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Research article

Proposal for a Specific Aerobic Test for Football Players: The "Footeval"

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Abstract
The aim of this study was to evaluate the reproducibility and validity of the "Footeval" test, which evaluates football players' aerobic level in conditions close to those of football practice (intermittent, including technical skills). Twenty-four highly trained subjects from an elite football academy (17.8 ± 1.4 years, 5 training sessions per week) performed two Footeval sessions in a period of 7 days. Physiological variables measured during these sessions (VO_2max 58.1 ± 5.6 and 58.7 ± 6.2 $ml·min^{-1}·kg^{-1}$; RER 1.18 ± 0.06 and 1.19 ± 0.05; LaMax 11.0 ±1.4 and 10.8 ±1.1 $\mu mol·L^{-1}$; HRmax 194 ± 6 and 190 ± 7 $b·min^{-1}$; Final step 10.71 ± 1.2 and 10.83 ± 1.13 and the RPE = 10) highlighted maximal intensity and confirmed that players reached physiological exhaustion. Comparison of values measured in both sessions showed large to very large correlations (Final level; 0.92, VO_2max; 0.79, HRmax; 0.88, LaMax; 0.87) and high ICC (Final level; 0.93, VO_2max; 0.87, HRmax; 0.90, LaMax; 0.85) except for RER (r = 0.22, ICC = 0.21). In addition, all subjects performed a time limit (Tlm) exercise with intensity set at maximal aerobic specific speed + 1 $km·h^{-1}$, in order to check the maximal value obtained during the Footeval test. Statistical analysis comparing VO_2max, HRmax and RER from the Footeval and Tlm exercise proved that values from Footeval could be considered as maximal values (r for VO_2max; 0.82, HRmax; 0.77 and ICC for VO_2max; 0.92, HRmax; 0.91). This study showed that Footeval is a reproducible test that allows maximal aerobic specific speed to be obtained at physiological exhaustion. Moreover, we can also affirm that this test meets the physiological exhaustion criteria as defined in the literature (RER ≥ 1, 1; LaMax ≥ 8 $\mu mol·L^{-1}$; HR = HRmax; no increase of VO2 despite the increase of speed; RPE =10).

Key words: Football, test, aerobic, MAS, validity.

Introduction

Footballers' performance levels rely on many simultaneous factors, including athletic, technical, tactical, mental, and physiological abilities. Performance in football has been described in the literature using the athletic factor (Anderson et al., 2008; Bradley et al., 2009; Di Salvo et al., 2009; Krustrup et al., 2003; Mohr et al., 2003; Rampinini E et al., 2007) or, more recently, based on actions performed with the ball (Wisloff et al., 1998; Hugues et al., 2005). We believe that those two components must be considered together in order to get a complete performance overview of a football game. The duration of a football game being 90 minutes, it is essentially based on aerobic metabolism. Bangsbo et al. (2008) and Krustrup et al. (2006a) show that high demands are made on the aerobic metabolism (average heart rate and peak respectively 85% and 98% maximum heart rate (HRmax). Footballers' aerobic potential is of paramount importance to their performance since it is the main factor determining speed of movement in the sport (Bangsbo et al., 2006) and also appears as a key factor in recovery during the repetition of efforts at very high intensity (Girard et al., 2011a; 2011b). Similarly, Bangsbo et al. (2006), Drust et al. (2000) and Stolen et al. (2005) have shown the positive effects of a high level of aerobic fitness on player performance in a game. Wisloff et al. (1998) reported a significant difference (P<0.05) in maximal oxygen uptake between the top ranked and lowest ranked teams in the Norwegian first division championship. Helgerud et al (2001) report that an increase in maximal oxygen uptake (VO_2max); 5ml/min/kg and in running economy (RE) of 7% influences physical performance during a game (distance covered +20%, p < 0.01; number of sprints +100%, p < 0.001). This increase also influences technical performance during the game (rate of involvement with the ball, +24.1%, p < 0.005) (Castagna et al., 2006a; Chamari et al., 2005). The anaerobic pathway plays a substantial role in performance, because it is the foundation for high-intensity actions, which influence the result of a match. According to MacMillan et al. (2005), the anaerobic period, or period of high intensity, represents about 10% of the total energy produced during a football game. It is used to perform sprints, high intensity runs, duels, and high-speed technical actions. These actions are decisive during a game (Sporis et al., 2009). The recovery times, frequency, and duration of these actions vary according to events during the match. Players with the greatest oxidative potential show a greater ability both to re-synthesize phosphocreatine and lactate and to eliminate H^+ ions (Buchheit et al., 2010; Bishop et al., 2004; Bishop et al., 2006) during periods of recovery following periods of high intensity during a game.

Given the importance of the aerobic system in football performance, as described above, evaluating this feature is therefore crucial when developing physical training programs. Physical tests must reproduce, as much as possible, the specific patterns of the sport they are tailored to, whether under laboratory conditions or on the field. The aim of the present study was to investigate the validity and reproducibility of the Footeval Test.

Presentation of "Footeval"

Footeval is an incremental, intermittent test based on the spatial organization of Léger's "20m shuttle run" test

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(Léger et al., 1982) in order to include direction changes (180°). The purpose of this test is to determine a global index of football players, providing a clear idea of their level, including their physical and technical skills. Notation takes into account players' aerobic power and technical capacities in real football conditions (MASS). This test allows VO_2max to be measured in specific conditions and will be influenced by many factors such as running economy, muscular abilities, or technical skills with the ball. It differentiates football players according to their level (Ziogas et al., 2011).

Protocol design

Footeval is an intermittent incremental test with thirty seconds of passive recovery between each step. The first step is designed as a warm-up and lasts two minutes (Figure 1). All other steps last one minute followed by a recovery phase of thirty seconds. The protocol was designed to reproduce the requirements of football as much as possible. Several studies have demonstrated that most recovery periods during a football game last less than thirty seconds (Bloomfield et al., 2007; Spencer et al., 2005; Vigne et al., 2010). For each step in this test, the intensity is set by speed in km/h. The first level starts at 6.5km/h and intensity is increased by 0.5 km/h between each workout phase. To ensure players accurately follow intensity increases, a specific soundtrack is played to provide audio feedback to players, allowing them to adjust their speed at each extremity of the test area (20m). A single beep signals the beginning or intermediate positions in the step, while a double beep indicates the end of the workout.

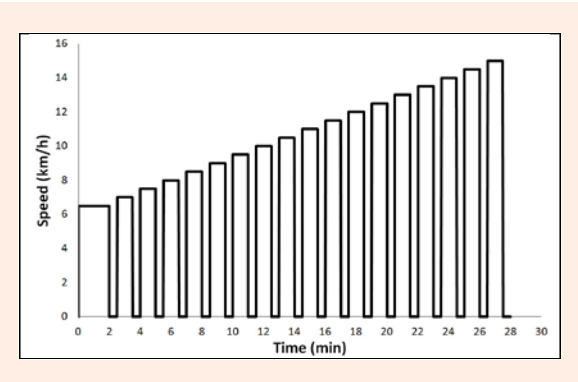

Figure 1. Workload protocol of the Footeval Test.

The test is over when the subject is no longer able to maintain the intensity indicated by the audio beep. If the player is more than 3 meters from the line, and not able to reduce the gap, we consider that the test is over. The test is also considered to have ended when the player is not able to restart a workout session after the recovery phase. Furthermore, the player is stopped if he makes more than 2 technical errors within a step. We considered bad passes, bad shots, or bad ball control to be technical errors.

The intermittent structure of the Footeval test is based on analysis of football as a sport and is designed to induce a substantial turnover of aerobic and anaerobic pathways. The duration of the different steps (two minutes for the first and one minute for the others), interspersed with a recovery period of 30", is justified by the works by Astrand et al. (2003). They have highlighted that respiratory and heart rate adjustments during the first two minutes of activity result in a deficiency of oxygen. During this period, the body relies on its anaerobic system (depending on the intensity of the exercise). Thus, the first two-minute level of Footeval was designed to obtain a stable cardiovascular level and to ensure a gradual warm up. After several different experiments, we decided to adjust the duration of each subsequent step to 1 minute, because a shorter duration might lead to overestimating the MASS and link the final result to anaerobic pathway. This balance between steps and recovery duration also allows for gradually improving fatigue and leads to an expected duration of the test that is between 12 and 18 minutes. This duration allows the player to adapt his own capacity to different physiological demands. Reilly et al. (1984; 2005) show an increase (8%) in VO_2 when the player runs with the ball compared to running at the same speed without a ball. Similarly, Stolen et al. (2005) point out that a change in speed of 1 $km \cdot h^{-1}$ generates a VO_2 increase of 5 $ml \cdot min^{-1} \cdot kg^{-1}$ and a 10-beat HR increase.

A passive recovery time of 30 seconds corresponds to the recovery times generally observed during official games. Balsom et al. (1992) have shown that VO_2 is directly influenced by recovery time: the shorter the recovery time, the more oxygen uptake will increase. Balsom et al. (1992) found respectively a 52, 57 and 66 ml/min/kg oxygen concentration for the same exercise (15x40m) with intermittent recovery times of 120 seconds, 60 seconds and 30 seconds. Recovery periods are short in football, less than 30 seconds according to Spencer et al. (2005), so the importance of the kinetics of the VO_2 is primary (Dupont et al., 2005; 2010). This refers to the concept of the metabolic efficiency of the aerobic system. 30 seconds is not sufficient time to allow complete recovery and maintains a high level of aerobic pathway for the start of the next level. The speed increase between each step during the test is of 0.5 km/h and the first step starts at 6.5 km/h. The goal of this increment is to delay substantial demands on the anaerobic pathway, as this will strongly impact assessment of the subject's aerobic potential. A higher increment of speed between each level could cause fast blood lactate accumulation and lead to the test ending too soon. Muscular acidosis increases results in a pH decrease, which leads to the reduction of muscular contractility (Westerblad et al., 2002) and glycolytic activity inhibition (Hollidge-Horvat et al., 1999). The oxidative potential that we want to assess relies on oxygen delivery and VO_2 (Buchheit et al., 2010; Glaister et al., 2005).

Footeval track

Figure 2 shows the spatial lay out of the "Footeval". To comply with the distance of 20m, as in Léger's "20m shuttle run test", we drew an optimal trajectory in the slalom using plastic strips (0.5m long and 1cm thick) located 0.5m from the center of the poles, which did not interfere with the player or the ball. The route of this optimal trajectory aims to help the player to respect the tempo beeps. We placed a marker at 0.4m from the first pole, so that the player would start his slalom at this point and not before. The last step completed by the player provides the Maximal Aerobic Speed Specific (MASS).

During each level, the subject must be at one end or the other, i.e. in the shooting zone or at line A. At the first beep, the player has to:

- Run with the ball for a distance of 2.6 m
- Slalom between poles separated by 2.5m
- After the last cone, the player has to run with the ball for a distance of 2.5m
- Then the player has to make a pass on the plastic board, located on the right or the left, and then control the ball. After controlling the ball, the player has to run with the ball for a distance of 4m up to line A, located 19m from the start.
- At the second beep, the player has to stop the ball on line A with the sole of his foot and do a U-turn.

If the player loses the ball in the first part of the route, he must finish it without the ball and pick up a new one at line A.

- For the return, the player has to run with the ball towards the shooting zone (width = 2m; depth = 0.5m) passing outside the cones. At the next beep, the player has to shoot from the shooting zone.

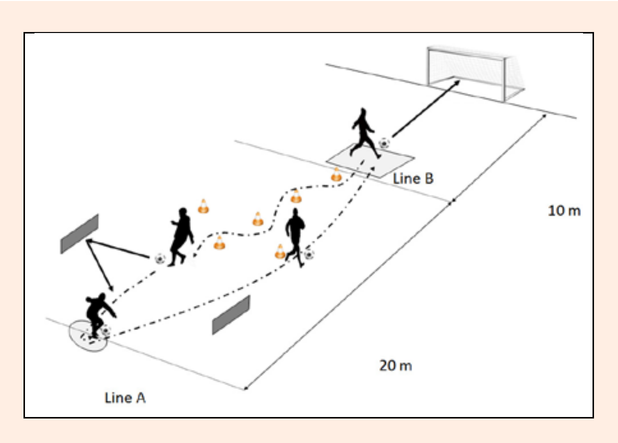

Figure 2. Material organization of the Footeval Test

Concerning the shot, in order to upgrade the difficulty, the player has to kick the ball directly into the goal without any rebound or grass contact. The ball must enter the goal directly without touching the ground. During the first levels, the player is asked to gradually increase the power of his shots in order to complete the warm-up. As soon as the player has kicked the ball, he has to take a new ball and perform the same exercise again, whilst respecting the beeps. The end of the level is marked by a double beep. The player then has thirty seconds of recovery time at line A or in the shooting zone. He then has to wait for the next beep to start the next level.

Methods

Experimental design

Our study is designed to assess the validity and reliability of the Footeval test. To realize this assessment, subjects performed the Footeval test twice in a period of 7 days and took part in a third measurement session where they performed a special limited time exercise (Tlm). During the Tlm exercise, the athletes did the Footeval track with the speed set at the best speed they had obtained during the Footeval test + 1 $km \cdot h^{-1}$. Such a protocol has already been used by (Dupont et al., 2003; 2004) to confirm the maximal intensity that could be reached during an exercise.

Each session was preceded by a period of rest of 48 hours. In order to standardize the test, it was carried out on the same field (synthetic), in favorable weather conditions, (no wind or rain), and at a temperature between 25 and 28°C.

Subjects

The study participants were twenty-four male, highly-trained (5 times/week), subjects from a 1st division training academy (height: 1.75 ± 0.06 m; weight: 66.9 ± 6.2 kg; body fat: 9.1 ± 1.6 %; age: 17.8 ± 1.4 years). All participants were informed that data was being collected for a study and gave their written consent (in the case of minors, the parents provided this consent). In addition, all players had already performed the Footeval test at least once during the last two seasons.

Physiological Measurement

Maximum Oxygen Uptake

During all sessions, Oxygen Uptake (O_2) was continuously measured breath-by-breath using a portable metabolic measurement device: Metamax 3B (Cortex Biophysics Gmhb, Liepzig, Germany). This tool measured respiratory flow with a bidirectional digital turbine and CO_2 and O_2 concentrations during inspiration and expiration. These data were computed by Metasoft 3.9.3 (Cortex Biophysic Gmhb, Liepzig, Germany) to calculate O_2 consumption (VO_2) and CO_2 output (VCO_2), Respiratory Exchange Rate (RER) and Maximum Oxygen Consumption (VO_2max). VO_2max was determined at the final completed level and corresponded to the peak value obtained in the last 15 seconds of this level (Castagna et al., 2006a; Castagna et al., 2006b; Glaister et al., 2005). Heart Rate (HR) was also recorded using a Polar Wearlink chest belt (Polar, Onlu, Finland) linked to the Metamax 3B. The highest 5-second average HR value obtained was considered as the HR peak value (b/min) and consequently considered as the Maximum Heart Rate (HRmax).

Regarding the Tlm exercise, we used the same process in order to determine VO_2max, RER, and HRmax.

As recommended by the manufacturer, the gas was introduced before each test series and volume calibration was performed before each test. The validity and reproducibility of this device has been demonstrated by Voggler et al. (2010) and Macfarlane et al. (2012).

Blood lactate measurement

Blood lactate was measured at rest, during each recovery period and 1, 3, 5, and 7 minutes after the end of the test in order to collect the blood Lactate Peak (LaMax). A capillary blood sample was extracted from the finger (0.5 µL) and analyzed using the Lactate Scout+ (EKF Diagnostic Gmhb, Barleben, Germany): its reproducibility and the validity of its measures have both been highlighted by Tanner et al. (2011). A verification process was performed before each test session.

Rating exercise perception

At the end of each step and at the end of the test, the subjects provided a rate of exercise perception using the CR10 Borg scale (CR-10) (Borg, 1974). These data were collected to assess the subjects' maximum exercise perception (RPE); the magnitude of effort and fatigue experienced.

Statistical analysis

Statistical analysis was performed using Sigmaplot software v12 (SAX Software, Karlsruhe, Germany) and Microsoft Excel 2007 (Microsoft, Redmond, USA). First, the distribution of each variable was examined with the Shapiro-Wilk normality test.

Data in tables are presented as means with standard deviations and 90% confidence intervals/limits (CI/CL). These probabilities were used to make a qualitative probabilistic mechanistic inference about reproducibility. The mean bias (in % and expressed as a standardized difference based on Cohen's effect size principle, using pooled standard deviations), the typical error of the estimate (TEE, both in % and standardized units), and the magnitude of the correlations between the approaches were all calculated. Reliability was assessed using the typical error of measurement (TE), expressed as a CV (in % and standardized units), and the single measure intraclass coefficient correlation (ICC).

The magnitude of the ICC was assessed using the following thresholds: >0.99, extremely high; 0.99-0.90, very high; 0.90-0.75, high; 0.75-0.50, moderate; 0.50-0.20, low; <0.20, very low. Finally, the following criteria were adopted to interpret the magnitude of the correlation: $r \leq 0.1$, trivial; $0.1 < r < 0.3$, small; $0.3 < r < 0.5$, moderate; $0.5 < r < 0.7$, large; $0.7 < r < 0.9$, very large; and $0.9 < r < 1.0$, almost perfect. If the 90% CI overlapped small positive and negative values, the magnitude was deemed unclear; otherwise that magnitude was deemed to be the observed magnitude (Hopkins et al. 2009).

Results

The results of the different measurements taken during the Footeval Test, Re-test and Tlm exercise look very similar. Values from the three sessions can be found in Table 1. This table shows the average and standard deviation value of the group for each session: VO_2max, HRmax, RER, LaMax. Regarding reproducibility, we noted that for the maximal values collected during the test and retest sessions, there was a very large correlation for the final level; 0.92 and a large correlation for VO_2max; 0.79, HRmax; 0.88, LaMax; 0.87, except for RER; 0.22. When assessing the agreement between both sessions for physiological variables and final level, the mean biases were very low for MASS; (1.2%, 90% confidence limits, CL, -0.3; 2.7), VO_2max; (1.5%, 90% confidence limits, CL, -0.4; 3.4), HRmax; (0.2%, 90% confidence limits, CL, -1.8; 2.3), and LaMax (-1.55%, 90% confidence limits, CL, -3.7;0.8), and the TEE results were low for the final level; (3.0%, 2.4;4.0), VO_2max; (2.8%, 2.8;4.1), HRmax; (2.2%, 3.4;5.7), LaMax (2.6%, 2.7;3.12). TEE for RER values were moderate between both sessions (1.5%, 1.2; 2.0). The results from statistical analysis shown in Table 2 also highlighted a high ICC for VO_2max; 0.87, HRmax; 0.90, LaMax; 0.85 and a very high ICC for the final level, 0.93, whereas RER was moderate (0.21).

Regarding validity, comparison of the physiological values obtained during Footeval (average of both sessions) with those from the supra max exercise (Tlm) showed a high correlation for VO_2max; 0.82, HRmax; 0.77 and a trivial correlation for RER; 0.17. When assessing the agreement between both the Footeval and Tlm session for physiological variables, the mean biases were very low for VO_2max; (-0.4%, 90% confidence limits, CL, -0.8; 0.6), HRmax; (-0.3%, 90% confidence limits, CL, -0.2; 0.8), and the TEE were low for VO_2max; (6.5%,4.7; 10.7), HRmax; (1.6%, 1.2; 2.6). TEE for RER

Table 1. Average values, standard deviation, for test and re-test sessions.

	VO_2max ($ml \cdot kg^{-1} \cdot min^{-1}$)	HRmax ($b \cdot min^{-1}$)	RER	LaMax ($mmol^{-1}$)	MASS ($Km \cdot h^{-1}$)	RPE (CR10)
Test	58.1 (5.6)	194 (6)	1.18 (.06)	11.0 (1.4)	11.3 (.6)	10 (0)
Re-test	58.7 (6.2)	191 (7)	1.19 (.05)	10.8 (1.1)	11.4 (.6)	10 (0)
Tlm	58.3 (4.2)	190 (5)	1.17 (.07)	-	-	-

Table 2. Statistical analysis of test and retest sessions and comparison between Footeval and Tlm sessions.

	Between Test and Retest			Between Footeval and Tlm		
	Bias (%) (90% CL)	TEE (%) (90% CL)	ICC (90% CL)	Bias (%) (90% CL)	TEE (%) (90% CL)	ICC (90% CL)
Final level	1.2 (-0.3;2.7)	3.0 (2.4;4.0)*	0.93 (0.87;0.97)	-	-	-
VO_2max ($ml \cdot kg^{-1} \cdot min^{-1}$)	1.5 (-0.4;3.4)	2.8 (2.1;4.1)*	0.87 (0.76;0.94)	-0.4 (-0.8;06)	6.5 (4.7;10.7)*	0.92 (0.78;0.97)
HRmax ($b \cdot min^{-1}$)	0.2 (-1.8;2.3)	2.2 (3.4;5.7)*	0.90 (0.81;0.95)	-0.3 (-0.2 ; 0.8)	1.6 (1.2;2.6)*	0.91 (0.74;0.97)
RER	0.5 (-0.2;1.3)	1.5 (1.2;2.0)**	0.21 (-0.14;0.51)	-.01 (-0.02;0.02)	2.3 (1.2;3.9)**	0.07 (-0.44;0.55)
LaMax ($mmol^{-1}$)	-1.55(-3.7; 0.8)	2.6 (2.7; 3.12)*	0.85 (0.72;0.93)	-	-	-

TE: typical error. ICC: intraclass correlation coefficient. *: small standardized TE. **: moderate standardized

Was moderate between Footeval and Tlm (2.3%, 1.2; 3.9). ICC for VO_2max and HRmax were very high, respectively 0.92 and 0.91 whereas ICC for RER was very low (0.07).

As previously mentioned, this test was designed based on a determinant of football performance analysis. Footeval is intended to allow players to reach physiological exhaustion with an incremental load that closely resembles the requirements of football. In order to check whether a player had reached physiological exhaustion during Footeval, we compared the physiological values collected during sessions with several criteria used to validate maximal tests in the literature (Lemmink et al., 2004).

- VO_2max achieved with the observation of a plateau (VO_2 steady state of 15 seconds)HRmax reached
- RER >1.1
- LaMax $\geq$ 8 μmol/L
- The subject is no longer able to keep pace despite encouragements.

In order to set the value and the achievement of VO_2max, we relied on Krustrup et al. (2003) and Castagna et al. (2006a; 2006b) who studied the YoYo Intermittent Recovery Test 2 (YoYo IR2) (Bangsbo et al., 2008). Castagna et al. (2006a; 2006b) indicates that VO_2max corresponds to the peak value measured during the last 15 seconds of the test and that this must appear in a plateau where oxygen consumption increase is ≤150ml·min^{-1} despite a speed increase (Sanchez-Otero et al., 2014). In our case, we found similar values for VO_2max and HRmax during Footeval and Tlm (ICC, VO_2max; 0.92 and HRmax; 0.91). In the Tlm session, we observed a plateau for all tests performed by players. In addition, we noted that the RER achieved at the end of the test were always over 1.1 during Footeval sessions (table 1) and the LaMax measured were also always over 8 μmol·L^{-1} (Table 1). Finally, all athletes finalized the Footeval test setting RPE at 10. This does not allow us to perform statistical analysis with this parameter.

Discussion

This study presented a new test allowing a global evaluation of subjects' aerobic potential in the football context. This test takes more skills into consideration than traditional tests (VamEval, Yo-Yo R2, 30-15 IFT, etc.) as it also evaluates technical skills, direction changes capability, and endurance. During the Footeval test, speed increments (0.5km·h^{-1}·step^{-1}) and exercise duration lead to a technical and physiological increase in intensity until the player is not able to maintain the required speed. As we have noted, this point is an original feature of our test, in contrast to the most commonly used tests, which evaluate more isolated capabilities. For example, the VamEval (Sanchez-Otero et al., 2014) test or the University of Montréal Track Test (Cazorla, 1990) are only affected by endurance capability and running economy capability. Other tests, such as the 20-m shuttle run (Léger et al.,1982), 30-15 IFT (Buchheit, 2008), and Yo-Yo R2 (Bangsbo et al. 2008), include direction in their track design and make it possible to obtain different neuromuscular and metabolic responses (Buchheit, 2008) in order to closer approximate team sports. Closer to actual practice, the 30-15 IFT, 45-15 Gacon, and Yo-Yo R2 tests propose recovery phases to obtain intermittent exercise. The Footeval test has combined and built on the benefits of all these previous studies. Contrary to many other tests, the Footeval test protocol incorporates technical skills that are specific to football in order to be more specific and to more closely resemble the requirements of actual practice. Based on these facts, we can assume that the results from such a test offer a more accurate way of differentiating between players' levels in football than other tests, which only evaluate physical or physiological capabilities. Furthermore, it is likely that the Footeval test would be more sensitive to training, and especially to technical training, which does not affect other tests, and that it could therefore be a better tool for identifying the best players during the scouting process. Today, many young player scouts use aerobic test evaluations, sprint speed measurements, and football games to evaluate players' technical and tactical capabilities. Our proposal would allow players to be ranked in order to then select the best ones for a final evaluation with a reduced number of players.

However, the fact that this test includes more skills could therefore mean it would be less readable for trainers or physical trainers. We noted that the MASS obtained in Footeval is largely correlated to VO_2max (ml·min^{-1}·kg^{-1}) (r = 0.73) but we can consider that many other factors may impact final performance. Given the multi-factorial nature of Footeval, future studies to further our understanding of the test will need to investigate the different determinants of performance it entails.

The present study has investigated the validity of the Footeval test. To perform this investigation, we realized two Footeval test sessions and one special Tlm Exercise with a set of subjects. Our results showed that the physiological values reached during the test are in accordance with physiological exhaustion and furthermore that they are close to those obtained in other studies (Dupont et al., 2005; 2010; Reilly et al., 1984). Maximum physiological values are interesting, but several studies have shown that they are related to measurement context (Carminatti et al., 2013; Hader K et al., 2014) and that physiological exhaustion can be reached with only small differences in the data. The best illustration of this is that the maximum values obtained during physical evaluation on a bike or a treadmill can differ (Basset et al. 2000). Comparison with a new exercise session set at MASS + 1 km/h is even more informative on this point because this significantly greater intensity does not produce higher physiological values. Our Footeval protocol was designed taking into consideration several important points leading to a gradual increase in physiological demands. Firstly, we chose to set the beginning of the test at 6.5 km/h, after performing the test with a different intensity. This allows the player to start at an intensity that is significantly lower than first ventilatory threshold intensity and also integrates a warm up into the test. This parameter also induces a test duration of 15 minutes, which is a perfect point for athletes to gradually reach their maximum performance. We found that a higher start intensity led to rapid lactate accumulation and slower VO_2max reached during the test. We also tested several exercise and recovery time combinations. In all other combinations (45s/30s, 30s/15s, 45s/15s), it was impossible for the player to obtain steady physiological values during exercise phases with smooth gradual increases in intensity.

Finally, our study demonstrates the high reproducibility of the Footeval test. This major attribute of the evaluation process was made possible due to extensive work on the protocol design and multiple preliminary evaluations. However, the high reproducibility of this test could also be caused by low sensitivity. We noted that standard deviations of MASS during the Footeval test and re-test sessions were 0.6 $km \cdot h^{-1}$. This is due to the fact that the majority of players from our study (>60 %; 2 x standard deviation) obtained results spread across three different intensities (11.0, 11.5 and 12.0 $km \cdot h^{-1}$). These inter-player differences from the same categories allow us to assume that Footeval might be sufficiently sensitive to rank athletes. At this stage, we do not yet have any evidence regarding sensitivity that could allow us to confirm that the test could be a relevant tool in evaluating the effect of training or of different training methods. Further studies need to be performed to investigate the sensitivity of Footeval and to provide additional evidence regarding the possibilities that this new test can offer.

Our study did identify some limitations regarding RER reproducibility (r = 0.21, ICC = 0.22). This lower reproducibility of RER can be linked to the physiological statements made by the subjects at the end of the exercise. We noted that different subjects have different respiration strategies and may also have an unstructured respiration rate at exhaustion. These situations can lead to VCO_2 variability measured breath-by-breath, thus inducing RER variability. In addition, it is well established that low RER dispersion of values can lead to reduced r and ICC values.

Nevertheless, Footeval provides an index (MASS) allowing an athlete's capabilities to be assessed in football conditions, unlike VamEval, Gacon (45/15), or 30-15 FIT. However, due to its complexity, the results obtained in the Footeval test do not enable evaluation of the intensity of exercise during training sessions. Many other tests, such as YoYo IR2, offer a less specific evaluation of football players' capacities, but do provide evaluations that can be more helpful during the training process.

The Footeval test enables evaluation of the player's capabilities and also quantifies performance improvement due to training (both technical and physical). It could therefore be a very helpful tool in the scouting process with young players (both boys and girls).

Additionally, it should be noted that this test has to be performed in neutral meteorological conditions (no wind or rain) in order to obtain a reliable evaluation. Windy or rainy conditions can lead to random difficulty during the test and make any interpretation of results less reliable.

Conclusion

The purpose of our study was to assess the reproducibility and validity of the Footeval test in evaluating football players' levels. Physiological variables collected during both the test and retest sessions highlighted high correlations (r values: final level; 0.92, VO_2max; 0.79, HRmax; 0.88, LaMax; 0.87) and high to very high reproducibility (ICC values: final level 0.93, VO_2max; 0.87, HRmax; 0.90, LaMax; 0.85). Comparison of physiological values between Footeval and a supra maximal test (Tlm) confirmed that Footeval is able to bring players to a state of physical exhaustion by reproducing the same maximum values (r values; VO_2max; 0.82, HRmax; 0.77 and ICC values; VO_2max; 0.92, HRmax; 0.91). This study also verified that the physiological values obtained during Footeval are in accordance with the criteria defined in the literature attesting to physiological exhaustion, such as VO_2max plateau, HRmax reached, RER >1.1, LaMax >8µmol/L and the inability of the subject to continue with the intensity despite encouragements. Our findings confirm that performance during the Footeval test respects these criteria and leads to a valid and reproducible assessment of a football player's level in a situation that more closely resembles actual practice than traditional incremental tests.

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Key points

- "Footeval" is a new test for football that is able to evaluate aerobic capacity in football specific conditions.
- This study evaluates reproducibility and validity of the "Footeval" test in elite football players.

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