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Estimated metabolic and mechanical demands during different small-sided games in elite soccer players

Paolo Gaudino *, Giampietro Alberti, F. Marcello Iaia

Department of Biomedical Science for Health, Università degli Studi di Milano, Milano, Italy

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The present study examined the extent to which game format (possession play, SSG-P and game with regular goals and goalkeepers, SSG-G) and the number of players (5, 7 and 10 a-side) influence the physical demands of small-sided soccer games (SSGs) in elite soccer players. Training data were collected during the in-season period from 26 English Premier League outfield players using global positioning system technology. Total distance covered, distance at different speed categories and maximal speed were calculated. In addition, we focused on changes in velocity by reporting the number of accelerations and decelerations carried out during the SSGs (divided in two categories: moderate and high) and the absolute maximal values of acceleration and deceleration achieved. By taking into account these parameters besides speed and distance values, estimated energy expenditure and average metabolic power and distance covered at different metabolic power categories were calculated. All variables were normalized by time (i.e., 4 min). The main findings were that the total distance, distances run at high speed (>14.4 km h^{-1}) as well as absolute maximum velocity, maximum acceleration and maximum deceleration increased with pitch size (10v10 > 7v7 > 5v5; $p < .05$). Furthermore, total distance, very high (19.8–25.2 km h^{-1}) and maximal (>25.2 km h^{-1}) speed distances, absolute maximal velocity and maximum acceleration and deceleration were higher in SSG-G than in SSG-P ($p < .001$). On the other hand, the number of moderate (2–3 m s^{-2}) accelerations and decelerations as well as the total number of changes in velocity were greater as the pitch

* Corresponding author. Address: Via Kramer 4, 20129, Milano, Italy. Mobile: +44 7586323450/+39 3388761433.
E-mail addresses: p.gaudino@hotmail.com (P. Gaudino), giampietro.alberti@unimi.it (G. Alberti), marcello.iaia@unimi.it (F. M. Iaia).

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dimensions decreased (i.e., 5v5 > 7v7 > 10v10; $p < .001$) in both SSG-G and SSG-P. In addition, predicted energy cost, average metabolic power and distance covered at every metabolic power categories were higher in SSG-P compared to SSG-G and in big than in small pitch areas ($p < .05$). A detailed analysis of these drills is pivotal in contemporary football as it enables an in depth understanding of the workload imposed on each player which consequently has practical implications for the prescription of the adequate type and amount of stimulus during exercise training.

1. Introduction

Small-sided games (SSGs) represent a common form of conditioning in soccer (Brandes, Heitmann, & Müller, 2012; Hill-Haas, Dawson, Impellizzeri, & Coutts, 2011; Iaia, Rampinini, & Bangsbo, 2009) serving as an effective alternative to traditional interval training for enhancing a player's soccer-specific endurance (Hill-Haas, Coutts, Rowsell, & Dawson, 2009; Impellizzeri et al., 2006). In addition to replicating the specific movement patterns associated with match-play such methods have the advantage of concurrent physical, cognitive and technical/tactical development (Brandes et al., 2012; Casamichana, Castellano, & Castagna, 2012; Hill-Haas et al., 2011; Mallo & Navarro, 2008).

In light of their growing popularity, a comprehensive understanding of the stimulus imposed on players during these drills is required in order to optimise the training adaptation. Manipulating variables such as the playing area, number of players and rules of the game influences the workload of SSGs (Brandes et al., 2012; Castellano, Casamichana, & Dellal, 2013; Dellal et al., 2012; Hill-Haas et al., 2011). For example, a larger pitch size and low number of players increases the strain incurred (Casamichana & Castellano, 2010; Dellal et al., 2011; Hill-Haas et al., 2011; Kelly & Drust, 2009). However, to date information concerning the load associated with SSGs has been predominantly assessed via heart rate (HR), blood lactate ([La]) and rating of perceived exertion (RPE) (Hill-Haas et al., 2011; Rampinini et al., 2007). It has been demonstrated that SSGs containing smaller numbers of players elicit greater HR, blood lactate and perceptual responses (Hill-Haas et al., 2011) that were also higher on medium and large pitch sizes compared with small pitches (Hill-Haas et al., 2011; Rampinini et al., 2007). The evolution of global positioning systems (GPS) now permits valid and reliable estimates of the external load incurred during SSGs (Brandes et al., 2012; Casamichana & Castellano, 2010; Castellano et al., 2013; Dellal et al., 2011). In this regard, recent studies reported that the largest game format is associated with a greater range of distances traveled at high speeds (Casamichana & Castellano, 2010; Hill-Haas et al., 2011). In addition, the total distance covered at high speed was higher when the number of ball contacts allowed was reduced (Dellal et al., 2011).

However, despite extensive research, to date there is still a general lack of load-related information on typical soccer drills used with elite players (e.g., SSG-P). In particular, little is known about some crucial physical (e.g., accelerations and decelerations) components taxed within drills of different type and size. The unpredictable and multifactorial nature of these conditioned games involving among others a great number of explosive actions and changes in velocity, implies a higher complexity in the quantification of the workload. Therefore, novel insight about the mechanisms taxed and the physiological demands imposed is warranted. Recent studies by Gaudino et al. (2013b, 2014), have indeed demonstrated that the physical requirements during SSGs are more demanding than suggested in much of the early literature based on running speed alone, and these differences are even greater when SSGs are played in small pitches. Previous investigations (di Prampero et al., 2005; Osgnach, Poser, Bernardini, Rinaldo, & di Prampero, 2010), have shown that the energy expenditure and distance covered at different metabolic power categories better inform about the true physical demands imposed on players, as this method takes into account accelerations and decelerations besides speed and distance values (di Prampero et al., 2005; Gaudino et al., 2013b, 2014; Osgnach