

## Match performances of soccer referees: the role of sports science

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***Running title:*** Science and soccer refereeing

### ***Abstract***

Sports science has extensively quantified the physical demands of soccer refereeing over the past 15 years. Early observational studies provided descriptive accounts of referee match activity profiles. More recently, sports science has examined factors influencing match activities, such as age, competition standard and player activities. Soccer referees' match physical performances are inextricably linked to their ability to make the correct judgment; decision-making is therefore a crucial aspect of refereeing. The aim of this brief commentary is to concisely review the role that sports science has played thus far in the understanding of soccer referees' match performances and then provide some recommendations for future scientific work to assist in the preparation for, and assessment of, match performance.

***Keywords:*** refereeing, match activities, training, injury, decision-making, research

### ***Résumé***

Les sciences du sport se sont largement focalisées sur les demandes physiques des arbitres de football lors de ces 15 dernières années. Plusieurs études ont ainsi permis de décrire des profils d'activités des arbitres au cours des rencontres. Plus récemment, les travaux ont examiné les facteurs qui pouvaient influencer cette activité comme l'âge, le type de compétition et l'activité des joueurs. Les performances des arbitres de football lors des rencontres sont inextricablement liées à leur capacité à effectuer un jugement correct ; la prise de décision étant alors une dimension déterminante de l'arbitrage. L'objectif est ainsi de passer en revue de manière concise le rôle que les sciences du sport ont joué jusqu'à présent dans la compréhension des performances des arbitres de football en match et de fournir quelques recommandations pour les futurs travaux scientifiques afin d'aider à la préparation et à l'évaluation de la performance arbitrale en football.

**Mots clés:** arbitrage, activités de match, entraînement, blessure, prise de décision, recherche

### ***Introduction***

The scientific interest in the match performances of soccer referees has grown substantially over the past two decades. Prior to 1995 there were two scientific papers published in international peer-reviewed journals, yet 22 papers were published between 1995 and 2007 (Castagna, Abt, & D'Ottavio, 2007). An updated PubMed search from 2007 to the present day (soccer OR football AND referees OR match officials) returned 49 relevant peer-reviewed articles, thereby demonstrating further interest in the scientific literature. A diversity of research topics and study design complexity complements this growth. Further to this, part-time or full-time employment of referee specialist sports scientists by many international and national referee governing bodies provides more evidence of the increasing role that sports science now plays in the preparation and evaluation of referees' match performances. The aim of this short commentary is to briefly review the existing evidence-base, and to use this research to propose future directions for the meaningful application of sports science to the match performances of soccer referees. Further, the scope of this brief commentary is confined to referees; therefore, the application of sports science to the performance of assistant referees performance is beyond the commentary's scope.

### ***Physical performance***

The quantification of a soccer referee's match physical demand enables the assessment of whether referees are able to meet the physical demands of the match, provides specific information for training programme design, and facilitates the effective planning and timing of subsequent training sessions. Observational research describing the physical demands of soccer refereeing reports distances of ~10 km per match and, therefore, the demands are predominantly aerobic (Catterall, Reilly, Atkinson, & Coldwells, 1993; Johnston & McNaughton, 1994). More recent descriptive accounts have demonstrated increased match

distances of ~11 km (D'Ottavio & Castagna, 2001, Krusturp & Bangsbo, 2001; Weston, Drust, Atkinson, & Gregson, 2011a). Comprehensive reviews of the physical and physiological match performances are available elsewhere (Castagna et al., 2007; Weston, Castagna, Impellizzeri, Bizzini, Williams, & Gregson, 2012). While match demands are relatively easy to quantify, interpretation is more problematic as the demands are influenced by playing standard (Krusturp & Bangsbo, 2001; Castagna, Abt, & D'Ottavio, 2004; Weston, Bird, Helsen, Nevill, & Castagna, 2006) referee age (Weston, Castagna, Impellizzeri, Rampinini, & Breivik, 2010), fitness (Krusturp & Bangsbo, 2001; Tessitore, Cortis, Meeusen, & Capranica, 2007; Weston, Castagna, Helsen, & Impellizzeri, 2009), hydration status (Da Silva, Fernandes, & Fernandez, 2011), and most importantly the physical performances of the players (Weston, Castagna, Impellizzeri, Rampinini, & Abt, 2007; Weston, Drust, & Gregson, 2011b). It is hardly surprising, therefore, that a high match-to-match variability exists in key measures of match physical performance, namely high-speed running and sprinting (Weston et al., 2011a).

The high match physical demand imposed on soccer referees (Castagna et al., 2007; Weston et al., 2012) necessitates a good level of physical fitness to ensure referees can keep up with play at all times and obtain optimal positions when making key decisions. Therefore, physical training programmes informed by the science of match analysis would appear logical. While physical considerations will always be secondary to the ability to fulfill a technical role on the field of play, inadequate physical preparation could limit technical functioning during a match (Mendez-Villanueva & Buchheit, 2013). With this in mind, training programmes with an emphasis on high-intensity running - the key physical performance indicator (Krusturp & Bangsbo, 2001) - are beneficial for the fitness of soccer referees (Krusturp & Bangsbo, 2001; Weston, Helsen, MacMahon, & Kirkendall, 2004; Weston et al., 2011c). Improved fitness

should translate to improved match physical performances, yet the high match-to-match variability that exists for referees' high-speed running and sprinting distances (coefficients of variation of  $25.9 \pm 10.1\%$  and  $54.0 \pm 20.7\%$ , respectively) dictates large sample sizes are needed to detect meaningful changes in these variables (Weston et al., 2012). For example, detecting a meaningful difference of 10% using a measure with a coefficient of variation of 30% would require a sample size of approximately 200 games (Batterham & Atkinson, 2005). As such, training-induced changes in the most relevant measures of match physical performance will be difficult to detect.

Injury rates in soccer referees have been reported to be in the range of 5.3 - 20.8 injuries per 1000 match hours (Bizzini, Junge, Bahr, Helsen, & Dvorak, 2009; Wilson, Byrne, & Gissane, 2011; Gabrilo, Ostojic, Idrizovic, Novosel, & Sekulic, 2013). A higher referee fitness level and a qualitative approach to training are recognized as protective factors against injury, however (Gabrilo et al., 2013). Reduced injury levels have obvious appeal to the referee and those responsible for referee appointments by increasing training and match availability. Consequently, the prevention of referee injury may provide sports science with the opportunity to evidence a meaningful performance enhancement. For example, the implementation of specific injury prevention programmes developed from an evidence-based understanding of injury type and location, in addition to a comprehensive understanding of match activity profiles, may help to reduce injury incidence.

Research into the training practices of soccer referees has demonstrated a prevalence of physical training sessions over skill practice (MacMahon, Helsen, Starks, & Weston, 2007; Catteuw, Helsen, Gilis, Wagemans, 2009); however, comparisons of the incidence of training injuries versus match injuries are equivocal (Bizzini et al., 2009; Wilson et al., 2011;

Bizzini, Junge, Bahr, & Dvorak, 2011). Nonetheless, given the high volume of matches and physical training sessions performed each season (MacMahon et al., 2007; Weston et al., 2011c) it is recommended that sports science pays close attention to the monitoring of referee physical training loads. Technological advances in the measurement of physical activity - such as GPS and heart rate monitors – now enable sport scientists to accurately gauge the actual work performed by the referees (i.e., distances covered) and the physiological response to this work (i.e., heart rates) (Weston, 2013). The long-term modelling of training load data with injury incidence and location data can identify training load ranges that are associated with acceptable and unacceptable risks of injury (Gabbett, 2010). Such practices pose a challenge to those scientists working day-to-day with soccer referees; overcoming this challenge could well be one of the most meaningful applications of sports science to the domain of soccer refereeing. It is recommended, however, that the use of technology is focused on informing and changing practice and not on convenient data collection for an easy publication or to showcase the technology.

### ***Perceptual-cognitive performance***

The main task of referee during a match is to safeguard the application of the laws of the game (Fédération Internationale de Football Association, 1993). As such, the most important aspect of soccer refereeing is considered to be the decision-making process (Helsen & Bultynck, 2004). Given that adopting a good location on the field of play is essential for correct decision-making (Mallo, Frutos, Juarez, & Navarro, 2012), it is important that the physical and perceptual-cognitive aspects of referee performance are not perceived to be mutually exclusive, however.

Consistent with studies examining the physical demands of soccer refereeing, early scientific investigations concerning referee decision-making were largely descriptive accounts. Helsen & Bultynck (2004) reported that elite soccer referees make 3-4 decisions per minute, with these decisions evenly distributed across the duration of a match. The 'correctness' of referees' decision-making during matches has received attention within the scientific literature, with evidence that a substantial number of referees' decisions might be 'incorrect' (Schweizer, Plessner, Kahlert, & Brand, 2011). Here, correctness of decisions was assessed by an 'expert' panel (Fuller, Junge, & Dvorak, 2004; Andersen, Engebretsen, & Bahr, 2004; Gilis, Weston, Helsen, Junge, & Dvorak, 2006; Mallo et al., 2012), with only moderate agreement rates reported (~75%). However, factors such as prior decisions (Plessner & Betsch, 2001), team reputation (Jones, Paull, & Erskine, 2002), crowd noise (Nevill, Balmer, & Williams 2002), crowd size (Downward & Jones, 2007), home advantage (Boyko, Boyko, & Boyko, 2007) elapsed time of the match (Unkelbach & Memmert, 2008), and the physical stature of players (van Quaquebeke & Giessner, 2010) all influence a referee's decision-making. Further to this, positioning influences the correctness of decisions taken by referees, with a lower number of 'incorrect' decisions awarded when the referees were positioned in the central area of the field (Mallo et al., 2012). However, the assessment of decision-making may well be flawed when using agreement scores with expert observer panels, as external factors are less likely to influence panel decisions. Furthermore, two referees observing the same play from distinct vantage points may be differentially predisposed to call a foul (Kranjec, Lehet, Bromberger, & Chatterjee, 2010). As such, a true understanding of the accuracy of referees' match decisions continues to elude the science of soccer refereeing.

While observational research designs provide valuable information pertaining to decision-making in soccer referees, no experimental data has been presented with regard to strategies

to improve decision-making. Many studies have suggested that perceptual-cognitive training sessions are introduced into the training schedules of elite referees, and such a practice is now commonplace in the training practices of elite soccer referees. Currently though, no experimental data exists on the effectiveness of these training sessions on match decision-making ability. Video-based decision-making training is oft cited as a training tool to improve the correctness of referees' match decisions. While decision-making can be improved by video-based training, as yet there is no evidence that learning effects are transferred to the real world (Schweizer et al., 2011).

Physical fatigue has been linked to performance degradation and human error in sport environments (Moore, Romine, O'Connor, & Tomporowski, 2012). However, it is not clear if exercise capacity actually may decrease the likelihood of incurring judgment errors during the game (Castagna et al., 2007) and there remains no experimental evidence on the relationship between physical aspects of referee performance (fitness and fatigue) with decision-making. Establishing a causal link, were it to exist, represents an attractive proposition to sports science, as it would improve our understanding of the intricacies of referees' match performances. Such research, however, could well be problematic to undertake as fatigue is difficult to discern from time-motion data and, as discussed previously, a true assessment of decision-making of referees in situ is difficult to undertake. As commented by Schweizer and colleagues (2011) there is still a lot of research to do in the domain of referees' decision-making, including both applied and basic research questions.

### ***Conclusion***

Over the past two decades, sports science has evidenced the high demands imposed on soccer referees during matchplay, factors influencing these demands and the potential for physical



and perceptual-cognitive training to improve match performance. However, given the abundance of descriptive accounts within the current literature it may be fair to conclude that sports science has exhausted this evaluative aspect of referee performance. Therefore, the challenge to sports science should now focus on overcoming concerns of research design and ecological validity to establish physical and perceptual-cognitive strategies that will have a quantifiable and meaningful impact on the match performances of soccer referees. Otherwise, the science of soccer refereeing may no longer assist in informing and developing the practice of soccer refereeing.

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