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PHYSICAL AND PHYSIOLOGICAL CHARACTERISTICS OF ELITE SERBIAN SOCCER PLAYERS

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Abstract. *The purpose of this study was to describe structural and functional characteristics of elite Serbian soccer players and to make comparisons with non-elite counterparts. One of the teams in the study (Squad A; $n_A = 16$) competed in the professional First National League while the other team (Squad B; $n_B = 16$) played in the amateur Third Division. Physiological measurements were made in 32 players, during the final week of the preparatory training period. Subjects from Squad A were older (23.8 ± 3.4 vs. 21.5 ± 3.2 years, $P < 0.05$) and more experienced (7.5 ± 3.1 vs. 4.8 ± 2.8 years, $P < 0.05$) as compared to players in Squad B. Players from Squad B had significantly lower estimated VO_2 max values compared with elite subjects in Squad A (42.9 ± 6.6 vs. 53.5 ± 8.6 $ml \cdot kg^{-1} \cdot min^{-1}$, $P < 0.05$). In addition, the highest heart rate frequencies during the last minute of the 20-m shuttle run test were lower in elite players (183.1 ± 6.1 vs. 189.9 ± 8.1 $beats \cdot min^{-1}$, $P < 0.05$). Vertical jump height was significantly higher in Squad A (47.6 ± 5.7 vs. 46.2 ± 5.5 cm, $P < 0.05$) and estimated percentage of fast muscle fibers (fast twitches) were higher in Squad A as compared to Squad B (62.8 ± 7.7 vs. 57.4 ± 8.1%, $P < 0.05$). The results of the present study support previous investigations indicating a strong relationship between aerobic fitness, anaerobic power and performance results in elite soccer.*

Key words: *soccer, body composition, VO_2 max, muscle fibre types*

1. INTRODUCTION

In the last two decades, there has been significant accumulation of scientific data regarding soccer physiology and medicine. Previous investigations (Raven, Gettman, Pollock, & Cooper, 1976; Rhodes et al., 1986; Mangine, Noyes, Mullen, & Barber, 1990; Bangsbo, Norregaarg, & Thorso, 1991; Chin, Lo, Li, & So 1992; Davies, Brewer, & Atkin, 1992; Green, 1992; Al-Hazzaa et al., 2001) have evaluated ideal physiological and

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anthropometric profile of successful soccer players mostly from Western Europe and America, although there is a lack of descriptive data concerning characteristics of elite soccer players from Eastern Europe. Aspects such as experience, body composition, endurance, balance between anaerobic power and aerobic power, among other factors, are of primary importance in evaluation of elite players (Ekblom, 1986; Tumilty, 1993; Rico-Sanz, 1998; Shephard, 1999; Ostojić, & Zivanić, 2001; Ostojić, 2003a). The purpose of this study was to describe structural and functional characteristics of elite Serbian soccer players and to make comparisons with non-elite counterparts. Also, understanding the profile of successful players could give coaches, trainers, and exercise scientists better working knowledge of this particular group of elite athletes.

METHODS

Two male soccer teams participated in the study. One of the teams in the study (Squad A; $n_A = 16$) competed in the professional First National League while the other team (Squad B; $n_B = 16$) played in the amateur Third Division. All of the subjects gave their informed consent and volunteered to participate in the study, which had the approval of the Academy's Ethical Advisory Commission. All participants were fully informed verbally and in writing about the nature and demands of the study as well as the known health risks. They completed a health history questionnaire, and were informed that they could withdraw from the study at any time, even after giving their written consent. Physiological measurements were made of 32 players (all positional roles were equally represented in both teams), during the final week of their preparatory training period. All subjects were assessed on the same day, and the tests were performed in the same order. Seven days before experiment all subjects consumed the same diet (55% of the calories were derived from carbohydrate, 25% from fat and 20% from protein) and the last meal was undertaken 3 hours before the test. After that period, all subjects drank only plain water after need. In the 24 hours before the experiment, the subjects did not participate in any prolonged exercise.

Subjects reported to the examination field in 10 A.M. after an overnight rest of between 10 and 12 hours. Upon entering the laboratory, hemoglobin (Hb), hematocrit (Hct) and lung function were measured for normative data comparisons. Blood was drawn from a fingertip and analyzed immediately for Hct and Hb determination by the procedures of microcentrifugation (Hawksley Ltd., Lancing, UK) and cyanometHb (Boehringer Mannheim GmbH test combination, Mannheim, Germany), respectively. Lung function expressed as forced viral capacity (FVC) and forced expiratory volume in one second (FEV1) was determined using a flow screen (Jaeger, Germany). Body mass was obtained to the nearest 0.1 kg using a balance scale (Avery Ltd., Model 3306 ABV) while height was measured using a stadiometer (Holtain Ltd.) to the nearest 0.5 cm. Body fat content was estimated by skinfold measurements. Skinfold thicknesses at seven sites were obtained using a Harpenden caliper (British Indicators Ltd., St. Albans, UK). The skinfold sites were triceps, subscapula, mid-axillary, anterior suprailiac, chest, abdomen, and thigh. The landmarks were identified and measured according to Wilmore, & Behnke (1969). Percentage of body fat was determined according to equations of Jackson, & Pollock (1978). After these preliminary tests, subjects completed a warm up (15-min of sprints and individual exercise). After that, vertical jump height and percentage of muscle

fiber types of leg extensor muscles were estimated using a force platform (Newtest Powertimer Testing System, Finland) in combination with specifically developed software according to Viitasalo, & Komi (1978). Afterwards, maximal oxygen uptake (VO_2 max) was indirectly obtained using a multistage 20-meters shuttle run test (Leger, & Lambert, 1982). Heart rate (HR) was determined during the test, using short-range radio telemetry (Polar Sporttester, Polar Electro Oy, Kempele, Finland) and the highest heart rate frequency during the last minute of the shuttle run test was recorded as HR_{max}. The athletes were familiar with mentioned procedures as part of their regular training process.

The data are expressed as means ± SD. Statistical analysis was performed using Student's *t* test with modified Bonferroni correction for repeated comparisons. *P* values of less than 0.05 were considered to be statistically significant. The data were analyzed using the statistical package SPSS, PC program, version 7.5 (SPSS Inc., USA).

RESULTS

All results are shown in Table 1. Subjects from Squad A were older ($P < 0.05$) and more experienced ($P < 0.05$) as compared to players in Squad B. Players from Squad B had significantly lower estimated VO_2 max values compared with elite subjects in Squad A ($P < 0.05$). In addition, the highest heart rate frequencies during the last minute of the shuttle run test were lower in elite players (Squad A) ($P < 0.05$). Vertical jump height was significantly higher in Squad A ($P < 0.05$) and estimated percentage of fast muscle fibers (fast twitches) were higher in Squad A as compared to Squad B ($P < 0.05$).

Table 1. Characteristics of elite (Squad A) and non-elite (Squad B) Serbian soccer players. Values are mean ± SD.

Variable	Squad A ($n_A = 16$)	Squad B ($n_B = 16$)
Age (years)	23.8 ± 3.4*	21.5 ± 3.2
Professional experience (years)	7.5 ± 3.1*	4.8 ± 2.8
Height (cm)	181.9 ± 5.7	180.8 ± 7.1
Weight (kg)	77.4 ± 5.9	74.4 ± 6.9
Fat content (%)	10.8 ± 2.1	10.4 ± 1.8
Hemoglobin ($mmol \cdot l^{-1}$)	133.1 ± 10.8	130.4 ± 11.4
Hematocrit (%)	0.41 ± 0.03	0.41 ± 0.04
Forced vital capacity (L)	5.6 ± 0.8	5.4 ± 0.9
Forced expiratory volume in one second (L)	4.8 ± 0.6	4.7 ± 0.8
Estimated VO_{2max} ($ml \cdot kg^{-1} \cdot min^{-1}$)	53.5 ± 8.6*	42.9 ± 6.6
HR_{max} ($beats \cdot min^{-1}$)	183.1 ± 6.1*	189.9 ± 8.1
Vertical jump height (cm)	47.6 ± 5.7*	46.2 ± 5.5
Fast twitches ‡ (%)	62.8 ± 7.7*	57.4 ± 8.1

Abbreviation: VO_{2max} = maximal oxygen uptake; HR_{max} = maximal heart rate obtained in the last minute of shuttle run test. ‡ Estimated percentage of muscle fiber types (fast twich) of leg extensor muscles.* Statistically significant at $P < 0.05$ for Squad A vs. Squad B.

DISCUSSION

To our knowledge, this study provided the most comprehensive comparison between professional and amateur soccer teams in East European soccer players up to date. The results of the present study support previous investigations indicating a strong relationship between aerobic fitness, anaerobic power and performance results in elite soccer.

In the present study, we found that elite soccer players (Squad A) were older and had significantly higher professional experience than amateur players in Squad B. Nowadays, elite soccer players participate in the game for longer than traditional (Reilly, 1994, 1996). This is probably due to fact that professional level of game-play requires competent and well-versed players and commercial attractions of maintaining players' career as long as possible. In addition, amateur competition squads are place for young talented players to improve their knowledge and perfect abilities and skills. However, further observations (i.e. correlation between age and learning effects, skills and abilities) will be needed to clear up this point.

The aerobic system is the main source of energy provision during soccer match-play and the average values of VO_2 max for top-level soccer players tend to be high, supporting the above statement (Tumilty, 1993; Reilly, Bangsbo, & Franks., 2000). While VO_2 max values may be influenced by differences in standards of play, training regimes and the phase of season, team with superior aerobic fitness would have the advantage, being able to play the game at a faster pace throughout (Ali, & Farrally, 1991; Bangsbo, & Lindquist, 1992; Reilly, Bangsbo, & Franks, 2000). Higher level of endurance capacity (higher VO_2 max, lower HR_{max}) will give elite players from Squad A, a better base for on-field performance regarding intensity and demands of soccer match-play. The estimated maximal oxygen uptake of the Squad A was 53.5 ± 8.6 ml·kg^{-1}·min^{-1} which is in general agreement with previous data (Ramadan, & Byrd, 1987; Chin, Lo, Li, & So, 1992; Davies, Brewer, & Atkin, 1992; Wislof, Helgerud, & Hoff, 1998) from other top-level soccer players. It appears that Serbian soccer players generally fall toward the center of the continuum of maximal oxygen consumption of elite soccer players from different countries.

The vertical jump height itself is a good measure of specific muscular performance (anaerobic power). For vertical jump heights, we found significantly higher results in elite group (Squad A) than in non-elite subjects. A higher level of anaerobic parameters would be preferable and would reduce the risk for injuries (Wislof, Helgerud, & Hoff, 1998) and allow for more powerful jumps, kicks, tackles, and sprints among other factors. It would be reasonable to expect that the elite soccer player have values higher than 50 cm according to the recent findings (Wislof, Helgerud, & Hoff, 1998; Shephard, 1999). Performance of soccer players in vertical jump test tends to show up influences of positional role and training stage, which requires more investigation.

Muscle performance characteristics of soccer players in many respects are determined by their distribution of different fibre types: fast twitches (FT) and slow twitches (ST) (Reilly, 1996). Soccer-play demands an ability to sustain physical effort, mostly discontinuous, over 90 minutes, some of which is at high intensity (Ekblom, 1987; Bangsbo, Norregaarg, & Thorso, 1991). As the activity profile is compatible with both slow and fast twitch muscle fibre characteristics, a combination of muscle fibre types (with predominant of fast twitches) would be expected in top players (Reilly, 1996). In the present study, we found a significantly higher estimated percentage of fast twitch muscle fibres in

elite players (Squad A), which is in accordance with previous investigations. Although, any conclusions about fitness level, muscle fibre type and elite soccer play could be incomplete. Method of assessment, position role, nature and intensity of training are, among others, factors that can influence measurement of fibre type distribution and amount (Anderson, Bangsbo, Klitgaard, & Saltin, 1992; Parente, Montagnari, De Nicola, & Tajana, 1992).

Further, we found that height, weight and body fat percentage were not different between groups. Data on height, body mass and body composition of soccer teams from other studies (Green, 1992; Rico-Sanz, 1998; Shephard, 1999; Ostojić 2003b) suggest that players vary widely in body size. Thus, these parameters are not essential factors for success in soccer; moreover, they might determine the playing positional role (Reilly, 1996). A particular body size may be an advantage in certain match-play situation while disadvantage in other.

Values for Hb, Hct, FVC and FEV1 in the present study were within the normal range of the male population and not significantly different between squads neither from values reported from studies of soccer players by other investigators (Resina et al., 1991; Biancotti et al., 1992).

CONCLUSION

In conclusion, more research work has to be done before definitive inference can be made; however, the results of the present study demonstrated relationship between aerobic and anaerobic power and level of performance in soccer. Such qualities are prerequisite and advantageous for playing soccer on elite levels. From a practical standpoint, this information is important for coaches and trainers to adjust training regimes and concentrate on the variables that are specific to improve performance and achieve success in soccer.

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FIZIČKE I FIZIOLOŠKE KARAKTERISTIKE VRHUNSKIH SRPSKIH FUDBALSKIH SPORTISTA

Sergej M. Ostojić

Osnovni cilj studije obuhvatio je opisivanje strukturalnih i funkcionalnih karakteristika vrhunskih srpskih fudbalskih sportista i poređenje ovih vrednosti sa vrednostima ne-vrhunskih fudbalera. Jedna od ekipa koja je učestvovala u studiji (Ekipa A; $n_A = 16$) takmičila se u profesionalnoj Prvoj Saveznoj ligi a druga (Ekipa B; $n_B = 16$) u trećoj amaterskoj ligi. Fiziološka merenja su izvedena na 32 ispitanika tokom poslednje nedelje pripremnog perioda. Ispitanici iz ekipe A bili su stariji (23,8 ± 3,4 vs. 21,5 ± 3,2 godina, $P < 0.05$) i većeg profesionalnog iskustva (7,5 ± 3,1 vs. 4,8 ± 2,8 godina, $P < 0,05$) u poređenju sa ispitanicima iz ekipe B. Ispitanici iz ekipe B imali su značajno niže procenjene vrednosti VO_2 max u odnosu na vrhunske fudbalere iz ekipe A (42,9 ± 6,6 vs. 53,5 ± 8,6 $ml \cdot kg^{-1} \cdot min^{-1}$, $P < 0,05$). Dalje, najveća vrednost srčane frekvence izmerene tokom poslednjeg minuta 20-m shuttle testa bila je niža kod vrhunskih fudbalera (183,1 ± 6,1 vs. 189,9 ± 8,1 $udara \cdot min^{-1}$, $P < 0,05$). Visina vertikalnog skoka je bila značajno veća u ekipi A (47,6 ± 5,7 vs. 46,2 ± 5,5 cm, $P < 0,05$) kao i procenjeni sadržaj brzih mišićnih vlakana u ekipi A, u poređenju sa ispitanicima iz ekipe B (62,8 ± 7,7 vs. 57,4 ± 8,1%, $P < 0,05$). Rezultati studije su u skladu sa ranijim istraživanjima koja su pokazala snažnu vezu između aerobne sposobnosti, anaerobne moći i rezultata u vrhunskom fudbalskom sportu.

Ključne reči: *fudbal, telesna kompozicija, VO_2 max, tipovi mišićnih vlakana*