FOOTBALL MATCH OFFICIALS DO NOT ATTAIN MAXIMAL SPRINTING SPEED DURING MATCHES

Daniel Castillo, Jesús Cámara, Julen Castellano, and Javier Yanci

Faculty of Education and Sport, University of the Basque Country, UPV/EHU, Vitoria-Gasteiz, Spain

Original scientific paper
UDC: 796.065:796.012.13

Abstract:

The aims of this study were, first, to analyse the differences between referees and assistant referees in 20- and 30-metre straight line sprinting test performance and in the maximum speeds registered in football matches; and, second, to analyse the differences between the maximum speeds registered in matches and in the straight line sprinting test. Twenty referees from the Spanish Third Football Division participated in this study. Participants were classified as field referees (FR; n=12, age=30.0±6.7 years; body height=178.1±6.6 cm; body mass=73.7±8.3 kg; BMI=23.2±1.8 kg·m^{-2}) and assistant referees (AR; n=8, age=26.0±7.9 years; body height=177.2±7.3 cm; body mass=75.1±8.8 kg; BMI=23.9±3.1 kg·m^{-2}). The maximum speed of each referee during an official competition match (V_{max} match) and during a straight line sprint test (SLST) (V_{max} 30 m sprint) was recorded using a global positioning system (GPS). The results show that no significant differences were found between FR and AR in the SLST (p>.05, d=.13-.14). However, large effect sizes were found in the maximum speeds recorded in matches (p<.076, d=.96). Furthermore, the maximum speeds of the FR and AR in the matches were significantly lower than the maximum speeds registered in the 30-m SLST (p<.01, d=2.32-2.51). Bearing in mind that field referees and assistant referees do not achieve the maximum speed registered in a 30-metre sprint test in actual football matches, the performance in such accreditation tests does not reflect the characteristics of actions they perform during matches.

Key words: *sprinting, speed, soccer, GPS, performance*

Introduction

Soccer refereeing is an intermittent activity for field and assistant referees because they have to be able to carry out actions at high speed during matches in order to assume the best position on the soccer field and, consequently, to ensure a proper course of the game (Castagna, Abt, & D'Ottavio, 2007). Although many studies have analysed physical (external load) and physiological (internal load) demands of playing football (Hill-Haas, Dawson, Impellizzeri, & Coutts, 2011; Impellizzeri, et al., 2013; Weston, et al., 2011a; Weston, Drust, Atkinson, & Gregson, 2011b), few studies have focussed on analyzing these aspects in football referees (Costa, et al., 2013; Weston, et al., 2012). The referees are in charge of regulating the behaviour of players and coaches and have the authority to enforce the rules of the game (Castagna, Impellizzeri, Bizzini, Weston, & Manzi, 2011). Given the work they have to perform, referees require well-developed physical and physiological qualities to be able to respond to the demands of the game (Barbero-Alvarez, Boullosa, Nakamura, Andrin, & Castagna, 2012). However, many of the fitness tests observed in the scientific literature did not significantly correlate with match activities (total distance covered, high-intensity running and sprinting distance) (Mallo, Navarro, García-Aranda, & Helsen, 2009). Obviously, the evaluation of elite-standard referees should be specific and related to activities performed during matches (Weston, Castagna, Helsen, & Impellizzeri, 2009).

In a football match referees cover a total of 11,770±808 m, of which 889±327 m are covered at a high speed (>19.8 km·h^{-1}) and they perform a total of 21.3-30.5 sprints (>25.2 km·h^{-1}) during the course of a match (Weston, et al., 2012). It has also been observed that for 13.2% of the total match time, the referee is moving backwards or sideways (D'Ottavio & Castagna, 2001b). In contrast, the activities of assistant referees are characterized by brief and intense forward and sideway movements, interspersed with long periods of moving at low intensity (Krustrup, et al., 2009). The knowledge of physical demands imposed on field (FR) and assistant referees (AR) during official matches could help personal trainers design adequate training programs. Besides, Committees of Soccer Referees could establish tests for accrediting these officials according to the actual demands of the sporting activity. Insight into the mean and maximal speeds attained by field and assistant referees in official matches could help physical trainers design training strategies to ensure an appropriate external training load (TL); however, few studies have measured and presented maximal speeds attained by field referees during football matches (Costa, et al. 2013; Weston, et al., 2011). Still, none have addressed them in assistant referees.

D`Ottavio and Castagna (2001a) showed that in football matches referees' sprints rarely lasted more than 4 seconds. In spite of this, most studies have involved tests of sprinting over distances of 40 metres (Fernandez, da Silva, & Arruda, 2008; Mallo, et al., 2009; Weston, et al., 2009) and 50 metres (Bartha, Petridis, Hamar, Puhl, & Castagna, 2009; Casajus & Castagna, 2007; da Silva, 2011). Further, the Fédération Internationale de Football Association (FIFA) uses a test of 6x40 metres to assess sprinting capacity in football referees. Since the maximum speed during a 40-metre sprint test has been observed to be much higher than that attained during a soccer match, it seems reasonable to use shorter sprinting distances to determine better the referees' maximum speed capacity during soccer matches. In this line, D`Ottavio and Castagna (2001b) proposed the assessment of sprinting speed capacity in referees over shorter distances. In fact, several studies have used shorter distances such as 5, 15 metres (Yanci-Irigoyen, 2014; Yanci, Los Arcos, Grande, & Casajús, 2016) and 30 metres (Krustrup, Mohr, and Bangsbo, 2002; Castillo, Yanci, Cámara, & Weston, 2016).

In spite of the fact that Krustrup and colleagues (2002) analysed sprinting speed in a 30-metre sprint test, observing that the performance of the assistants in this test decreased after the matches (before: 4.74±.08 seconds; after: 4.92±.07 seconds), we have found only one other study where distances of less than 40 metres were analysed (Castagna, Bendiksen, Impellizzeri, & Krustrup, 2012). Bearing in mind the scarcity of information available on sprinting capacity in sprints lasting about 4 seconds and the importance of measuring physical qualities in conditions which are as similar as possible to those of a football match, we considered it would be worthwhile for the improvement of physical preparation of match officials to analyse referees' performances in sprints over distances less than 40 metres.

Therefore, the objectives of this study were, on the one hand, to analyse the differences between the maximum movement speeds reached by referees both in matches and in a sprint test, and on the other hand, to determine the differences in performance between field referees and assistant referees in 20-metre and 30-metre sprint tests.

Methods

Participants

Twenty official referees from the Spanish Third Football Division, Group XV (age=28.40±7.26 years; body height=177.75±6.69 cm; body mass=74.30±8.34 kg; BMI=23.51±2.37 kg·m^{-2}) took part in this research during the 2014/15 season, after having been informed about the characteristics of the study and having given their written consent. All the referees had at least ten years of experience in refereeing and had been in action for at least six seasons at this competitive level. The participants were classified according to their function into two groups: field referees (FR; n=12, 30.0±6.7 years; body height=178.1±6.6 cm; body mass=73.7±8.3 kg; BMI=23.2±1.8 kg·m^{-2}) and assistant referees (AR; n=8, 26.0±7.9 years; body height=177.2±7.3 cm; body mass=75.1±8.8 kg; BMI=23.9±3.1 kg·m^{-2}). This research was carried out according to the criteria established by the Declaration of Helsinki (2013) and was approved by the Ethics Committee of the University of the Basque Country (UPV/EHU).

Procedure

The maximum speed of each referee was recorded during official competition matches (V_{max} match) and during a straight line sprint test (SLST) (V_{max} 30 m sprint). The SLST took place five days before the start of the season. Recordings were made during twelve matches in the period between September and December of the 2014/2015 season. Both in the tests and in the matches, the field and assistant referees wore a jacket with a pocket on their backs where a GPS monitoring device was inserted operating at a frequency of 10 Hz (MinimaxX 4.0, Catapult Innovations®, Melbourne, Australia). Data were collected during what were considered to be good GPS conditions in terms of the weather and satellite conditions (number of satellites = 10.0±.2 and 10.3±.4 for 20- and 30-metre sprints during testing sessions, respectively, and 10.1±.2 during match plays). Castellano, Casamichana, Calleja-González, San Román, and Ostojic (2011) assessed the reliability (coefficient of variation, CV=.7%) and accuracy (standard error of measurement, SEM=5.1%) of the devices used in this study in short distance runnings. All the referees performed a similar warm-up before the matches and the SLST, which consisted of seven minutes of gentle jogging followed by sprints and passive stretching.

Straight Line Sprint Test (SLST). The referees carried out three SLSTs of 30 metres at maximum intensity (Krustrup, et al., 2002) with a 90-second rest between each (Gorostiaga, et al., 2009). The subjects positioned themselves 0.5 metres behind the start line (Yanci-Irigoyen, 2014) and, when they felt ready, ran as fast as they could to the finish line which was the total of 30 metres away. Mean speed was measured over the first 20 metres (V_{mean} 20 m sprint) and over the total of 30 metres (V_{mean} 30 m sprint) attending to the average speed registered in each distance. Maximum speed was also registered (V_{max} 30 m sprint) as the highest speed achieved during the 30-metre sprint. The best 30-metre trial was used for statistical analysis. The CVs obtained for the V_{mean} 20 m sprint, V_{mean} 30 m sprint and V_{max} 30 m sprint were .79±.38%, .93±.56% and 2.03±.56%, respectively. All the measures were registered using a GPS monitoring device operating at a frequency of 10 Hz (MinimaxX 4.0, Catapult Innovations®, Melbourne, Australia).

Football matches. V_{max} match was recorded for all the FR and AR. Only the AR who carried out the SLSTs were chosen for our study. So, although twelve FR and twenty-four AR refereed a total of twelve matches, only eight AR participated in this study. Since the other sixteen AR did not perform the SLST, due to the second-chance examinations of soccer game rules, we decided not to consider them for the study. All the matches analysed were played at four different sports facilities of similar dimensions (100x64 metres) and the same playing surface (the third generation artificial turf).

Statistical analysis

The results are presented as means (M) ± standard deviation (SD). The coefficient of variation (CV)=(SD·M^{-1}) x 100 (Atkinson & Nevill, 1998) was used to assess the reproducibility of the 30 m sprint test. A *t*-test for independent samples was used to compare the results (time variables obtained in the 20 and 30 metres sprints: V_{mean} 20 m sprint, V_{mean} 30 m sprint, V_{max} 30 m sprint and V_{max} match) between FR and AR. A *t*-test for related samples was used to analyse the differences between the variables of maximum speed in the matches and in the sprint tests (V_{max} match and V_{max} 30 m sprint) independently for each group (FR, AR, and the whole group). Practical differences were assessed using Cohen's d effect size (large: >.8; moderate: between .8 and .5; small: between .5 and .2; trivial <.2) (Cohen, 1988). Pearson's correlation coefficient (r) with a confidence interval (CI) of 95% was used to observe the relation between the variables V_{max} 30 m sprint and V_{max} match. Relationships between V_{max} 30 m sprint and V_{max} match were examined using correlation coefficients, with 90% confidence limits (CL). The following scale of magnitudes was used to interpret the values of the correlation coefficients: <.1, trivial; .1-.3, small; .3-.5, moderate; .5-.7, large; .7-.9, very large; >.9, nearly perfect (Hopkins, Marshall, Batterham, & Hanin, 2009). The data analysis was carried out using the Statistical Package for Social Sciences (version 21.0 for Windows, SPSS® Inc, Chicago, IL, USA). Statistical significance was set at p<.05.

Results

The results obtained by the total number of field and assistant referees (n=20) in the V_{max} 30 m sprint was 29.45±1.67 km·h^{-1}. The recorded mean speed for the total number of field and assistant referees in the 20 and 30 m sprints was 23.93±1.20 and 25.66±1.36 km·h^{-1}, respectively. Total mean time for the whole sample in covering the 20 and 30 metres was 3.02±0.27 s and 4.21±.29 s, respectively. No significant differences were observed (p>.05) between FR and AR in the time needed to cover 20 and 30 metres, in the V_{mean} 20 m sprint and V_{mean} 30 m sprint or in the V_{max} 30 m sprint and the effect sizes were trivial (d<.14) (Table 1).

Both the field and assistant referees achieved values of V_{max} 30 m sprint that were higher than those attained during the matches (p<.01, FR: 29.64±1.32 vs 26.34±2.27 km·h^{-1}, d=2.51, V_{max} match=88.37% V_{max} 30 m sprint; AR: 29.15±2.15 vs 24.16±2.62 km·h^{-1}, d=2.32, V_{max} match=82.88% V_{max} 30 m sprint). In the total sample of referees, significant differences were also observed between V_{max} 30 m sprint and V_{max} match (All: 29.45±1.67 vs 25.47±2.59 km·h^{-1}, p=.00, d=2.39). The V_{max} match corresponds to 86.49±8.62% of the V_{max} 30 m sprint. Furthermore, although FR did not demonstrate higher V_{max} match values than AR (26.34±2.27 vs 24.16±2.62 km·h^{-1}, p=.076), the effect size was large (d=.96).

Small and moderate correlations were observed between V_{max} 30 m sprint and V_{max} match (All: r=.292, p=.211; FR: r=.446, p=.146; AR: r=.106, p=.803).

Table 1. Results of the straight line sprint tests taken by the field (FR) and assistant referees (AR)

Variables	FR	AR	Difference of means (%)	d
20 m sprint (s)	3.02±0.28	3.00±0.31	0.67	.14
V_{mean} 20 m sprint (km·h^{-1})	23.86±1.12	24.02±1.40	0.67	.14
30 m sprint (s)	4.20±0.28	4.19±0.30	0.62	.13
V_{mean} 30 m sprint (km·h^{-1})	25.60±1.23	25.76±1.72	0.62	.13

Note. d: effect size; V_{mean}: mean velocity recorded; V_{max}: maximum velocity attained.

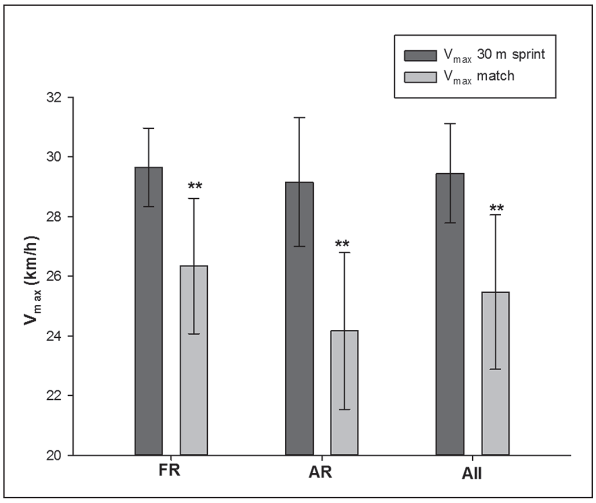

Figure 1. Maximum velocities (V_{max}) reached in the 30 m sprint test and in the football matches differentiating between total sample (All), field referees (FR) and assistant referees (AR).

Discussion and conclusions

Sprint capacity has already been studied in football referees (Costa, et al., 2013; Krustrup, et al., 2002), and some authors have compared physical condition (da Silva, 2011) and activity in competition (Mallo, Navarro, Garcia-Aranda, Gilis, & Helsen, 2008) between field referees and assistants. However, we have found no studies which determined V_{mean} and V_{max} in straight line sprint tests nor V_{max} in field and assistant referees in the official Spanish football competitions. Thus, the objectives of this study were to analyse the differences between the maximum speed reached during matches and sprint tests (i.e. 20 and 30 metres) and to determine the differences in performance between FR and AR in a 20-metre and a 30-metre sprint test and in the maximum speed attained during matches. This is the first study that compares the maximum speed achieved by FR and AR in official matches and in a sprinting test. The main results of this study show that the maximum speeds reached by both the FR and AR in the matches were significantly lower than those recorded in the 30-metre straight line sprint test. Furthermore, no significant differences were found between FR and AR in the SLST but for the differences in the maximum running speed reached in the matches.

Although a previous study had analysed maximum velocity in football referees in matches (Costa, et al., 2013), our study is the first to analyse this aspect also in assistant referees. During the matches we observed V_{max} of 26.34±2.27 km·h^{-1} in the case of the field referees. These results are higher (by 26.3%) than those recorded by Costa et al. (2013) (19.4±1.4 km·h^{-1}). Equally, the results of the assistant referees were also higher (by 19.7%) than those reported by Costa et al. (2013) in the field referees. On the other hand, Weston et al. (2009) obtained higher maximum velocities (by 15.0%) in elite-standard soccer referees than in our study. These differences could be due to the different measurement instruments used in these studies or to the difference in the categories of the referees studied. Since sprint capacity seems to be lower at non-professional competitive-levels (i.e. Third Division), it seems appropriate to evaluate the sprint capacity in distances below 40 metres. Given that maximum speeds achieved during matches by soccer referees depend on the competitive level, it would be useful to adjust the tests' sprinting length to respective competitive level.

Straight line sprint tests have often been used to assess sprinting capacity in footballers (Carling, Le Gall, & Malina, 2012; Haugen, Tonnessen, & Seiler, 2013; Tonnessen, Hem, Leirstein, Haugen, & Seiler, 2013). However, fewer studies on football referees have been found (Bartha, et al., 2009; Mallo, et al., 2009; Weston, et al., 2009). The results obtained in the current study by the field and assistant referees were similar to those observed by Krustrup et al. (2002) (4.21±.29 vs 4.34±.35 s, respectively). Previous research had used distances of more than 40 m (Bartha, et al., 2009; da Silva, 2011; Weston et al., 2009), possibly because maximum velocity cannot be attained over a distance of 30 metres (Buchheit, Simpson, Peltola, & Mendez-Villanueva, 2012). Sprinting tests over distances of 15 and 30 metres have been used to evaluate acceleration capacity in soccer referees (Castillo, et al., 2016; Yanci, et al., 2015); however, the relationship between V_{max} match and sprinting tests has not been studied.

The results of our study show that the field and assistant referees reach values of V_{max} in matches that are clearly lower than those observed in the straight line sprint test over 30 metres (FR, difference of means=3.30±2.05 km·h^{-1}, 11.1%; and AR, difference of means=4.99±3.21 km·h^{-1}, 17.1%). Although FIFA has established a test to assess sprint capacity over a distance of 40 metres, attending to our mentioned results, it might be interesting to assess this quality over shorter distances, especially in lower categories. We suggest considering the maximum velocities achieved at each competitive level in order to design appropriate sprinting tests. According to our results both the field and assistant referees did not carry out actions at maximum speed during matches. Perhaps it would not be necessary to perform maximum velocity tests. It may be more interesting to analyse more specific actions such as changes of direction, sideways running and sprinting over short distances. Although more research is needed to corroborate the results of our study, the lower maximum velocity reached during matches suggests that it may not be necessary to use tests over a distance of more than 30 m for football field and assistant referees. Soccer referees do not achieve their maximum speeds during official matches in the observed national division; thus, acceleration capacity seems to be more relevant than maximum velocity. Therefore, tests over shorter distances may be more interesting and football refereeing – specific (Arcos, Yanci, Mendiguchia, & Gorostiaga, 2014).

Interestingly, in our study although the field referees attained maximum velocities which were higher (8.3%, d=.96) than those of the assistant referees in the matches (26.34±2.27 km·h^{-1} vs 24.16±2.62 km·h^{-1}, respectively), their performance in SLST was not better. These results agree with those of da Silva (2011) who did not find differences between the field and assistant referees in a 50 m test either. Also, these results are consistent with the results obtained in previous studies which stated that the activity carried out by field referees and assistant referees (metres covered, running intensity, time spent in different zones related to percentages of maximum heart rate) is not the same (Helsen & Bultynck, 2004; Krustrup, et al., 2009; Mallo, et al., 2009). This suggests that physical demands of matches imposed on the field and assistant referees should be taken into account. Similar sprinting performance of FR and AR could be due to their equal physical training. However, physical demands in the competition are different. Thus, it could be necessary to carry out specific training to improve sprinting capacity in AR. Therefore, fitness coaches should include specific strategies in the training to improve acceleration capacity attending to physical demands of football matches imposed on FR and AR. This is in accordance with the idea of Mendez Villanueva and Buchheit (2013) who affirmed that as long as a soccer player is able to do his "job" satisfactorily on the field, all other (physical) considerations are secondary. In our study, although assistant referees obtained a high performance in a sprint test, they did not reach their maximum speeds during competition due to their activity is limited to the half of the field and their physical requirements imposed on the game.

References

Arcos, A.L., Yanci, J., Mendiguchia, J., & Gorostiaga, E.M. (2014). Rating of muscular and respiratory perceived exertion in professional soccer players. *Journal of Strength and Conditioning Research, 28*(11), 3280-3288.

Atkinson, G., & Nevill, A.M. (1998). Statistical methods for assessing measurement error (reliability) in variables relevant to sports medicine. *Sports Medicine, 26*(4), 217-238.

Barbero-Alvarez, J.C., Boullosa, D.A., Nakamura, F.Y., Andrin, G., & Castagna, C. (2012). Physical and physiological demands of field and assistant soccer referees during America`s Cup. *Journal of Strength and Conditioning Research, 26*(5), 1383-1388.

Bartha, C., Petridis, L., Hamar, P., Puhl, S., & Castagna, C. (2009). Fitness test results of Hungarian and international-level soccer referees and assistants. *Journal of Strength and Conditioning Research, 23*(1), 121-126.

Buchheit, M., Simpson, B.M., Peltola, E., & Mendez-Villanueva, A. (2012). Assessing maximal sprinting speed in highly trained young soccer players. *International Journal of Sports Physiology and Performance, 7*(1), 76-78.

Carling, C., Le Gall, F., & Malina, R.M. (2012). Body size, skeletal maturity, and functional characteristics of elite academy soccer players on entry between 1992 and 2003. *Journal of Sports Sciences, 30*(15), 1683-1693.

Casajus, J.A., & Castagna, C. (2007). Aerobic fitness and field test performance in elite Spanish soccer referees of different ages. *Journal of Science and Medicine in Sport, 10*(6), 382-389.

Castagna, C., Abt, G., & D'Ottavio, S. (2007). Physiological aspects of soccer refereeing performance and training. *Sports Medicine, 37*(7), 625-646.

Castagna, C., Bendiksen, M., Impellizzeri, F.M., & Krustrup, P. (2012). Reliability, sensitivity and validity of the assistant referee intermittent endurance test (ARIET)–a modified Yo-Yo IE2 test for elite soccer assistant referees. *Journal of Sports Sciences, 30*(8), 767-775.

Castagna, C., Impellizzeri, F.M., Bizzini, M., Weston, M., & Manzi, V. (2011). Applicability of a change of direction ability field test in soccer assistant referees. *Journal of Strength and Conditioning Research, 25*(3), 860-866.

Castellano, J., Casamichana, D., Calleja-Gonzalez, J., Roman, J.S., & Ostojic, S.M. (2011). Reliability and accuracy of 10 Hz GPS devices for short-distance exercise. *Journal of Sports Science and Medicine, 10*(1), 233-234.

Castillo, D., Yanci, J., Cámara, J., & Weston, M. (2016). The influence of soccer match play on physiological and physical performance measures in soccer referees and assistant referees. *Journal of Sports Sciences, 34*(6), 557-563.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Hillsdale: Lawrence Erlbaum Associates.

Costa, E.C., Vieira, C.M.A., Moreira, A., Ugrinowitsch, C., Castagna, C., & Aoki, M.S. (2013). Monitoring external and internal loads of Brazilian soccer referees during official matches. *Journal of Sports Science and Medicine, 12*(3), 559-564.

D'Ottavio, S., & Castagna, C. (2001a). Analysis of match activities in elite soccer referees during actual match play. *Journal of Strength and Conditioning Research, 15*(2), 167-171.

D'Ottavio, S., & Castagna, C. (2001b). Physiological load imposed on elite soccer referees during actual match play. *Journal of Sports Medicine and Physical Fitness, 41*(1), 27-32.

da Silva, A.I. (2011). Somatotype and physical fitness of the assistant referees in soccer. *International Journal of Morphology, 29*(3), 792-798.

Fernandez, G.E., da Silva, A., & Arruda, M. (2008). Anthropometric profile and physical fitness of the professional referees Chilean soccer. *International Journal of Morphology, 26*(4), 897-904.

Gorostiaga, E.M., Llodio, I., Ibanez, J., Granados, C., Navarro, I., Ruesta, M., . . . Izquierdo, M. (2009). Differences in physical fitness among indoor and outdoor elite male soccer players. *European Journal Applied Physiology, 106*(4), 483-491.

Haugen, T.A., Tonnessen, E., & Seiler, S. (2013). Anaerobic performance testing of professional soccer players 1995-2010. *International Journal of Sports Physiology and Performance, 8*(2), 148-156.

Helsen, W., & Bultynck, J.B. (2004). Physical and perceptual-cognitive demands of top-class refereeing in association football. *Journal of Sports Sciences, 22*(2), 179-189.

Hill-Haas, S.V., Dawson, B., Impellizzeri, F.M., & Coutts, A.J. (2011). Physiology of small-sided games training in football: A systematic review. *Sports Medicine, 41*(3), 199-220.

Hopkins, W.G., Marshall, S.V., Batterham, A.M., & Hanin, J. (2009). Progressive statistics for studies in sports medicine and exercise science. *Medicine and Science in Sports and Exercise, 41*(1), 3-13.

Impellizzeri, F.M., Bizzini, M., Dvorak, J., Pellegrini, B., Schena, F., & Junge, A. (2013). Physiological and performance responses to the FIFA 11+ (part 2): A randomised controlled trial on the training effects. *Journal of Sports Sciences, 31*(13), 1491-1502.

Krustrup, P., Helsen, W., Randers, M.B., Christensen, J.F., MacDonald, C., Rebelo, A.N., & Bangsbo, J. (2009). Activity profile and physical demands of football referees and assistant referees in international games. *Journal of Sports Sciences, 27*(11), 1167-1176.

Krustrup, P., Mohr, M., & Bangsbo, J. (2002). Activity profile and physiological demands of top-class soccer assistant refereeing in relation to training status. *Journal of Sports Sciences, 20*(11), 861-871.

Mallo, J., Navarro, E., Garcia-Aranda, J.M., Gilis, B., & Helsen, W. (2008). Analysis of the kinematical demands imposed on top-class assistant referees during competitive soccer matches. *Journal of Strength and Conditioning Research, 22*(1), 235-242.

Mallo, J., Navarro, E., Garcia-Aranda, J.M., & Helsen, W.F. (2009). Activity profile of top-class association football referees in relation to fitness-test performance and match standard. *Journal of Sports Science, 27*(1), 9-17.

Mendez-Villanueva, A., & Buchheit, M. (2013). Football-specific fitness testing: Adding value or confirming the evidence? *Journal of Sports Sciences*, *31*(13), 1503-1508.

Tonnessen, E., Hem, E., Leirstein, S., Haugen, T., & Seiler, S. (2013). Maximal aerobic power characteristics of male professional soccer players, 1989-2012. *International Journal of Sports Physiology and Performance, 8*(3), 323-329.

Weston, M., Batterham, A.M., Castagna, C., Portas, M.D., Barnes, C., Harley, J., & Lovell, R.J. (2011a). Reduction in physical match performance at the start of the second half in elite soccer. *International Journal of Sports Physiology and Performance, 6*(2), 174-182.

Weston, M., Castagna, C., Helsen, W., & Impellizzeri, F. (2009). Relationships among field-test measures and physical match performance in elite-standard soccer referees. *Journal of Sports Sciences, 27*(11), 1177-1184.

Weston, M., Castagna, C., Impellizzeri, F.M., Bizzini, M., Williams, A.M., & Gregson, W. (2012). Science and medicine applied to soccer refereeing: An update. *Sports Medicine, 42*(7), 615-631.

Weston, M., Drust, B., Atkinson, G., & Gregson, W. (2011b). Variability of soccer referees' match performances. *International Journal of Sports Medicine, 32*(3), 190-194.

Yanci-Irigoyen, J. (2014). Changes in the physical fitness of soccer referees: A longitudinal study. *International Journal of Sports Sciences, 10*(38), 336-345.

Yanci, J., Los Arcos, A., Grande, I., & Casajús, J.A. (2016). Change of direction ability test differentiates higher level and lower level soccer referees. *Biology of Sport, 33*, 173-177.

Submitted: June 29, 2015
Accepted: February 15, 2016

Correspondence to:
Javier Yanci, Ph.D
Faculty of Education and Sport
University of the Basque Country, UPV/EHU
Lasarte 71, 01007, Vitoria-Gasteiz, Spain
E-mail: javier.yanci@ehu.es

Acknowledgements

We are grateful to the University of the Basque Country (UPV/EHU) and the Department of Physical Education and Sport for providing funding. This work was supported by the Basque Country Government under a doctoral Grant number reference PRE_2014_2_54.