived from the reliability studies (A. Ali, et al., 2008; A. Ali, et al., 2007; Le Moal, et al., 2014; McDermott, et al., 2015) described above (Table 6). The MDC values (MDC_{50} and MDC_{95}) were defined at two different levels of confidence (50% and 95%). It is only when an individual's difference or change score exceeded these levels, that the interpretation of the different test scores can be right $>$ 50% or $>$ 95% of the time.

Feasibility

As shown in Table 6, MDC values were distinctly greater than SWC, especially the MDC_{95}. Accordingly, any change or difference greater than the MDC threshold is considered meaningful. Figures. 4 and 5, combined with results obtained from the included 24/25 studies that reported discriminative validity or responsiveness, showed where the raw and percentage difference or change in the LSPT TT are located in the MDC threshold range (minimum to maximum). From these figures, the majority of the difference values used for discriminating the players of different levels and ages were greater than the maximum of MDC_{50}, but less than the maximum of MDC_{95}. However, most of the change values caused by various external interventions were lower than the maximum of MDC_{50} and the minimum of MDC_{95}. Finally, a summary checklist of the measurement quality for the LSPT was displayed in Table 7. As seen in the table, the LSPT is relatively easy to perform and administer (e.g. short duration, two examiners, simple process, and low-cost resources).

Discussion

This is the first review comprehensively investigating the LSPT and contributing to our understanding of its measurement properties and feasibility systematically. On the whole, the LSPT has a certain degree of practical application with ease of undertaken and administered, acceptable retest reliability, and relatively good discriminative validity for the evaluation of participants of different playing levels and ages. Conversely, the ability of LSPT to relate with similar measures or an accepted external practical standard is unclear and even questionable due to current insufficient evidence. Notably, current research is not yet available on some important properties such as inter-rater reliability, internal consistency, SWC and MDC. Therefore, this systematic review, with an overall perspective of available evidence, will serve as a valuable reference for future applications and scientific research of the LSPT.

Study Methodological Quality

The major limitation with the included studies was the small sample size, and very few studies provided evidence of having performed a sample size calculation. An appropriate sample size would contribute to define the relatively precise estimates of reliability or validity that will increase the statistical power to detect small but important change or difference (Copay, et al., 2007). Authors should confirm whether the sample sizes were adequate to achieve the purposes at the beginning of their future work. Moreover, the lack of clear participant details and eligibility criteria in many

studies should be noted. Authors should be suggested to provide sufficient information to allow the reader to generalize the study to a specific population. Notably, a final consideration focuses on the amount of time was varied between the assessments in the studies. Although it is difficult to provide an objective standard for an exact interval duration, authors are recommended to avoid using excessively long or short intervals, as this would reduce the impact of fatigue or skill improvement (Hopkins, 2000).

Reliability

By assessing the evidence included, we found two apparent flaws in reliability. First, we found no evidence for inter-rater reliability. The investigator of the LSPT was responsible for deciding the accuracy of the pass and performance. Despite the strict guidelines, different investigators might award different scores to the same participant (A. Ali, 2011). Thus, further studies are essential for addressing this issue. Second, as the LSPT total performance time (TT) consists of two components: movement time (MT) and penalty time (PT), the internal consistency of the test should be checked; however, any evidence does not exist. According to our statistical estimate, the adjusted Cronbach's alpha was 0.67, this was a potential concern as values lower than 0.7 indicate that the internal consistency reliability was questionable (Kline, 2000). Thus, whether the two components (MT and PT) measure a single unidimensional latent construct is still unclear. Therefore, the rationality of scoring method of the

LSPT (e.g. the outcome measure is expressed in time rather than distance, the passing inaccuracy is translated as time penalty rather than scale score, and the assumption of equal distance on the scale between MT and PT) might necessitate re-examination. For instance, While the test-retest reliability of the LSPT TT was acceptable, the LSPT PT was largely variable (r = 0.22-0.86, ICC = 0.26-0.89) in assessing the passing accuracy, which indicated that the penalty component of the test could be improved further.

In addition to the internal structure of the test, the participants' characteristics such as playing level, age, and sex also affected the measurement error which is an alternative representation of reliability. As shown in Table 4, the reduction in the measurement errors was accompanied by a higher playing level, older age and male sex. This trend might be related to the penalty rule of the test; a penalty time of 1 s was awarded 1 s every second taken over the allocated 43 s to complete the test. Hence, as suggested by previous studies (A. Ali, 2011; A. Ali, et al., 2007), researchers are recommended to use highly skilled adult male players when using the LSPT for detecting small but important change or difference in performance. A modified version of the LSPT with adjustable penalty threshold would be optimal for use with a specific population.

Validity

Results from the included studies demonstrated the ability of LSPT to discriminate

players of different competitive levels, whether male or female, adult or adolescent. Moreover, the discrimination of players by age and sex can also be clearly identified from Figure 2, wherein a total of 35 groups from 25 studies were sorted in an ascending order. The first half of the bar graph (18 groups, LSPT TT from 40.2 s to 56.4 s) demonstrated that all participants were males and only two groups with participants from high-level state representative team were aged less than 18 years; whereas, in the second half of the bar graph (17 groups, LSPT TT from 58.1 s to 97.5 s), only four groups were aged more than 18 years, and the participants were females in three of these four groups.

Only two studies focused on the relationship between the LSPT and other external measures or standard. The findings indicated that the LSPT scores were strongly correlated with motor speed, agility and leg power (Benounis, et al., 2013); however, it was correlated poorly with the in-game passing performance (Serpiello, et al., 2017). This may be relevant to the ability of the LSPT to assess not only the passing technique, but also the multiple soccer skills including passing, dribbling, control, and decision making. Owing to inadequate reporting and inherent limitation of the study design such as defined populations, fewer samples, multi-factor influences on in-game performance, and uncertain reliability and validity of the designed analytical method itself, the available evidence is relatively limited for drawing definite conclusions, further investigations are essential.

Responsiveness and Feasibility

Previous studies (H. M. Ali, et al., 2016; Foskett, et al., 2009; Impellizzeri, et al., 2008; Zago, et al., 2016; Zois, et al., 2013) have demonstrated that the LSPT performance of soccer players responds to some external interventions. The ability of a test to monitor the statistical significant change in an experimental study is influenced not only by the size of the sample being tested; but also by the measurement error of the test itself (Copay, et al., 2007). In addition, only the amount of difference or change greater than the SWC or MDC threshold can be considered to be meaningful or worthwhile, which renders the test feasible for interpreting the inter-individual difference or intra-individual change in practice (Hopkins, 2004).

The range of the MDC threshold values were calculated based on the SEM of the test obtained from included studies. As demonstrated in Figures. 4 and 5 with MDC_{50} for reference, the LSPT is practically feasible for examining the inter-individual differences between players of different playing levels and ages; however, its ability to detect intra-individual change of skill performance over a period under most of the external interventions is still unclear. However, at the 95% confidence level (MDC_{95}), nearly all the differences and changes are considered to be unclear or even undetectable, although the LSPT is able to discriminate the players of different playing levels under specific conditions (e.g. adult male soccer). As an earlier article suggested (Hopkins, 2004), MDC_{95} may be too conservative and impractical for athlete testing; thus we used 50% as our confidence level of MDC. Nevertheless,

further improvements of testing reliability (e.g. re-checking the rationality of scoring method and improving the way of scoring in assessing the passing accuracy) and modified versions of the LSPT (e.g. increasing or decreasing the penalty threshold according to different populations) are strongly recommended.

Limitations

One limitation of our review was that some important properties such as inter-rater reliability, internal consistency, SWC and MDC were not reported in the literature; thus, we were only able to make estimates based on the available data. A second limitation was that the use of LSPT as a valid test of in-game passing performance was still questioned due to inadequate evidence on the criterion validity. In addition, the applicability of the test to general population was unclear, as female adolescent samples were absent. Furthermore, we retrieved papers written in only English, and did not contact authors to seek missing or unpublished data.

Conclusion

This systematic review indicated that the LSPT has acceptable test-retest reliability and discriminative validity to assess the multi-faceted aspects of soccer skill, although these properties are influenced by factors such as playing level, age and sex. Future studies should concentrate on establishing the inter-rater reliability, internal consistency and criterion validity of the test. Despite the responsiveness to an external intervention in some experimental studies, the LSPT may not be effective in

interpreting the intra-individual changes of skill performance in practice due to the large measurement error (SEM of TT: range from 1.9 to 11.3 s). Further work should be carried out to improve the testing reliability and to add more modified versions for the LSPT.

Disclosure statement

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33 **Table 1** Characteristics of included studies

Study	Sample size, *n*	Participants	Mean age (SD), years	Gender	Baseline mean MT / PT / TT (SD), s	Measurement properties outcome
A. Ali, et al. (2007)	48	University Association Football Club players Elite (*n* = 24); Non-elite (*n* = 24)	Elite: 20.5 (2.0); Non-elite: 19.9 (0.8)	Male	Elite: 40.2 (2.5) / 3.3 (3.2) / 43.6 (3.8); Non-elite: 42.2 (3.7) / 10.3 (4.8) / 52.5 (7.4); ALL: 41.2 (3.2) / 6.8 (5.4) / 48.0 (7.3)	Reliability (test-retest); Validity (construct and criterion)
A. Ali, et al. (2008)	35	Local club players Elite (*n* = 19); Non-elite (*n* = 16)	Elite: 20.9 (4.9); Non-elite: 23.3 (8.3)	Female	Elite: 54.6 (5.3) / 22.8 (7.2) / 77.4 (11.6); Non-elite: 61.6 (6.5) / 35.9 (11.5) / 97.5 (17.2); ALL: 57.6 (6.6) / 29.9 (10.5) / 87.5 (15.8)	Reliability (test-retest); Validity (construct and criterion)
Andrade-Souza, et al. (2015)	11	University soccer players	25.4 (2.3)	Male	NR / NR / 48.5 (14.9)	Reliability (test-retest); Responsiveness (fluid ingestion)
Benounis, et al. (2013)	42	Tunisian Championship Division 1 soccer players	14.8 (0.4)	Male	45.8 (3.9) / 16.8 (6.9) / 62.6 (9.1)	Reliability (test-retest); Validity (construct);
Huijgen, et al. (2013)	319	Netherlands professional soccer club development programs U12-U19 Selected (*n* = 269); De-selected (*n* = 50)	10-18	NR	Selected: 39.6-47.1 / 0.6-10.3 / 40.2-57.4; De-selected: 43.4-48.0 / 3.4-5.9 / 49.3-61.4[a]	Validity (criterion)
Le Moal, et al. (2014)	87	French soccer players Elite (*n* = 44); Sub-elite (*n* = 22); Non-elite (*n* = 21)	Elite: 15.1 (0.5); Sub-elite: 15.3 (0.5); Non-elite: 15.1 (0.5)	Male	Elite: 35.9 (4.7) / 4.3 (5.8) / 40.3 (8.3); Sub-elite: 42.2 (3.3) / 15.9 (9.0) / 58.1 (10.2); Non-elite: 46.0 (5.8) / 20.6 (8.6) / 66.6 (11.7)	Reliability (test-retest); Validity (construct)

McDermott, et al. (2015)	77	Local club or school U13-Competitive (*n* = 26); U13-Recreational (*n* = 26); U19-Competitive (*n* = 25)	U13-Competitivec: 11.49 (0.6); U13-Recreational: 11.16 (0.9); U19-Competitive: 20.2 (1.5)	Male	U13-Competitive: 50.7 (8.5) / 8.8 (6.2) / 60.3 (12.7); U13-Recreational: 62.7 (4.0) / 12.4 (7.8) / 75.9 (14.0); U19-Competitive: 44.2 (9.9) / 5.6 (5.5) / 50.4 (7.5)a	Reliability (test-retest); Validity (construct)
Naser and Ali (2016)	24	NZ Futsal league players Elite (*n* = 8); Sub-elite (*n* = 8); Non-elite (*n* = 8)	Elite: 24.2(2.7); Sub-elite: 22.8(3.6); Non-elite: 26.2(3.1)	Male	Elite: 43.6 (3.1) / 3.1 (2.3) / 46.6 (5.3); Sub-elite: 47.5 (3.3) / 6.1 (3.3) / 53.6 (5.9); Non-elite: 49.7 (4.3) / 6.7 (2.6) / 56.4 (4.8)	Validity (construct)
O'Regan, et al. (2007)	17	Early pubescent soccer players Sub-elite (*n* = 8); Novice (*n* = 9)	11-12	NR	Sub-elite: 61.4 / 6.8 / 68.2; Non-elite: 65.2 / 16.2 / 81.4	Validity (construct)
Serpiello, et al. (2017)	22	Australian U18 national team soccer players	15.1 (0.6)	Male	43.5 (2.9) / 3.1 / 46.6 (6.0)	Validity (criterion)
H. M. Ali, et al. (2016)	90	Basic 9th school students	15.5 (0.5)	Male	56.2 (3.7) / 16.3 (4.8) / 72.5 (7.4)	Responsiveness (learning)
Zago, et al. (2016)	26	Regional U12 sub-elite soccer players	11.5 (0.27)	Male	51.4 (3.91) / 17.2 (8.0) / 68.7 (11.0)	Responsiveness (training)
Zois, et al. (2013)	8	Federation Division 1 soccer players	23.6 (4.1)	Male	NR / NR / 55.3 (5.9)[a]	Responsiveness (warm-up)
A. Ali and Williams (2009)	17	University team soccer players	20.9 (2.5)	Male	37.4 (2.0) / 4.3 (4.1) / 41.6 (4.6)[a]	Responsiveness (fluid ingestion)
A. Ali, et al. (2011)	10	Local Premier Division or higher soccer players	25.5 (5.2)	Female	52.5 (4.3) / 27.6 (9.1) / 80.0 (11.5)	Responsiveness (fluid ingestion)

Foskett, et al. (2009)	12	Regional Premier Division soccer players	23.8 (4.5)	Male	42.4 (3.7) / 9.2 (4.2) / 51.6 (6.6)	Responsiveness (fluid ingestion)
Gant, et al. (2010)	14	Regional Premier Division soccer players	21.3 (3.0)	Male	40.2 (3.4) / 12.9 (9.6) / 53.1 (7.9)	Responsiveness (fluid ingestion)
Owen, et al. (2013)	13	Semi-professional standard team soccer players	22.2 (3.1)	Male	45.2 (2.5) / 3.2 (2.3) / 48.5 (4.1)	Responsiveness (fluid ingestion)
Draganidis, et al. (2013)	10	Local U21 Division 1 soccer players	20 (0.7)	Male	NR / NR / 53.3 (4.7)	Responsiveness (fatigue)
Impellizzeri, et al. (2008)	26	Junior soccer team players	17.8 (0.6)	NR	Pre-fatigue: 44.7 (5.8) / 16.1 (3.1) / 60.7 (4.1); Pre-training: 46.2 (6.4) / 15.4 (4.8) / 61.9 (4.2)[a]	Responsiveness (fatigue and training)
Lyons, et al. (2006)	20	College students	22.9 (5.3)	Male	41.1 (10.8) / 13.5 (6.1) / 54.6	Responsiveness (fatigue)
Rampinini, et al. (2008)	16	Professional soccer team junior players	17.6 (0.5)	NR	48.6 (3.0) / 17.1 (7.5) / 65.6 (9.5)	Responsiveness (fatigue)
Smith, et al. (2016)	14	Belgian league Division 2-7 soccer players	19.6 (3.5)	Male	47.9 (4.1) / 5.2 (7.6) / 53.1 (10.5)	Responsiveness (fatigue)
Sinclair and Artis (2013)	12	Regional academy team soccer players	13.7 (0.5)	Male	49.5 (0.7) / 13.7 (1.5) / 63.2 (2.0)	Responsiveness (fatigue)
Jacobson (2011)	12	University soccer team players	19.4 (1.8)	Male	51.3 (4.6) / 16.8 (8.6) / 68.1 (12.2)	Responsiveness (fatigue)

[a] = data derived from figure; SD = standard deviation; NR = not report; MT = movement time (s); PT = penalty time (s); TT = total performance time (s).

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Table 2 Methodological quality of the reviewed studies

Study	Details of participants	Inclusion / exclusion criteria	Sample size	Familiarization session	Stability of conditions	Time between assessments
A. Ali, et al. (2007)	Yes	Partial	++	Yes	Yes	YES (1 day)
A. Ali, et al. (2008)	Yes	Partial	++	Yes	Yes	YES (7 days)
Andrade-Souza, et al. (2015)	Yes	Partial	+	Yes	Yes	YES (7 days)
Benounis, et al. (2013)	Yes	Partial	++	Yes	Yes	NR
Huijgen, et al. (2013)	Partial	Yes	++++	Yes	Yes	NA
Le Moal, et al. (2014)	Yes	Partial	+++	Yes	Yes	YES (10 min and 7 days)
McDermott, et al. (2015)	Yes	Partial	+++	Yes	Partial	YES(Immediately and 7 day)
Naser and Ali (2016)	Yes	Partial	+	Yes	Yes	YES (2 days)
O'Regan, et al. (2007)	Partial	NR	+	NR	NR	NA
Serpiello, et al. (2017)	Partial	Yes	+	Yes	NR	NA
H. M. Ali, et al. (2016)	Yes	Partial	+++	Yes	Yes	NA
Zago, et al. (2016)	Yes	Yes	+	Yes	Yes	YES (22 weeks)
Zois, et al. (2013)	Yes	Partial	+	Yes	Yes	YES (15 min)
A. Ali and Williams (2009)	Yes	Partial	+	Yes	Yes	YES (7 days)
A. Ali, et al. (2011)	Yes	Partial	+	Yes	Yes	YES (7 days)
Foskett, et al. (2009)	Yes	Yes	+	Yes	Yes	YES (7 days)
Gant, et al. (2010)	Yes	Partial	+	Yes	Yes	YES (7 days)
Owen, et al. (2013)	Yes	Partial	+	Yes	Yes	YES (7 days)
Draganidis, et al. (2013)	Yes	Partial	+	Yes	Yes	YES (40-45 min)
Impellizzeri, et al. (2008)	Partial	Yes	+	Yes	Partial	YES (5 min)
Lyons, et al. (2006)	Yes	Partial	+	Yes	Yes	YES (1 min)
Rampinini, et al. (2008)	Yes	NR	+	Yes	Yes	YES (90 min and 5min)

Smith, et al. (2016)	Yes	Partial	+	Yes	Yes	YES (30 min)
Sinclair and Artis (2013)	Yes	Partial	+	Yes	Yes	YES (4 days)
Jacobson (2011)	Yes	Yes	+	Yes	Yes	YES (90 min and 5min)

+ = less than 30 participants; ++ = between 30 and 49 participants; +++ = between 50 and 99 participants; ++++ = more than 100 participants; NA = not applicable to this particular investigation; NR = not reported.

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Table 3 Reliability and validity of the LSPT

Study	Reliability (MT / PT / TT)	Validity (MT / PT / TT)			
	Test-retest	Construct		Criterion	
		Discriminative	Convergent	Concurrent	Predictive
A. Ali, et al. (2007)	Elite (*r* = 0.75 / 0.37 / 0.43; ICC = 0.75 / 0.37 / 0.42; CV% = 4.7 / NA / 11.2; %95LoA = -5.1 to 2.3 / -9.8 to 7.4 / -12.2 to 7.0) Non-elite (*r* = 0.70 / 0.38 / 0.51; ICC = 0.65 / 0.38 / 0.51; CV% = 8.0 / NA / 16.0; %95LoA = -9.0 to 4.2 / -16.0 to 9.2 / -21.8 to 11.2) ALL (*r* = 0.73 / 0.58 / 0.64; ICC = 0.70 / 0.58 / 0.64; CV% = 6.7 / NA / 14.4; %95LoA = -7.2 to 3.6 / -13.2 to 8.6 / -17.4 to 9.6)	Playing levels: *t*-tests Elite vs. Non-elite (MD = -2.0 / -7.0 / -8.9, *P* < 0.05)	NR	Expected rankings: Median-split analysis (the majority of players were in the expected group)	NR
A. Ali, et al. (2008)	Elite (*r* = 0.67 / 0.39 / 0.55; CV% = 8.8 / NA / 17.1; %95LoA = -9.4 to 9.2 / -23.2 to 15.6 / -29.9 to 22.1) Non-elite (*r* = 0.80 / 0.54 / 0.66; CV% = 7.0 / NA / 16.7; %95LoA = -7.6 to 9.2 / -25.8 to 25.2 / -31.5 to 32.5) ALL (*r* = 0.81 / 0.63 / 0.73; CV% = 7.8 / NA / 17.0; %95LoA = -8.5 to 9.1 / -24.6 to 20.2 / -30.7 to 26.9)	Playing levels: *t*-tests Elite vs. Non-elite (MD = -7.0 / -13.1 / -20.1, *P* < 0.01)	NR	Expected rankings: Median-split analysis (the majority of players were in the expected group)	NR
Andrade-Souza, et al. (2015)	ICC = NR / NR / 0.84	NR	NR	NR	NR

Benounis, et al. (2013)	ICC = 0.92 / 0.89 / 0.93	NR	Alternate measures: Pearson correlation coefficient Sprints tests (*r* = 0.18-0.36 / 0.32-0.54 / 0.49-0.60) Agility-15m (*r* = 0.39 / 0.71 / 0.75) Ball-15m (*r* = 0.51 / 0.62 / 0.71) Illinois agility test (*r* = 0.18 / 0.65 / 0.72)	NR	NR
Huijgen, et al. (2013)	NR	Ages: Multilevel models analysis (*P* <0.01)	NR	Expected rankings: *t*-tests Selected vs. De-selected (MD = NS / NR / 4.0-9.1,*P* < 0.05)	NR
Le Moal, et al. (2014)	Elite (*r* = 0.73 / 0.86 / 0.96; CV% = 1.2 / NA / 1.8; %95LoA = -10.0 to 9.8 / -10.2 to 9.4 / -8.7 to 7.7) Sub-elite (*r* = 0.77 / 0.22 / 0.35; CV% = 1.7 / NA / 1.8; %95LoA = -6.2 to 4.6 / -22.2 to 22.8 / -24.4 to 23.4) Non-elite (*r* = 0.50 / 0.53 / 0.47; CV% = 1.8 / NA / 3.9; %95LoA = -12.1 to 10.9 / -17.2 to 15.6 / -25.2 to 22.4)	Playing levels: ANOVA Elite vs. Sub-elite (MD = -6.3 / -11.6 / -17.8, *P* < 0.01) Elite vs. Non-elite (MD = -10.1 / -16.3 / -26.3, *P* < 0.01) Sub-elite vs. Non-elite (MD =-3.8 / -4.7 / -8.5, *P* < 0.01)	NR	NR	NR
McDermott, et al. (2015)	U13-Competitive (ICC = 0.85 / 0.50 / 0.80; %95LoA = -7.5 to 8.0 / -9.5 to 8.4 / -13.5 to 13.0) U13-Recreational (ICC = 0.63 / 0.26 / 0.51; %95LoA = -13.2 to 11.4 / -9.7 to 22.9 / -11.0 to 23.2)	Playing levels: ANOVA U13-Competitive vs. U13-Recreational (MD = -12 / -3.6 / -15.6, *P* < 0.05)	NR	NR	NR

	U19-Competitive (ICC = 0.91 / 0.69 / 0.92; %95LoA = -3.6 to 2.0 / -4.8 to 7.4 / -4.0 to 6.6)	Ages: ANOVA U13-Competitive vs. U19-Competitive (MD = -6.5 / NS / -9.9, $P < 0.05$)[a]			
Naser and Ali (2016)	NR	Playing levels: ANOVA Elite vs. Non-elite (MD = -3.9 / -3.0 / -7.0, $P < 0.01$)	NR	NR	NR
O'Regan, et al. (2007)	NR	Playing levels: *t*-tests Sub-elite vs. Non-elite (MD = -3.8 / -9.4 / -13.2, $P < 0.05$)	NR	NR	NR
Serpiello, et al. (2017)	NR	NR	NR	NR	Match passing performance: Adjusted validity coefficient (*r* = 0.39-0.46 / NR / 0.30-0.47)

[a] = data derived from figure; MT = movement time (s); PT = penalty time (s); TT = total performance time (s); MD = mean difference (s); NR = not report; NS = not significant; *r* = correlation coefficients; ICC = intraclass correlation coefficient; CV = coefficient of variation; LoA = limits of agreement (s); ANOVA = analysis of variance.

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Table 4 SEM (s) of the LSPT in different group

	Male		Female	
	Elite	Non-elite	Elite	Non-elite
Adult	3.47	5.96	9.19	11.31
Adolescent	4.78	6.17		

SEM = standard error of measurement (s).

Table 5 Responsiveness of the LSPT

Study	Responsiveness	Mean MT / PT / TT (SD), s		Mean difference in MT / PT / TT, s	Statistical analyses (MT / PT / TT)
		Pre-stage or control	Post-stage or intervention		
H. M. Ali, et al. (2016)	Learning strategy (visual and verbal)	56.2 (3.7) / 16.3 (4.8) / 72.5 (7.4)	Verbal: 55.3 (4.3) 13.2 (3.7) 62.8 (4.3); Visual and Verbal: 49.5 (4.7) / 9.4 (3.8) / 58.9 (5.4)	Verbal: -0.9 / -3.1 / -9.7; Visual and verbal: -6.7 / -6.9 / -13.6	ANOVA Verbal: (NS / 19% / 13% improved, $P < 0.05$); Visual and Verbal: (12% / 42% / 19% improved, $P < 0.01$);
Zago, et al. (2016)	Training (combined technique and agility)	51.4 (3.91) / 17.2 (8.0) / 68.7 (11.0)	48.1 (4.0) / 16.2 (4.3) / 64.5 (6.8)	-3.3 / -1.0 / -4.2	ANOVA (6.4% / NS / NS improved, $P < 0.05$)
Zois, et al. (2013)	Warm-up strategy (3-min small-sided game)	NR / NR / 55.3 (5.9)[a]	NR / NR / 51.7 (4.0)[a]	NA / NA / -3.6	Effect size statistics (NR / NR / 7% improved)
A. Ali and Williams (2009)	Fluid ingestion (Carbohydrate)	38.3 (4.2) / 5.9 (5.9) / 44.2 (7.8)a	37.6 (1.9) / 5.2 (6.0) / 42.8 (6.0)[a]	-0.7 / -0.7 / -1.4	ANOVA (NS / NS / NS improved, $P > 0.05$)
A. Ali, et al. (2011)	Fluid ingestion (water)	51.5 (5.5) / 34.8 (9.3) / 86.3 (14.1)	50.5 (5.9) / 31.0 (11.1) / 81.5 (14.3)	-1.0 / -3.8 / -4.8	ANOVA (NS / NS / NS improved, $P > 0.05$)
Andrade-Souza, et al. (2015)	Fluid ingestion (carbohydrate and / or caffeine)	NR / NR / 42.1 (2.8)[a]	Carbohydrate: NR / NR / 45.2 (4.1); Caffeine: NR / NR / 41.0 (3.9); Carbohydrate+Caffeine: NR / NR / 45.4 (3.1)[a]	Carbohydrate: NR / NR / 3.1; Caffeine: NR / NR / -1.1; Carbohydrate+Caffeine: NR / NR / 3.3	General linear model Carbohydrate and / or caffeine: (NS / NS / NS improved, $P > 0.05$)
Foskett, et al. (2009)	Fluid ingestion (caffeine)	42.8 (3.4) / 12.1 (6.3) / 54.8 (6.9)	41.5 (3.4) / 9.5 (7.7) / 51.0 (7.4)	-1.3 / -2.6 / -3.8	ANOVA (NS / 20% / 4.3% improved, $P < 0.05$)
Gant, et al. (2010)	Fluid ingestion (carbohydrate and caffeine)	40.8 (4.1) / 15.1 (9.9) / 55.9 (12.5)	39.6 (4.1) / 14.6 (9.9) / 54.2 (9.7)	-1.2 / -0.5 / -1.7	General linear model (NS / NS / NS improved, $P > 0.05$)

Owen, et al. (2013)	Fluid ingestion (libitum or prescribed fluid)	47.9 (4.1) / 6.7 (2.1) / 54.6(4.2)	Libitum: 48.4 (2.3) / 6.8 (2.2) / 55.3 (3.2); Prescribed: 47.5 (2.7) / 5.8 (2.0) / 53.3 (3.8)	Libitum: 0.5 / 0.1 / 0.7; Prescribed: -0.4 / -0.9 / -1.3	General linear model (NS / NS / NS improved, $P > 0.05$)
Draganidis, et al. (2013)	Fatigue (HIE: resistance)	NR / NR / 53.3 (4.7)	NR / NR / 56.1 (3.1)[a]	NA / NA / 2.8	ANOVA (NA / NA / 5% impaired, $P < 0.05$)
Impellizzeri, et al. (2008)	Fatigue (HIE: running), Training (aerobic interval)	Pre-HIE: 44.7 (5.8) / 16.1 (3.1) / 60.7 (4.1); Pre-training: 46.2 (6.4) / 15.4 (4.8) / 61.9 (4.2)[a]	Post-HIE: 45.8 (5.8) / 20.3 (2.9) / 66.1 (4.7); Post-training: 43.9 (3.7) / 14.9 (3.9) / 59.0 (2.2)[a]	HIE: 1.1 / 4.2 / 5.4; Training: -0.8 / -1.2 / -1.7	ANOVA HIE: (3% / 26% / 9% impaired, $P < 0.05$); Training: (NS / NS / NS improved, $P > 0.05$)
Lyons, et al. (2006)	Fatigue (HIE: split squats)	41.1 (10.8) / 13.5 (6.1) / 54.6	44.3 (10.7) / 17.0 (6.9) / 61.3	3.2 / 3.5 / 6.7	ANOVA (8% / 26% / 12% impaired, $P < 0.05$)
Rampinini, et al. (2008)	Fatigue (HIE: running, Match)	Pre-HIE: 48.6 (3.0) / 17.1 (7.5) / 65.6 (9.5); Pre-match: 48.8 (3.3) / 16.9 (7.8) / 65.2 (9.7)	Post-HIE: 48.7 (3.7) / 20.4 (7.4) / 69.1 (9.8); Post-match: 50.9 (3.2) / 27.3 (6.3) / 78.1 (7.4)	HIE: 0.1 / 3.3 / 3.5; Match: 2.3 / 10.2 / 12.5	ANOVA HIE: (NS / 19% / NS impaired ,$P < 0.05$); Match: (5% / 62% / 20% impaired, $P <0.01$)
Smith, et al. (2016)	Fatigue (Stroop mentally fatiguing task)	47.9 (4.1) / 5.2 (7.6) / 53.1 (10.5)	47.8 (4.9) / 9.9 (6.5) / 57.7 (8.5)	-0.1 / 4.7 / 4.6	*t*-tests (NS / 90% / NS impaired, $P < 0.05$)
Sinclair and Artis (2013)	Fatigue (match)	49.5 (0.7) / 13.7 (1.5) / 63.2 (2.0)	50.7 (0.9) / 25.0 (1.1) / 75.7 (1.7)	1.2 / 11.3 / 12.5	ANOVA (2% / 83% / 20% impaired, $P < 0.05$)
Jacobson (2011)	Fatigue (match)	51.3 (4.6) / 16.8 (8.6) / 68.1 (12.2)	49.5 (4.2) / 10.0 (5.2) / 59.5 (8.3)	-1.8 / -6.8 / -8.6	ANOVA (NS / NS / NS impaired, $P > 0.05$)

[a] = data derived from figure; MT = movement time (s); PT = penalty time (s); TT = total performance time (s); MD = mean difference (s); NR = not report; NS = not significant; ANOVA = analysis of variance; HIE = ligh-intensity exercise; LIST = Loughborough intermittent shuttle test.

Table 6 Calculated SWC and MDC for the LSPT

	MT	PT	TT
SWC	0.5-2.0	0.6-2.3	0.8-3.8
MDC_{50} (SEM)	1.0-4.4	2.9-9.0	1.9-11.3
MDC_{95}	2.8-12.3	8.1-25.5	5.3-32.0

MT = movement time (s); PT = penalty time (s); TT = total performance time (s); SWC = smallest worthwhile change (s); MDC = minimum detectable change (s); SEM = standard error of measurement.

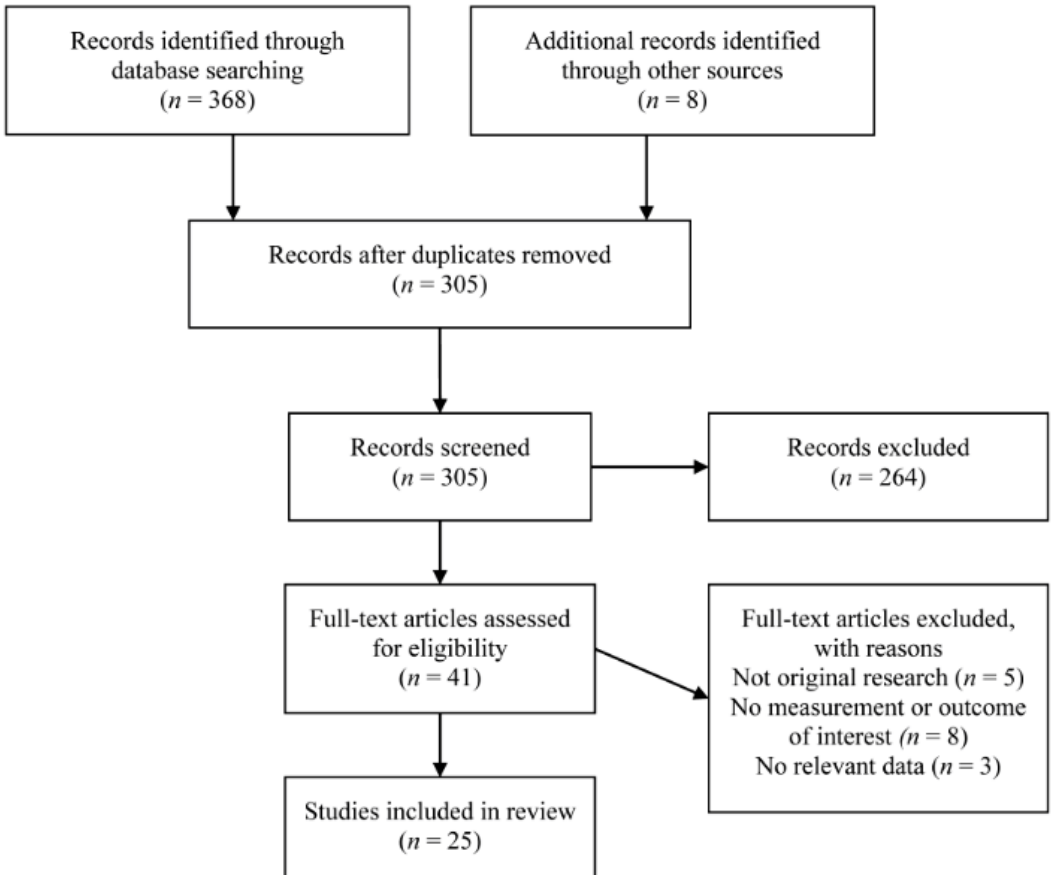
Table 7 Summary checklist of measurement quality for the LSPT total performance time

	Assessed?	Source	Results
Level 1			
Test-retest reliability	YES	A. Ali, et al. (2008); A. Ali, et al. (2007); Andrade-Souza, et al. (2015); Benounis, et al. (2013); Le Moal, et al. (2014); McDermott, et al. (2015)	Moderate to excellent (r = 0.43-0.99, ICC = 0.42-0.93)
Intra-rater reliability	NO		NR
Inter-rater reliability	NO		NR
Content validity	YES	A. Ali, et al. (2007)	The test was developed to assess the multifaceted aspect of soccer skill including passing, dribbling, control and decision making
Discriminant validity	YES	A. Ali, et al. (2008); A. Ali, et al. (2007); Huijgen, et al. (2013); Le Moal, et al. (2014); McDermott, et al. (2015); Naser and Ali (2016); O'Regan, et al. (2007)	Sensitive to discriminate players of different playing levels and ages (P < 0.05)
Responsiveness / sensitivity to change	YES	A. Ali, et al. (2011); A. Ali and Williams (2009); H. M. Ali, et al. (2016); Draganidis, et al. (2013); Foskett, et al. (2009); Gant, et al. (2010); Impellizzeri, et al. (2008); Jacobson (2011); Lyons, et al. (2006); Owen, et al. (2013); Rampinini, et al. (2008); Sinclair and Artis (2013); Smith, et al. (2016); Zago, et al. (2016); Zois, et al. (2013)	Sensitive to some external interventions (learning: 13%-19% improved; training: NS; warm-up: 6.4% improved; fluid ingestion: NS to 4.3% improved; fatigue: NS to 20% impaired. P < 0.05)
SWC / MDC	NO but estimate	Table 6	MDC > SWC (SWC = 0.8-3.8, MDC_{50} = 1.9-11.3, MDC_{95} = 5.3-32.0)
Interpretability	NO but estimate	Figures 4 and 5	The LSPT total performance time is practical in discriminating players of different playing levels and ages than detecting the change in status after an external intervention.

Familiarity required	YES	A. Ali, et al. (2007); Le Moal, et al. (2014); McDermott, et al. (2015)	Trail order and familiarization effects were detected.
Duration	YES	A. Ali, et al. (2008); A. Ali, et al. (2007)	The mean duration was less than 1 min.
Level 2			
Stability	NO		NR
Internal consistency	NO but estimate	Figure 3	Questionable (Cronbach's α = 0.67)
Convergent validity	YES	Benounis, et al. (2013)	Positively correlated with some alternate measures (Sprint tests: *r* = 0.49-0.60, Agility-15m: *r* = 0.75, Ball-15m: *r* = 0.71, Illinois agility test: *r* = 0.72)
Concurrent validity	YES	A. Ali, et al. (2008); A. Ali, et al. (2007); Huijgen, et al. (2013)	Strong association between the LSPT scores and expected rankings.
Predictive validity	YES	Serpiello, et al. (2017)	Poor relationship with match passing performance (*r* = 0.30-0.47).
Floor and ceiling effects	NO		NR
Scoring complexity	YES	A. Ali, et al. (2008); A. Ali, et al. (2007)	The first examiner is in charge of recording the movement time, the second examiner records the penalty time points accrued during the trials. These two variables make up the total performance time.
Completion complexity	YES	A. Ali, et al. (2008); A. Ali, et al. (2007)	The participants began with the ball by the central cone, and then completed eight long and eight short passes to the targets were called. The players were informed that they would have to perform the test as quickly as possible while making the fewest mistakes.
Cost	YES	A. Ali, et al. (2008); A. Ali, et al. (2007)	Four benches / boards were placed marking the 12×9.5m grid; four colored targets, one piece of aluminum, one ball, one hand-held stopwatch, and two examiners were needed.

MD = mean difference (s); SWC = smallest worthwhile change (s); MDC = minimum detectable change (s); NR = not report; NS = not significant; *r* = correlation coefficients; CV = coefficient of variation; ICC = intraclass correlation coefficient; LoA = limits of agreement (s).

Figure 1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Additional records identified through other sources (n = 8)
Records after duplicates removed (n = 305)
Records screened (n = 305)
Records excluded (n = 264)
Full-text articles assessed for eligibility (n = 41)
Full-text articles excluded, with reasons
Not original research (n = 5)
No measurement or outcome of interest (n = 8)
No relevant data (n = 3)
Studies included in review (n = 25)

Figure 2

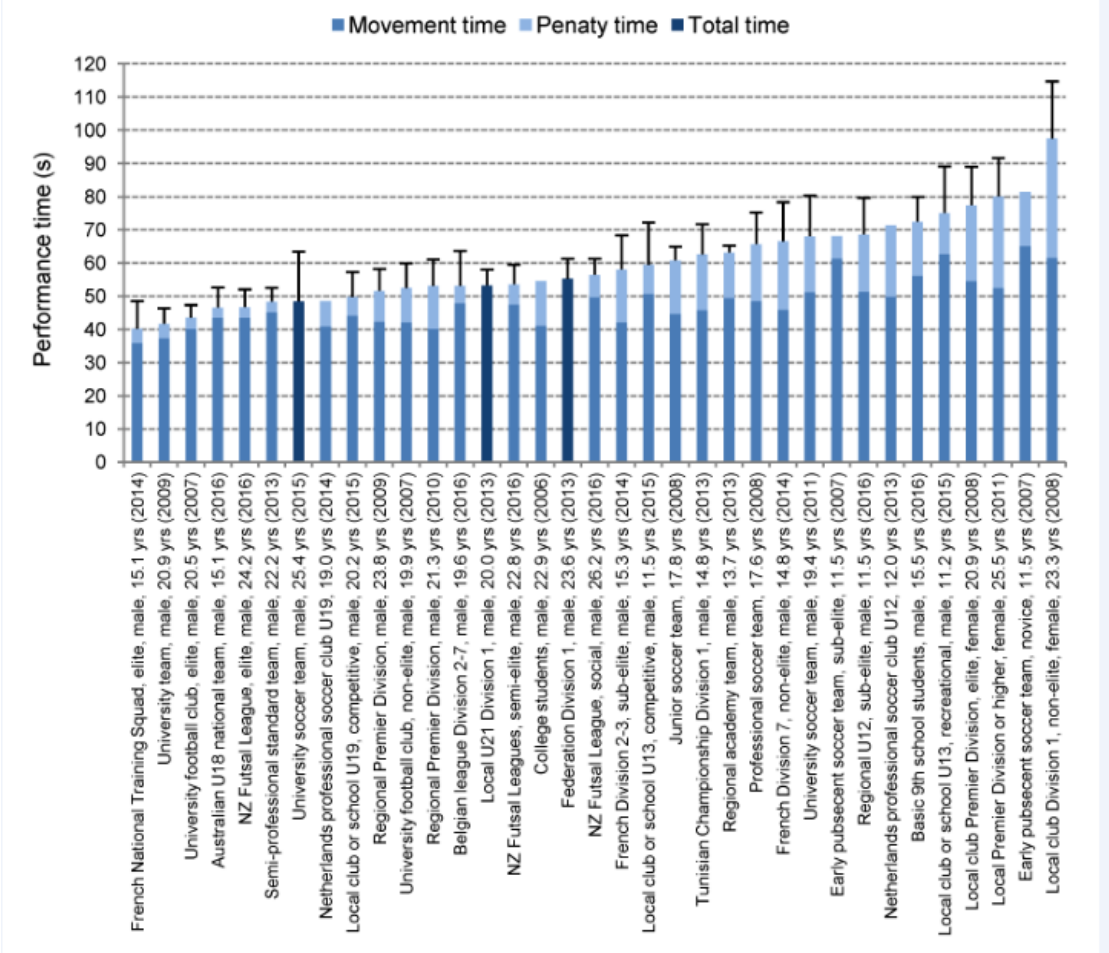

Movement time
Penaty time
Total time
Performance time (s)
120
110
100
90
80
70
60
50
40
30
20
10
0
French National Training Squad, elite, male, 15.1 yrs (2014)
University team, male, 20.9 yrs (2009)
University football club, elite, male, 20.5 yrs (2007)
Australian U18 national team, male, 15.1 yrs (2016)
NZ Futsal League, elite, male, 24.2 yrs (2016)
Semi-professional standard team, male, 22.2 yrs (2013)
University soccer team, male, 25.4 yrs (2015)
Netherlands professional soccer club U19, 19.0 yrs (2014)
Local club or school U19, competitive, male, 20.2 yrs (2015)
Regional Premier Division, male, 23.8 yrs (2009)
University football club, non-elite, male, 19.9 yrs (2007)
Regional Premier Division, male, 21.3 yrs (2010)
Belgian league Division 2-7, male, 19.6 yrs (2016)
Local U21 Division 1, male, 20.0 yrs (2013)
NZ Futsal Leagues, semi-elite, male, 22.8 yrs (2016)
College students, male, 22.9 yrs (2006)
Federation Division 1, male, 23.6 yrs (2013)
NZ Futsal League, social, male, 26.2 yrs (2016)
French Division 2-3, sub-elite, male, 15.3 yrs (2014)
Local club or school U13, competitive, male, 11.5 yrs (2015)
Junior soccer team, 17.8 yrs (2008)
Tunisian Championship Division 1, male, 14.8 yrs (2013)
Regional academy team, male, 13.7 yrs (2013)
Professional soccer team, 17.6 yrs (2008)
French Division 7, non-elite, male, 14.8 yrs (2014)
University soccer team, male, 19.4 yrs (2011)
Early pubsecent soccer team, sub-elite, 11.5 yrs (2007)
Regional U12, sub-elite, male, 11.5 yrs (2016)
Netherlands professional soccer club U12, 12.0 yrs (2013)
Basic 9th school students, male, 15.5 yrs (2016)
Local club or school U13, recreational, male, 11.2 yrs (2015)
Local club Premier Division, elite, female, 20.9 yrs (2008)
Local Premier Division or higher, female, 25.5 yrs (2011)
Early pubsecent soccer team, novice, 11.5 yrs (2007)
Local club Division 1, non-elite, female, 23.3 yrs (2008)

Figure 3

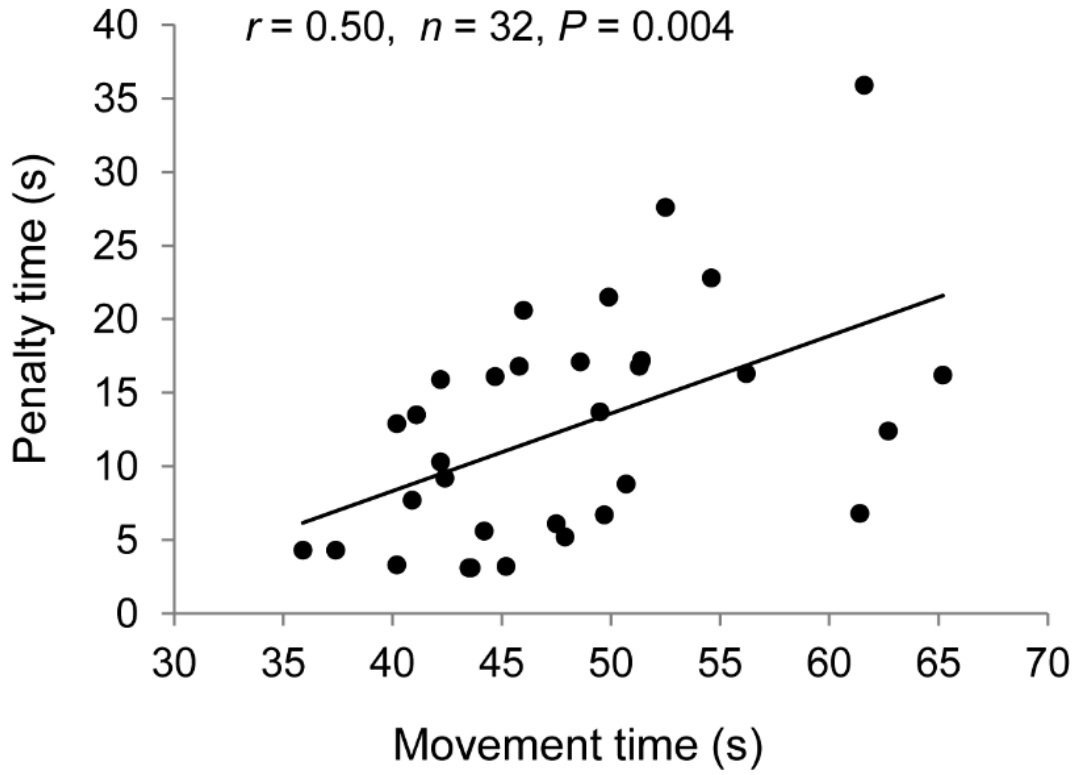
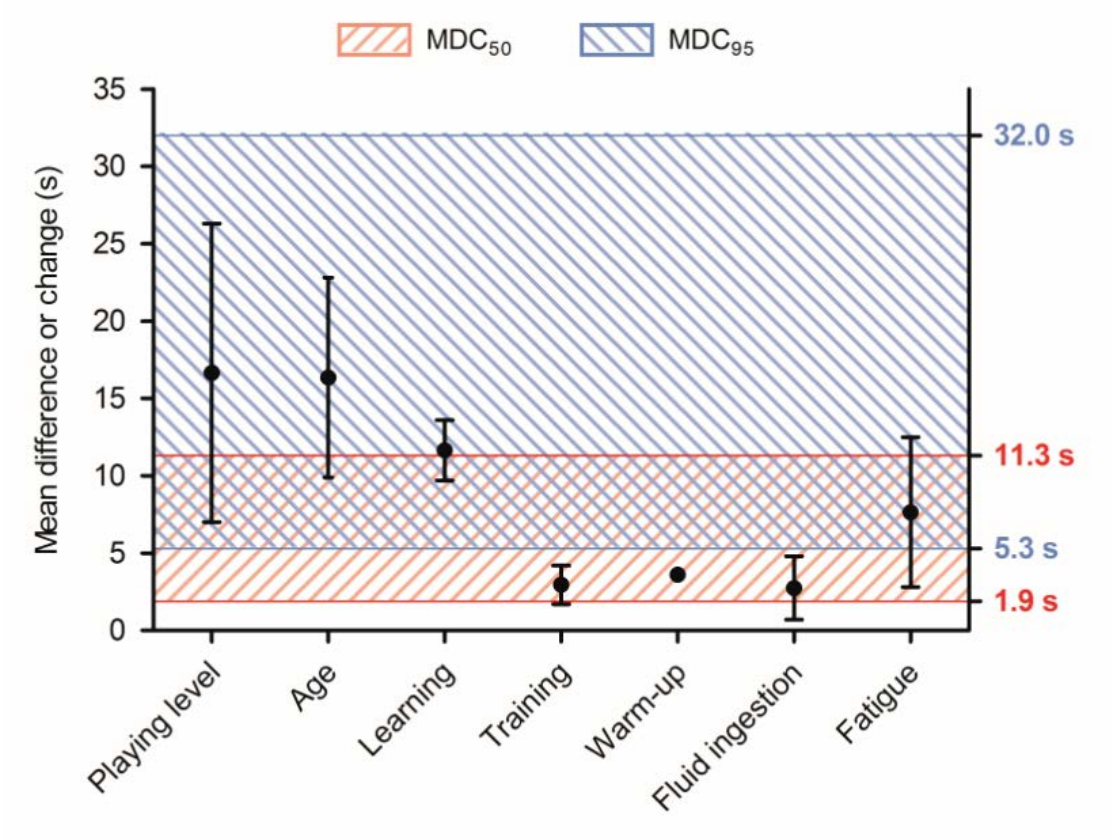
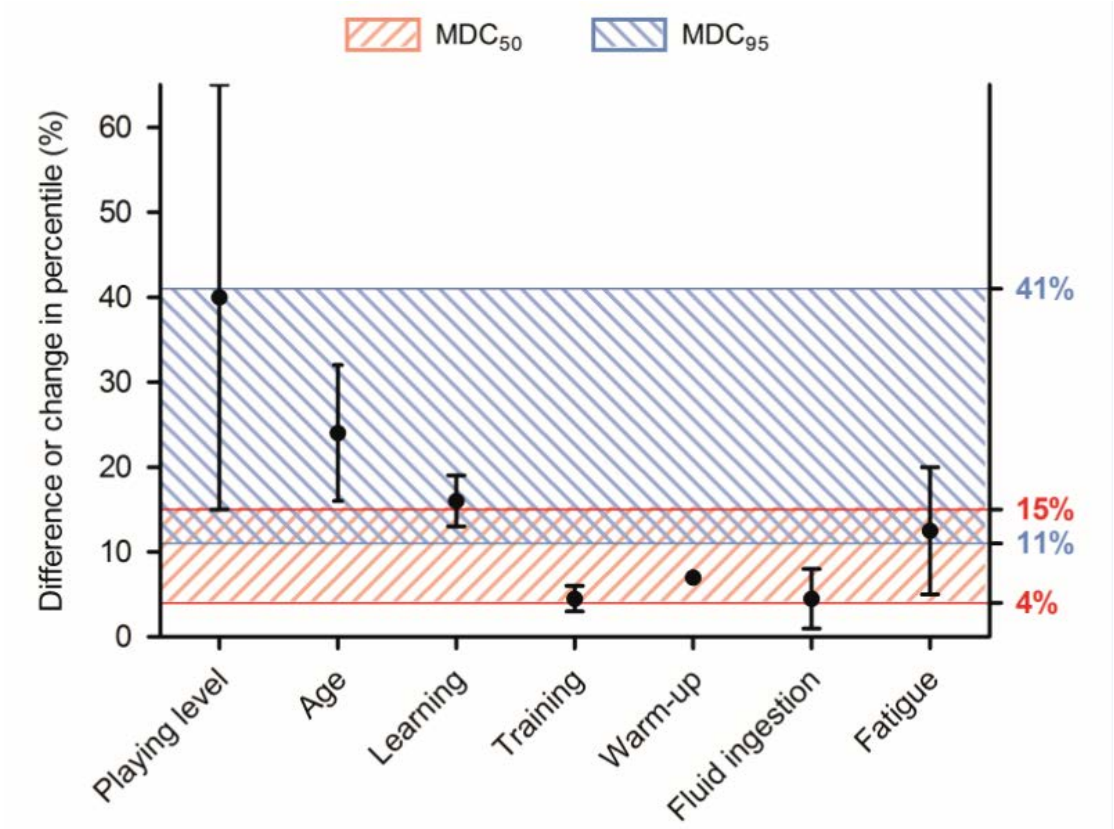

r = 0.50, n = 32, P = 0.004
Penalty time (s)
Movement time (s)
0
5
10
15
20
25
30
35
40
30
35
40
45
50
55
60
65
70

Figure 4-5


MDC50
MDC95
Mean difference or change (s)
35
30
25
20
15
10
5
0
32.0 s
11.3 s
5.3 s
1.9 s
Playing level
Age
Learning
Training
Warm-up
Fluid ingestion
Fatigue


MDC50
MDC95
Difference or change in percentile (%)
60
50
40
30
20
10
0
41%
15%
11%
4%
Playing level
Age
Learning
Training
Warm-up
Fluid ingestion
Fatigue