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Association Between Speed, Repeated Sprint Ability and Aerobic Endurance Parameters in Professional Greek Soccer Players

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Abstract

We examined the association between speed, repeated sprint ability (RSA), and aerobic endurance parameters. At the beginning of the preparation period, 18 professional soccer players performed a speed test to determine first step quickness (5 m), acceleration (10 m) and maximal speed (30 m) performance, an RSA test consisting of 6 x 40 m with 20s active recovery, and an incremental treadmill test to determine endurance parameters (velocity at 2mM (V2), 4mM (V4) lactate and maximal velocity (Vpeak)). Best time in a single trial (RSAbest) was moderately correlated to Vpeak (r=-0.36; 90%CL, -0.66 to 0.05) and 30 m (r=0.32; 90%CL, -0.09 to 0.34). Mean RSA was almost perfectly correlated to RSAbest (r=0.93; 90%CL, 0.84 to 0.94), and moderately correlated to V4 (r=-0.46; 90%CL, -0.73 to 0.07) and Vpeak (r=-0.42; 90%CL, -0.70 to 0.02). Percent speed decrement (%dec) was moderately correlated to V2 (r=-0.36; 90%CL, -0.66 to 0.05) and to V4 (r=-0.32; 90%CL, -0.64 to 0.09) expressed as % of Vpeak. These findings indicate that, at the start of the preparation period, RSA is more related to aerobic endurance than speed parameters in professional Greek soccer players.

Keywords: *testing, magnitude-based inferences, pre-season, correlation*

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Ερευνητική

Συσχετισμός Μεταξύ Παραμέτρων Ταχύτητας, Ικανότητας Επαναλαμβανόμενης Ταχύτητας και Αερόβιας Αντοχής σε Επαγγελματίες Έλληνες Ποδοσφαιριστές

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Περίληψη

Εξετάσαμε τη συσχέτιση μεταξύ παραμέτρων ταχύτητας, ικανότητας επαναλαμβανόμενης ταχύτητας (ΙΕΤ) και αερόβιας αντοχής. Στην αρχή τής περιόδου προετοιμασίας, 18 επαγγελματίες ποδοσφαιριστές εκτέλεσαν μία δοκιμασία ταχύτητας για να προσδιορίσουμε την ταχύτητα του πρώτου βήματος (5 μ), επιτάχυνση (10 μ) και μέγιστη ταχύτητα (30 μ), μία δοκιμασία ΙΕΤ που περιελάμβανε 6 Χ 40 μ με 20 δευτερόλεπτα ενεργή αποκατάσταση, και μια προοδευτικά αυξανόμενη δοκιμασία σε δαπεδοεργόμετρο για τον προσδιορισμό παραμέτρων αντοχής (ταχύτητα στα 2 mM (V2), 4 mM (V4), γαλακτικό και μέγιστη ταχύτητα (Vpeak). Η μέγιστη ταχύτητα σε μια επανάληψη (IETbest) ήταν μέτρια συσχετισμένη με την Vpeak (r=-0.36; 90%CL, -0.66 to 0.05) και 30 μ (r=0.32; 90%CL, -0.09 to 0.34). Η μέση ΙΕΤ ήταν σχεδόν τέλεια συσχετισμένη με IETbest (r=0.93; 90%CL, 0.84 to 0.94) και μέτρια με την V4 (r=-0.46; 90%CL, -0.73 to 0.07) και Vpeak (r=-0.42; 90%CL, -0.70 to 0.02). Ποσοστιαία μείωση ταχύτητας (%dec) ήταν μέτρια συσχετισμένη με την V2 (r=-0.36; 90%CL, -0.66 to 0.05) και την V4 (r=-0.32; 90%CL, -0.64 to 0.09) εκφραζόμενη ως ποσοστό της Vpeak. Αυτά τα ευρήματα υποδεικνύουν ότι, στην αρχή της περιόδου προετοιμασίας, η ΙΕΤ σχετίζεται πιο πολύ με παραμέτρους αερόβιας αντοχή παρά με αυτούς της ταχύτητας σε επαγγελματίες Έλληνες ποδοσφαιριστές.

Λέξεις κλειδιά: *αξιολόγηση, συμπεράσματα βασισμένα σε μεγέθη, περίοδος προετοιμασίας, συσχέτιση*

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Introduction

Soccer players sprint approximately 20 - 60 times per game, with a total sprint distance of about 700 -1000 m, and they must be able to recover rapidly between sprints (Reilly & Thomas, 1976; Ekblom, 1986; Spencer et al., 2005). One of the important soccer fitness components is the repeated sprint ability (RSA), a measure of the ability to recover and maintain maximal effort during subsequent sprints (Stølen et al., 2005).

RSA tests consisting of several sprints, interspersed with brief recovery periods, mirror physiological responses to actual matches, such as decrease in muscle pH, phosphocreatine and ATP, and activation of anaerobic glycolysis (Spencer et al., 2005; Svensson & Drust, 2005; Wragg et al., 2000). Even though the validity of classic RSA tests has been questioned, as shorter accelerations that do not reach speeds necessary to qualify them as sprints, they have been shown to be important in game-specific situations (Schimpchen et al., 2016). Therefore, evaluation of RSA has formed a basis for the development and evaluation of the effectiveness of training strategies (Svensson & Drust, 2005) and talent identification (Reilly et al., 2000). However, the physiological determinants of RSA and the relative contributions of speed and aerobic endurance parameters in RSA are still debatable (Spencer et al., 2005; Sanders et al., 2017).

A potential reason for the discordant findings could be the different sprint distances (20-30 m vs. 40 m), modes of exercise (i.e., running compared to cycling) employed for the RSA tests, and possibly the age and level of athletes (i.e., young vs. adult and elite versus vs. non-elite; Sanders et al., 2017). Another reason for the lack of agreement could be certain methodological shortcomings in previous studies. For example, Pyne et al., (2008) reported a stronger relationship of RSA to speed than aerobic endurance. However, in the aforementioned study, endurance performance, and estimated VO2max, was determined indirectly with a 20 m multistage shuttle-run test that significantly underpredicts VO2max (Ahmaidi et al., 1992; Flouris et al., 2010), and thus biased the reported correlations. Even though direct determination of VO2max provides support to the importance of aerobic capacity for RSA, by enhancing recovery from repeated sprints (Jones et al., 2013), da Silva et al. (2010) reported that RSA is more strongly related to velocity at onset of blood lactate accumulation (vOBLA) and velocity at maximal oxygen uptake (vVO2max) than maximal oxygen uptake (VO2max). However, in the study by da Silva et al. (2010), speed was not measured with a dedicated speed test, but it was extracted from the RSA protocol. Considering that acceleration, maximum speed, and agility are specific qualities and relatively unrelated, it is deduced that specific speed protocols assessing the different parameters of speed, i.e., first step quickness (5 m), acceleration (10 m) and maximal speed (30 or 40 m) performance are more appropriate for evaluating the relationship of speed parameters with RSA (Little & Williams, 2005).

Therefore, the aim of the present study was to address the above-mentioned methodological considerations and assess the relationship between different speed parameters, RSA and aerobic endurance. Also, considering that different indices of RSA have been used in previous studies to identify its relationship with other fitness components, a secondary aim was to identify the RSA index with the strongest correlation.

Methods

Volunteers

Eighteen well trained soccer players (22.9 ± 3.4 years; 181 ± 8 cm; 75.3 ± 6.5 kg; 8.1 ± 2.4% body fat) from a team in the top professional Greek league volunteered. Written informed consent was received from all participants after explanation of the aims, benefits and risks of the study. Participants were free to withdraw from the study at any time without penalty and all procedures were approved by the university ethics committee.

Protocol

Players subjected to the following tests at the beginning of the preparation period (end of June): (a) a speed test to determine 5 m (first step quickness), 10 m (acceleration) and 30 m (maximal speed) performance, (b) an RSA test consisting of 6 x 40 m with 20s active recovery, (c) an incremental run to exhaustion on a treadmill to determine endurance parameters (velocity at 2mM (V2), and (d) 4mM (V4) of lactate and maximal speed (Vpeak)). Testing took place at the same time on 3 different days separated by 48 hours. The speed test was performed first, followed by RSA and endurance tests.

Anthropometric assessment

Height and weight were measured using calibrated stadiometer and scale (Seca, Hamburg, Germany).

Speed test

A natural turf soccer pitch, with players wearing soccer shoes, was used to measure 0–5 m (Lockie et al., 2015), 0–10 m (Boone et al., 2012), and the 0–30 m time as a measure of maximum velocity specific to soccer that has been reliably used (Lockie et al., 2013) in the assessment of soccer players (Sporis et al., 2009). Gates were positioned at 0 m, 5 m, 10 m, and 30 m, to measure the 0–5 m, 0–10 m, and 0–30 m intervals and time was recorded to the nearest 0.001 s with a timing lights system (Newtest Power Timer, Finland). Prior to the speed test all players completed a standardised warm up of low-intensity running, static and dynamic stretching exercises and short acceleration efforts. Every player performed 3 attempts and the best was used in the subsequent analysis.

RSA test

RSA was measured by 6 x 40 m (20 + 20 m sprints with 180° turns) shuttle sprints separated by 20 s of passive recovery (Rampinini et al., 2007; Impellizzeri et al., 2008). The athletes started from a line, sprinted for 20 m, touched a line with a foot and came back to the starting line as fast as possible. The timing equipment used for the speed test was also used for the RSA test. Best time in a single trial (RSAbest), mean time (RSAmean) and percent decrement (%dec, defined as RSAmean/RSAbest expressed as percent) were determined according to Rampinini et al., (2007). The reliability (typical error expressed as a coefficient of variation) for RSAmean has been reported to be 0.8% (Ferrari-Bravo et al., 2005) and there are significant correlations between RSAmean time and match performance variables (i.e., very high intensity running and sprinting distance) assessed by match analysis systems Rampinini et al. (2007).

Aerobic endurance (V2, V4 and Vpeak)

All volunteers performed incremental treadmill (Technogym Runrace 1200, Gambettola, Italy) exercise to exhaustion. During warm-up, the subjects walked for 3 min at self-selected pace and jogged for 5 min at 8 km·h-1. As the first stage of the incremental test the subjects run at 10 km·h-1 for 3 min and then the speed was increased by 2 km·h-1 every 3 min until exhaustion (Impellizzeri et al., 2006). At the end of each 3 min stage, the volunteers stepped on the side of the treadmill belt to allow capillary blood sampling that were analysed immediately for lactate using an automated analyser (Accutrend, Roche Diagnostics, Mannheim, Germany). All volunteers were verbally encouraged to provide maximal effort. The criteria used for verification of maximal effort were met by all subjects and were: (a) exhaustion (subjective evaluation), (b) HR at ± 2.5% of age predicted HRmax, and (c) maximal blood lactate after exercise greater than 8 mM. Blood lactate values were plotted against speed, and V2 and V4 were calculated using liner interpolation (Mc Millan et al., 2005) and expressed as % of Vpeak (V2%Vpeak and V4%Vpeak, respectively), while Vpeak was the velocity at exhaustion (Machado et al., 2013).

Statistical analyses

All data are presented as mean ± SD. Relative changes in performance are expressed as percent with 90% confidence limits (90%CL). The distribution of each variable was examined with the Kolmogorov-Smirnov normality test. Homogeneity of variance was verified by the Levene test. Pearson's correlation coefficient was used to evaluate the association between RSAbest, RSAmean, dec% and V2, V4, Vpeak, 5 m, 10 m and 30 m. The magnitude of correlation r (90%CL) was characterised according to the following thresholds: < 0.1, trivial; < 0.1 – 0.3, small; < 0.3 – 0.5, moderate; < 0.5 – 0.7, large; < 0.7 – 0.9, very large; and < 0.9 – 1.0, almost perfect. If the 90% confidence intervals overlapped small positive and negative values, the magnitude was deemed unclear; otherwise the magnitude was deemed as observed (Hopkins et al., 2009). Analyses were carried out using SPSS 19 (SPSS Inc, Chicago, USA) and P values of < 0.05 were considered significant.

Results

Endurance and speed parameters are presented in Table 1. The interrelationships between RSA parameters appear in Table 2, while relationships between speed (5, 10 and 30 m), RSA (RSAmean, RSAbest, %dec), and aerobic endurance (V2, V4, Vpeak) are summarised in Table 3. RSAmean was almost perfectly positively correlated to RSAbest. % dec had a likely large negative correlation to RSAbest but the relationship to RSAmean was unclear. V4 had a likely moderate negative relationship to RSAmean. Vpeak had a likely moderate negative relationship to both RSAmean and RSAbest. Maximal speed had a likely moderate positive relationship to RSAbest. V2%Vpeak and V4%Vpeak had a likely moderate negative relationship to %dec.

Table 1. Endurance and speed parameters.

V_2		V_4		V_{peak}	5 m	10 m	30 m	RSA_{mean}	RSA_{best}	%dec
$km \cdot h^{-1}$	$\%V_{peak}$	$km \cdot h^{-1}$	$\%V_{peak}$	$km \cdot h^{-1}$	s	s	s	s	s	
11.0	59.6	13.7	74.2	18.5	1.029	1.757	4.179	7.346	7.115	3.3
(± 1.0)	(± 3.9)	(± 0.9)	(± 4.2)	(± 1.0)	(± 0.040)	(± 0.054)	(± 0.092)	(± 0.170)	(± 0.203)	(± 1.2)

Velocity at 2mM (V2) and 4mM (V4) of lactate, and maximum velocity (Vpeak). Time for 5 (first step quickness), 10 (acceleration) and 30 m (maximal speed) performance variables in soccer players (n=18). Values are mean ± SD.

Table 2. Correlations between RSA parameters.

	RSA_{mean}	RSA_{best}	%dec
RSA_{mean}		r=0.93	r =-0.31
		(0.84 to 0.97)	(-0.63 to 0.10)
		P < 0.001	*P* = 0.212
		most likely almost perfectly+	unclear
RSA_{best}			r =-0.64
			(-0.83 to -0.32)
			P = 0.004
			very likely large-
%dec			

Correlation coefficient (90%CL), p value and observed magnitude of the relationship.

Table 3. Relationships between RSA, endurance and speed performance parameters.

	V_2		V_4		V_{peak}	5m	10m	30m
	km·h^{-1}	%V_{peak}	km·h^{-1}	%V_{peak}	km·h^{-1}	s	s	s
RSA_{mean}	r=-0.28	r=-0.002	r=-0.46	r=-0.14	r=-0.42	r=-0.07	r=0.17	r=0.25
	(-0.61 to 0.14)	p=0.992	(-0.73 to 0.07)	(-0.51 to 0.28)	(-0.70 to 0.02)	p=0.788	(-0.25 to 0.53)	(-0.17 to 0.59)
	p=0.268	trivial	p=0.054	p=0.568	p=0.084	trivial	p=0.496	p=0.309
	unclear		likely moderate-	unclear	likely moderate-		unclear	unclear
RSA_{best}	r=-0.13	r=0.14	r=-0.28	r=0.06	r=-0.36	r=-0.05	r=0.15	r=0.32
	(-0.5 to 0.29)	(-0.28 to 0.51)	(-0.61 to 0.14)	p=0.981	(-0.66 to 0.05)	p=0.854	(-0.27 to 0.52)	(-0.09 to 0.34)
	p=0.613	p=0.592	p=0.254	trivial	p=0.148	trivial	p=0.556	p=0.197
	unclear	unclear	unclear		likely moderate-		unclear	likely moderate+
%dec	r=-0.26	r=-0.36	r=-0.24	r=-0.32	r=0.03	r=-0.02	=-0.02	r=-0.29
	(-0.60 to 0.16)	(-0.66 to 0.05)	(-0.58 to 0.18)	(-0.64 to 0.09)	p=0.898	p=0.940	p=0.940	(-0.62 to 0.13)
	p=0.309	p=0.141	p=0.345	p=0.197	trivial	trivial	trivial	p=0.248
	unclear	likely moderate-	unclear	likely moderate-				unclear

Correlation coefficient (90%CL), p value and observed magnitude of the relationship.

Discussion

This study examined the associations between speed, RSA and aerobic endurance parameters and found that RSA is more related to aerobic endurance than speed. This finding is in agreement with studies using indirectly derived speed parameters (da Silva et al., 2010), or sprint distances less than 40 meters (Sanders et al., 2017). The novelty of our study is that speed was assessed with a specific speed test and endurance was assessed with sub-maximal aerobic endurance indices.

It should be considered that even though VO2max is widely recognised as the most valid indicator of aerobic fitness it may not be the most appropriate index for evaluating the contributing role of aerobic endurance to RSA. VO2max is thought to be determined mainly by central factors, such as cardiac output (Volianitis & Secher, 2016), whereas RSA has been associated more with peripheral factors, such as accumulation of metabolites in active muscles (Spencer et al., 2005).

Da Silva et al., (2010) have observed that the velocity at VO2max and at the onset of blood-lactate accumulation were correlated more with RSA parameters than VO2max. The velocity at VO2max is a better index than VO2max for the association between maximum aerobic power and movement economy, as players with similar VO2max can have different velocity at VO2max, due to differences in movement economy (Billat et al., 1994). The Vpeak observed in our study is comparable to that found in previous studies (Billat et al., 1994; Denadai et al., 2006; da Silva et al., 2010) in trained endurance athletes and confirms the fitness level of our subjects.

The negative association between V4 and RSAmean in our study is also reflected in the negative association between V4%Vpeak and %dec and provide support to previous suggestion that an enhanced aerobic capacity may facilitate recovery between bouts of high intensity activity (Aziz et al., 2000). In support, our findings in soccer players appear to track with the findings in ice hockey players where oxygen consumption at ventilatory threshold has been associated with RSA and %dec, despite differences in sport demands, and protocols used to evaluate RSA (Lowery et al., 2018). An explanation for the relationship between V4 and RSA may be that the lactate threshold reflects better the buffering capacity to attenuate peripheral fatigue provoked by repeated sprinting (da Silva et al., 2010). Limited buffering capacity appears to be one of the primary limiting factors inducing fatigue during RSA performance. (Bishop et al., 2011). In addition to the enhanced buffering capacity, aerobic fitness also enhance recovery from high intensity intermittent exercise through increased aerobic response, improved lactate removal and enhanced PCr regeneration (Tomlin & Wenger, 2001).

The association observed in the present study between maximal speed (30 m) and RSAbest is in agreement with the study of da Silva et al., (2010), where the fastest sprint time explained most of the variance of the RSA test, albeit the speed parameters in the latter study were derived from the RSA test instead of measured directly with dedicated speed test. In support, Pyne et al., (2008) and Wadley & Rossignol, (1998) also reported an association (r=0.66 and r=0.83, respectively) between 20 m sprint performance and RSA. Taken together, maximal speed appears to be also a critical determinant of RSA.

The soccer season is commonly planned in three distinct periods: the preparation, in-season, and transition periods (Silva et al., 2016). The preparation period is characterized by high frequency of training sessions, which focus on fitness rebuilding following the transition period. During this period, players are typically exposed to friendly games and are subjected to rapid increases in training load that contribute to substantially increasing the physiological stress of the pre-season period that can be more intense than in-season training (Jeong et al., 2011).

Considering the critical importance of RSA for soccer fitness and the contributing roles of both anaerobic and aerobic components, it is advantageous to optimize the determinants of RSA during the preparation period by combining both repeated-sprint training to improve sprint performance plus interval training to improve the recovery between sprints (Bishop et al., 2011). With regards to aerobic fitness, the use of small-sided games, even though are primarily aimed to improve VO2max and technical skills, nevertheless, they can improve RSA performance (Hill-Haas et al., 2009).

In conclusion, our findings indicate that, at the start of the preparation period, RSA is related more to aerobic endurance than speed parameters in professional Greek soccer players, suggesting that specific training should target both aerobic and anaerobic components.

Implications for Competitive Sports

Our results suggest that coaches should be aware that even though RSA is more related to aerobic endurance than speed parameters, nevertheless maximal speed is also a critical factor. Therefore, specific training during the preparation season should be aimed at developing both speed and aerobic endurance by utilizing repeated-sprint and interval training combined with small-sided games.

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