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MATCH RUNNING PERFORMANCE OF ELITE SOCCER PLAYERS AND CORRELATIONS WITH ANTHROPOMETRIC AND POWER INDEXES

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ABSTRACT

The aim of this study was to investigate possible correlations between a) jumping ability (squat jump and countermovement jump performance) and c) anthropometric indexes with the distances covered at different intensities during soccer matches by Greek elite soccer players (n=11). Match running performance was analyzed using a global positioning system (GPS) within the second division professional league. Body weight and height were moderately correlated with the distance that was covered in the first half with the speed from 19.7 to 23.7 km/h (r=-0.605, p<0.05 and r=-0.616, p<0.05, respectively). No correlations were found between SJ and CMJ performance with match running performance in all the velocities. The players covered greater distances in the first half at all speed levels except for walking (6–11.9 km/h: 1,548 vs. 1,260 m, p<0.01; 12–15.7 km/h: 896 vs. 696 m, p<0.001; 15.8–19.6 km/h: 438 vs. 347 m, p<0.01; 19.7–23.7 km/h: 176 vs. 142 m, p<0.01; 23+ km/h: 71 vs. 52 m, p<0.001). The results demonstrated that match running performance depends on the tactical strategies of each team. Shorter players and who weight less may perform better in higher velocities. However, more studies with greater samples are needed to estimate the relations that were mentioned.

Contribution/Originality: This study is one of very few studies which have investigated the relationship between match running performance with anthropometric and power indexes. The paper's primary contribution is finding that match running performance does not correlated with player's power and shorter players may perform better in higher velocities.

1. INTRODUCTION

Soccer is an intermittent type of sport which incorporates actions with low and high intensity and duration. The global positioning systems (GPSs) that have been used for few decades to help coaches to quantify the physiological demands of soccer (Bangsbo *et al.*, 1991). Elite soccer players during a match cover a distance around 9-14 km (Bradley *et al.*, 2010) and perform a lot of activities like accelerations, decelerations, jumps, changes of direction and other (Mohr *et al.*, 2005).

Power actions seem to be critical for the outcome of the match (Castagna *et al.*, 2003). Reilly *et al.* (2000) had mentioned that these actions can discriminate a successful and an unsuccessful performance. High intensity running represents only 10% of the total distance that is covered but is crucial in scoring, keeping ball in possession and stopping an opponent from scoring (Dalen *et al.*, 2016). In addition, changes of direction (COD) and acceleration ability are basic elements for soccer performance (Reilly, 1990; Bangsbo *et al.*, 1991). Researchers understand the significance of high intensity activities in soccer and most research focuses on these movements (Mascio and Bradley, 2013). A lot of studies present the verities of high intensity running: a) across playing positions (Mascio and Bradley, 2013), b) at different levels (Ingebrigtsen *et al.*, 2012) and c) during the match (Mohr *et al.*, 2005).

Soccer players have to perform a lot of high and low intensity actions for an extended period of time (90 minutes). Energy systems, the aerobic and the anaerobic are necessary to provide energy to muscles during the match. However, for high intensity actions that last less than 7 sec the basic energy system that is being activated is phosphagen system which is also called "ATP-CP system". This is the quickest way to resynthesize ATP and more specific creatine phosphate in muscles is a donor of a phosphate to ADP to produce ATP. This is an anaerobic process because it does not use oxygen (Mougios, 2006). However, the amount of CP in muscles is limited so this system provides energy for just a few seconds.

In the literature only a few studies have looked into the correlations between match running performance and aerobic indexes (Castagna *et al.*, 2010; Bradley *et al.*, 2014) and even fewer studies have focused on the examination of the relationship between match running performance and performance on anaerobic tests (Rampinini *et al.*, 2007; Redkva *et al.*, 2018). In these two studies concerning anaerobic indexes, researchers used tests to assess repeated sprint ability (RSA) and vertical jump ability of soccer players. Rampinini *et al.* (2007) mentioned that correlations were observed between performances at RSA test and the distance that was covered in very high intensity running (> 19.8 km/h) and with sprints, but no correlation with vertical jump performance was observed and Redkva *et al.* (2018) mentioned that no correlation between repeated sprint ability and match running performance were observed either. It is known that a high level of aerobic power helps soccer players to perform more frequent maximal anaerobic actions of short time (Bishop *et al.*, 2004). Vertical jump performance is being used by coaches as an index of bottom limb muscular power (Brocherie *et al.*, 2014). Furthermore, researchers have mentioned associations between jump tests and player in a competitive level (Arnason *et al.*, 2004). The majority of sprints in the field last 1-2 sec and all the other power actions like heading, tackling, shooting last less than 2 sec (Dwyer and Gabbett, 2012). All of the above actions are being characterized by power. No research today has looked into the relation between vertical jump performance in two tests and (squat jump (SJ) and countermovement jump (CMJ)) and the distance that is covered in elite soccer players during a season. Therefore, it is assumed that jump performance in SJ and CMJ is not related to the total distance that is covered and other running intensities. Finally, it is known that an anthropometric profile can affect performances. More specifically, it is known that, high body fat percentage or decreased lean body mass can affect one's aerobic performance, speed and jumping ability (Maciejczyk *et al.*, 2014). However, in the literature there are not any studies that research the correlation of anthropometric indexes and match running performance. The aim of this study was to assess the correlations of a) SJ performance and the total distance that is covered in a soccer match and in each half, b) SJ and the distance covered in a different running intensity during a soccer match and in each half particularly, c) CMJ performance and the total distance that is covered in a soccer match and in each half particularly, d) CMJ and the distance covered in different running intensities in a soccer match and in each half particularly, e) anthropometric characteristics and the total distance that is covered in a soccer match and in each half particularly, and f) to determine the differences in running performances within the 2 halves of the matches.

2. METHODS

2.1. Experimental Approach to the Problem

The purpose of this study was to test the hypothesis that the performance of SJ and CMJ may be correlated with the high speed running performance (velocity > 19.7 km/h) of the match in elite soccer players. Moreover, it investigates the distance that was covered in the two halves and the total distance in different velocities. Furthermore, to avoid having differences in the participation time among the players, the participants were only players who played 90 minutes with the goalkeepers being excluded from the study. The duration of the training season for all athletes was 46 weeks per year. More specifically, the participants performed six 90-minute training sessions per week and had an additional personal training session every week for individual improvement. Additionally, all soccer players played 1 match per week throughout the season. The duration of the study was 1 season, from the beginning to end, in which the team performed 31 official matches.

2.2. Subjects

Eleven, healthy, professional adult soccer players from the second division of the Greek league volunteered to participate in this study. All the players have trained for at least 12 years. All testing procedures and any possible risks or discomforts were fully explained in detail to the participants before the beginning of the study. The study was approved in advance by the ethical committee of the Department of Physical Education and Sport Science, University of Thessaloniki in accordance with the ethical standards in sport and exercise research. Each participant voluntarily provided written informed consent before participating. Participants' characteristics are shown in Table 1.

Table-1. Participants' physical characteristics. *+

Variable	Value
Age (y)	27.5 ± 4.7
Height (cm)	180 ± 5.7
Weight (kg)	76.3 ± 6.1
Body fat (%)	9.8 ± 2.7

+Data are presented as mean ± SD.

2.3. Anthropometrics

Body mass was measured as close as possible to 0.1 kg using an electronic digital scale, the participants were in their underclothes and barefoot. Their height was measured as close to 0.1 cm as possible (Seca 220e, Hamburg, Germany). The participants body fat percentage was estimated based on the sum of four (biceps, triceps, suprailiac, subscapular) skinfold thicknesses measured using a specific caliper (Lafayette, Ins. Co., Indiana) on the right side of the body. Furthermore, the estimation of the body density was calculated according to the Durnin and Rahaman (1967) equation for males older than the age of 16 years old, and estimated by the equation of Siri (1956).

2.4. Vertical Jump Testing

The participants performed 2 jump tests: a) SJ and b) CMJ. In SJ participants in a stationary semi-squatted position (90° angle at the knees) performed a maximal VJ. In CMJ the participants from an upright standing position performed a fast preliminary motion downwards by flexing their knees and hips followed by an explosive upward motion by extending their knees and hips. All 2 tests were performed with the arms in akimbo. The VJ height was measured with an ergojump contact platform (Chronojump-Boscosystem, Spain). Flight times was measured by a digital timer connected to the contact platform and was used for the jump height to be calculated. The coefficients of variation for test-retest trials were 2.8 and 3 % for SJ and CMJ respectively.

2.5. Global Positioning System Analysis (GPS)

To measure the match performance, players wore 50-Hz GPS units (LAGALACOLLI Sport, Roma, Italy) on their upper torso in a vest garment to reduce movement artefacs. Units were activated according to the manufacturer's guidelines right before the pre match warm-up. Players wore the same GPS devices for each match to avoid any interunit variation. After each match the data was analyzed using 6 indices for each half and for the entire match (0.1 – 5.99 km/h-walking, 6 – 11.9 km/h-jogging, 12 – 15.7 km/h-running, 15.8 – 19.6 km/h-high intensity running, 19.7 – 23.7 km/h-fast running, 23.8+ km/h-sprint, total distance). The match indices' intraclass correlation coefficient (ICC) and coefficient of variation (CV) ranged 0.93 and 0.97 and 13% respectively.

3. STATISTICAL ANALYSIS

Data is being presented as means ± SD. Data normality was verified with the 1-sample Kolmogorov-Smirnoff test; therefore, a non-parametric test was not necessary. All statistical analyses were conducted using SPSS (version 16.0; SPSS Inc., Chicago, IL, USA). Results are reported as mean ± SD. Relationships between SJ and CMJ performance and anthropometric characteristics with selected running indices were evaluated using a bivariate correlation. Paired samples t-test was used to compare the distances covered by the players in the first and second halves of the match. Statistical significance was set at $p \leq 0.05$.

4. RESULTS

The distance that was covered by the soccer players in the first half using high speed running (19.7 - 23.7 km/h) was moderated in correlation to height ($r = -0.616$, $p < 0.05$) and weight ($r = -0.605$, $p < 0.05$) Table 2. No correlations were found between performances in SJ and CMJ with all the other indices of match running performance ($p > 0.05$) Table 2.

Table-2. Correlation coefficients between anthropometric characteristics and jump performance with match running distances at different intensities.

First half distance covered							
	0.1-5.99	6-11.9	12-15.7	15.8-19.6	19.7-23.7	23.8+	Total
Height	r = 0.52	r = -0.43	r = -0.44	r = -0.49	r = -0.62*	r = -0.38	r = -0.51
Weight	r = 0.54	r = -0.44	r = -0.49	r = -0.55	r = -0.61*	r = -0.22	r = -0.54
% Body fat	r = 0.54	r = -0.24	r = -0.18	r = -0.17	r = -0.35	r = -0.25	r = -0.13
SJ	r = -0.09	r = -0.15	r = -0.22	r = -0.09	r = 0.26	r = 0.58	r = -0.17
CMJ	r = 0.04	r = -0.34	r = -0.34	r = -0.23	r = 0.12	r = 0.55	r = -0.33
Second half distance covered							
Height	r = 0.56	r = 0.06	r = -0.3	r = -0.36	r = -0.52	r = -0.25	r = 0.01
Weight	r = 0.51	r = 0.06	r = -0.31	r = -0.37	r = -0.38	r = -0.05	r = -0.01
% Body fat	r = -0.4	r = -0.58	r = -0.36	r = -0.35	r = -0.30	r = -0.41	r = -0.55
SJ	r = -0.09	r = -0.20	r = -0.28	r = -0.15	r = 0.07	r = 0.42	r = -0.2
CMJ	r =0.010	r = -0.23	r = -0.39	r = -0.28	r = -0.12	r = 0.37	r = -0.25
Total distance covered							
Height	r = 0.58	r = -0.01	r = -0.36	r = -0.42	r = -0.53	r = -0.18	r = -0.18
Weight	r = 0.53	r = 0.01	r = -0.38	r = -0.43	r = -0.39	r = -0.01	r = -0.21
% Body fat	r = -0.38	r = -0.46	r = -0.24	r = -0.18	r = -0.27	r = -0.49	r = -0.42
SJ	r = -0.11	r = -0.31	r = -0.34	r = -0.20	r = 0.06	r = 0.41	r = -0.33
CMJ	r = -0.02	r = -0.39	r = -0.46	r = -0.36	r = -0.13	r = 0.39	r = -0.46

SJ: squat jump; CMJ: countermovement jump; Significant correlation ($p < 0.05$).

Furthermore, the main total distance covered during a match was 8,618 m. Additionally, players covered greater distances in the first half at all running speed levels (velocity >5.99 km/h). More specifically, they ran 288 m (18.6 %) more when jogging ($p < 0.01$) (6 – 11.9 km/h), 200 m (22.3 %) more when running ($p < 0.001$) (12 – 15.7 km/h) and 91 m (20.6 %) more in high intensity running ($p < 0.01$) (15.8 – 19.6 km/h). In addition, they covered a 34 m (19.4 %) greater distance when running at high speed ($p < 0.01$) (19.7 – 23.7 km/h) and 19 m (26.1 %) more when sprinting ($p < 0.001$) (23.8+ km/h). Finally, the total distance that was covered during the first half was 752 m (16.1 %) greater ($p < 0.01$) than that covered during the second half of a match Figure 1a.

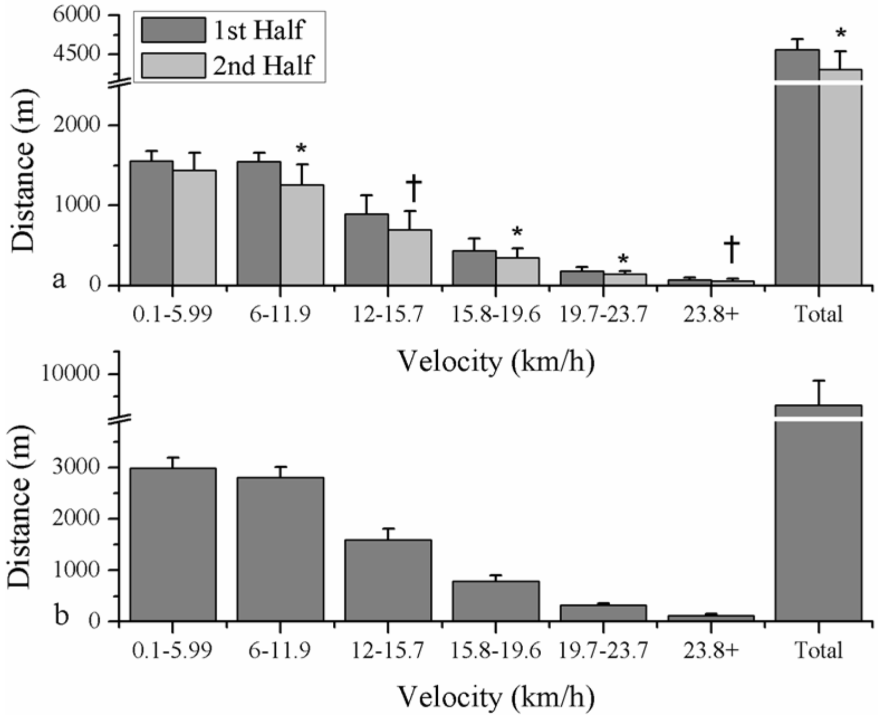

Figure-1a. Distance covered at different speed velocities by players during the first and second half. * Denotes significant ($p < 0.01$) difference with 1st half distance. † Denotes significant ($p < 0.001$) difference with 1st half distance. **b.** Total distance covered at different speed velocities by players during the match.

5. DISCUSSION

The body mass and height of the soccer players were related to the distance covered in the first half using high speed running (19.7 – 23.7 km/h). In the literature we can find only one study (Rienzi *et al.*, 2000) who have tried to correlate anthropometric profile of soccer players with a match running performance. (Rienzi *et al.*, 2000)observed that body mass and muscle mass was related to the total distance covered by South American international players. However, (Rienzi *et al.*, 2000) used video analysis of the national team matches and not GPS to estimate the covered distance. High body fat is not useful for players because in increases the physiological strain (Rienzi *et al.*, 2000) and it is a disadvantage in activities which involve body displacement. Furthermore, jump performance and acceleration can be negatively influenced by high body fat due to an increased body weight. Therefore, soccer players with low body fat percentages may be able to perform better. However, all elite players have an upper standard value of percentage level and this may be the reason why there were not any correlations observed between in body fat percentage and match running performance. The results from our study indicate that shorter and thinner players can cover greater distances in high speed running (19.7 – 23.7 km/h) than the taller and heavier players during the first half. Surprisingly, no other correlations were observed between anthropometric indexes and other match running variables.

The findings show that there are no correlations of SJ and CMJ performances and match running performance. In the literature two researchers' have tried to correlate the performances in anaerobic tests (vertical jump, repeated sprint tests) and the distances covered during a soccer match. More specifically, Redkva *et al.* (2018) mentioned no correlations between repeated sprint test and match running performance. Additionally, another study, Rampinini *et al.* (2007) observed a significant correlation between the ability of repeated sprint and match running performance, but no correlations to vertical jump performance. Furthermore, it should be mentioned that the study of Redkva *et al.* (2018) was performed in friendly soccer matches and not official. This may influence the results of their study.

As mentioned before the present study failed to show a significant correlation between SJ and CMJ performance to the selected soccer match variables. Similar results had been mentioned by Rampinini *et al.* (2007) the only known study which was tried to correlate a VJ to match running performance. Jump tests are used as indexes of bottom limb power. Our hypothesis was that a soccer player with a high level of power could perform more meters with high speed running during a match (> 19.7 km/h). These kinds of activities (jumps, sprints) use energy from the same system (posphagen system). A possible explanation for the lack of correlations may be the fact that SJ and CMJ are two specific activities that differ from the actions presented by the players during a soccer match. More specifically, during a match, players perform short sprints (~ 6 – 16 m), which last around 2 sec and are repeated every 72 sec (Dwyer and Gabbett, 2012). Additionally, it is known that aerobic metabolism can influence the repeated maximum short efforts because it helps the resynthesis of phosphocreatine stores (Bishop and Edge, 2006). Furthermore, the tactical role of players, individual playing position, the quality of the opponent, and the degree of motivation can alter the relationship between jump performance and match running variables.

The total distance that was covered during the second half of the soccer patches was 16.1 % shorter than the first half. This finding is in accordance with previous studies among professional soccer players which presented decreases from 1 to 12.6 % (Bradley *et al.*, 2010; Metaxas, 2018). In the present study significant differences between the two halves in all running velocities (> 5.99 km/h) were observed. In addition, coaches and researchers pay more attention to high intensity running, where in the present study decreases were observed in the distance covered from 19.4 % to 26.1 %. Many researchers have mentioned similar results (Krustrup *et al.*, 2005; Metaxas, 2018) to ours but some researchers did not observe any differences between the two half times in one of the best European teams (Salvo *et al.*, 2007). Furthermore, one crucial factor for the reduction of the covered distance during the second half could be fatigue. Finally, formation and tactical strategies could influence the match running performance during the two halves (Aquino *et al.*, 2017).

6. CONCLUSION

In conclusion, the results indicate that the players' match running performance do not depend on the index of vertical jumping ability. Height and weight could be related to some intensities of a match running performance, but the small sample and the moderate negative correlations which were found do not allow their use for predictive reasons. The players cover greater distances during the first half of a soccer match. Coaches have to pay attention in aerobic fitness training which could help players limit their fatigue during the second half.

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