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SPIROERGOMETRIC PARAMETERS OF ELITE SOCCER PLAYERS

SPIROERGOMETRIJSKI PARAMETRI VRHUNSKIH NOGOMETAŠA

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SUMMARY

The aim of the study was to determine the central and the dispersive parameters of some morphological characteristics and functional abilities in 17 elite Croatian soccer players tested by all-out VO_{2max} treadmill test. Also, the present study investigated the differences in analyzed spiroergometric values in regard to the playing position. The research has been conducted in Sports diagnostic centre of the Faculty of Kinesiology in Zagreb. The differences between attackers, defenders and midfielders in analyzed parameters were determined (MANOVA results: Wilks' Lambda=0.314, Raos'R=8,52, $p<0.02$). Midfielders were the players with highest values of VO_{2max}. Defenders had highest values of oxygen consumption at ventilatory threshold and were the tallest and the heaviest player in the team. The lowest values of maximal breathing frequency were found in attackers while the midfielders and the defenders had similar values. As expected, the ventilatory lung functions were satisfactory and did not represent the limit for maximal performance. In conclusion, aerobic abilities of Croatian soccer players are within reported values for international elite soccer player, but still in the lower range for midfielders (59,92 mL/kg min^{-1}). Therefore, Croatian soccer players, especially the midfielders should improve aerobic fitness, which might contribute to the overall better match performance.

Key words: soccer, spiroergometry, playing positions

SAŽETAK

Cilj istraživanja bio je utvrditi centralne i disperzivne parametre nekoh morfoloških karakteristika i funkcionalnih pokazatelja 17 vrhunskih hrvatskih nogometaša. Sekundarni cilj ovog rada bio je utvrditi pozicijske razlike temeljem testiranih karakteristika i sposobnosti. Istraživanje je provedeno u Sportsko dijagnostičkom centru Kineziološkog fakulteta u Zagrebu. Utvrđena je statistički značajna razlika između igrača prema poziciji na kojoj igraju (MANOVA; Wilks' lambda=0.314, Raos'R=8,52, $p<0.02$). Vezni igrači imali su najveće vrijednosti VO_{2max} dok su obrambeni igrači imali najveće vrijednosti primitka kisika pri anaerobnom pragu, a ujedno su bili najviši i najteži. Što se tiče ventilacijske funkcije pluća, najniže vrijednosti maksimalne frekvencije disanja imali su napadači i kao što se i očekivalo, nije bilo ograničenja postizanja maksimalnog opterećenja od strane ventilacijske funkcije pluća. Aerobni kapaciteti hrvatskih nogometaša su unutar raspona objavljenih rezultata vrhunskih svjetskih nogometaša, iako se vrijednosti aerobnog kapaciteta posebno za vezne igrače nalaze na donjoj granici preporučenih (59,92 mL/kg min^{-1}). Testirani vezni igrači trebali bi poboljšati svoje aerobne kapacitete, što bi moglo utjecati i na poboljšanje samog nastupa na utakmicama.

Ključne riječi: nogomet, spiroergometrija, pozicije igrača

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INTRODUCTION

Soccer training is a complex programmed process, directed towards the development and maintenance of numerous skills of the soccer players (1-3). For the purpose of optimizing training process, it is necessary to have an insight in current condition of all skills of the soccer players, and especially of the functional capabilities. But soccer training is largely based on the game itself, and a common recruitment of pattern from player to coach (16). Problem of professional soccer is a fact that managements are often more engaged in selection process rather than in development (16). Individual technique, tactics and physical resources share importance when evaluating performance differences in soccer (4). The average importance each of these first level analytic approaches to differences in performance is close to one-third.

Considering that a top soccer players runs 8 12 km during 90 minutes of a match (1,10) it becomes clear that aerobic endurance is essential in soccer. The term „ventilatory threshold" (VT) is defined as the level of work or O_2 consumption just below that at which metabolic acidosis and the associated changes in gas exchange occur.

Previous studies have determined a correlation between VO_{2max} and the distance ran during a match (12). The high-intensity bouts that are dependant on anaerobic or alactic enegy source are restored using aerobic energy. This makes it necessary for players to spend a substantial time at intensity lower than anaerobic threshold (5,6). Danish league players (1) confirm earlier results that 5-9% greater distance is covered in the first than in second half of a mach; nevertheless aerobically fit players my be spared this decrement in performance (15). However, no correlation has been found between a percentage VO_{2max} at lactate threshold and decrement in performance over the course of a game (3). Previous study demonstrated a significant relationship between VO_{2max} and both distance covered during a mach (2,11). The mean of Vo2max of elite soccer players was reported in the range of 55-67 mL kg min^{-1} (18, 5, 8, 10,14, 19).

The main purpose of this study was to determine central and dispersive values of the spiroergometric parameters of the elite soccer players on an incremental maximal exercise test. Secondary purpose of this study was to assess the differences in analyzed spiroergometric parameters between soccer players regarding their game playing positions.

SUBJECTS AND METHODS

The research has been conducted in the season 2004/05, during the second week of the competition period, at 17 elite Croatian soccer players (five defenders, six midfielders and six attackers), in the age group 23.79±3.8. One minute incremental maximal exercise tests were performed on a motor-driven treadmill (Run race, Technogym, Italy), with 1.5% inclination. Quark b2 „breath-by-breath" gas analysis system (Cosmed, Italy) was used for respiratory gas exchange monitoring. Heart rate was monitored using a Polar Vantage NV (Polar ElectroOi, Finland) heart rate monitor. The maximal exercise test was interrupted when a plateau of oxygen consumption was noted or when subject perceived

Table 1. Central and dispersive parameters of morphological and functional characteristics of Croatian soccer players

Tablica 1. Centralni i disperzivni pokazatelji morfoloških i funkcionalnih karakteristika hrvatskih nogometaša

	Mean	Min	Max	Range	Std.Dev.
AGE	23,79	19	31,5	12,5	3,80
WEIGHT (kg)	78,01	68,4	89,6	21,2	5,73
HEIGHT (cm)	179,73	165,9	188,5	22,6	5,81
VO_{2max} (L/min)	4,61	3,86	5,49	1,63	0,42
$VO_{2maxREL}$ (mLkg min-1)	58,84	54,4	65	10,6	3,37
HR_{MAX} (bpm)	191,18	179	211	32	9,21
VO_2_HR (mL/bpm)	24,70	19,6	28,6	9	2,60
VE_{MAX} (L/min)	158,96	126,8	177,6	50,8	12,51
RF_{MAX} (bpm)	57,94	49	65	16	4,96
$SPEED_{max}$ (km/h)	18,38	17,5	19	1,5	0,49
HR_{VT} (bpm)	172,47	160	187	27	7,71
VO_{2VT} (mLkg min^{-1})	52,66	45,9	54,1	8,2	12,31

VO_2-oxygen consumption, VO_{2REL}-relative oxygen consumption, HR_{MAX}- maximal heart rate, VO_2_HR-maximal oxygen pulse, VE_{MAX}- maximal minute ventilation, RF_{MAX}-maximal breathing frequency, SPEED-maximal running speed, HR_{VT} -heart rate at anaerobic threshold, VO_{2VT}-oxygen consumption at anaerobic threshold

volitional fatigue. VT was assessed by a nonlinear increase in carbon dioxide to oxygen consumption ratio (V-slope method). For this purpose, nine functional parameters were analyzed or calculated (VO_2-oxygen consumption (L/min), VO_{2REL}-relative oxygen consumption (mLkg min-1), HR_{MAX}- maximal heart rate (bpm), VO_2_HR-maximal oxygen pulse (ml/bpm), VE_{MAX}- maximal minute ventilation (L/min), RF_{MAX}-maximal breathing frequency (bpm), $SEED_{VT}$-maximal running speed (km/h), HR_{VT}-heart rate at anaerobic threshold (bpm), VO_{2VT}-oxygen consumption at anaerobic threshold (mLkg min^{1}).

Data processing methods

The statistical Package for Social Sciences SPSS (v11.5, SPSS Inc., Chicago, IL) was used for the statistical analysis. The following was computed: basic statistical parameters (mean, minimum and maximum results, standard deviation, coefficient of variability, degree of asymmetry and warp degree), the Kolmogorov-Smirnov test for testing distribution normality, homogeneity of variance was tested by Leven´s test, MANOVA was used to determinant differences between measurements, and between control and experimental group.

Table 2. Central and descriptive spiroergometric parameters regarding playing positions
Tablica 2. Centralni i disperzivni spiroergometrijski parametric s obzirom na poziciju igrača

	DEFENCE		MIDFIELD		ATTACK	
	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
AGE	24,96	4,10	24,40	4,03	22,22	3,41
WEIGHT (kg)	81,24	4,90	76,35	7,03	76,97	4,63
HEIGHT (cm)	183,86	3,99	178,73	8,09	177,28	2,12
VO_{2max} (L/min)	4,78	0,26	4,44	0,62	4,64	0,26
$VO_{2maxREL}$ (mLkg min^{-1})	57,33	3,54	59,92	3,14	58,45	3,74
HR_{MAX} (bpm)	184,00	3,24	193,67	9,05	194,67	10,37
VO_2_HR (ml/bpm)	26,46	1,60	23,63	3,30	24,30	2,02
VE_{MAX} (L/min)	167,84	7,67	152,37	14,41	158,15	10,67
RF_{MAX} (rf/min)	58,20	6,87	58,83	4,58	56,83	4,17
$SPEED_{VT}$(km/h)	18,50	0,50	18,50	0,45	18,17	0,52
HR_{VT} (bpm)	167,60	2,30	173,83	7,99	175,17	9,35
%VO_{2VT}(%)	85,9%	22,44	83%	1,89	86,2%	1,90

VO_2-oxygen consumption, VO_{2REL}-relative oxygen consumption, HR_{MAX}- maximal heart rate, VO_2_HR-maximal oxygen pulse, VE_{MAX}- maximal minute ventilation, RF_{MAX}-maximal breathing frequency, $SEED_{VT}$-maximal running speed, HR_{VT}-heart rate at ventilatory threshold, VO_{2VT}-percentage of oxygen consumption at ventilatory threshold

RESULTS

Average values for maximal oxygen consumption and maximal relative oxygen consumption were 4,61±0,42 L/min and 58.84±3.37 mL/kg min^{-1}, respectively. Average of maximal running speed achieved at incremental exercise test and the speed achieved at ventilatory threshold were 18,38±0,49 km/h and 13,97±0,62 km/h, respectively. (Table 1.). All variables had normally distributed data. Leven´s test showed no violation of homogeneity of variance.

The tested parameters were also analysed according to the playing position of the subject.

The attackers, midfielders and defenders differed in the tested spiroergometric values (MANOVA:Wilks' lambda=0.314, Raos'R=8.52, p<0.02). Defenders were the tallest and the heaviest player in the team. The highest average heart rate frequencies at ventilatory threshold were observed among attackers. Midfielders were the players with the highest values of VO_{2max} (Table 2.). Defenders had the highest values of oxygen consumption at ventilatory threshold. Lowest values of maximal breathing frequency had attackers while the midfielders and defenders had similar values, though highest values of percentage of oxygen at ventilatory threshold had the attackers.

DISCUSSION

According to the determined average values of VO_{2max}/kg (58.84±3.37 mL/kg min^{-1}), the Croatian soccer players had similar results as world top soccer players, whose values varied from 55 to 67 mL/kg min-1 (5,8,10,14,18,19). The values of VO_{2max} indicate moderate conditioning fitness (endurance) of attackers and defenders, while values of midfielders are in the lower range of reported international results (average values 59,92 mL/kg min^{-1}) (7,8). The VO_{2max} values for midfielders should be around 62 mL/kg min^{-1} (16). It is known that defenders covered averagely 8.4 km, attackers 9.8 km, while midfielders covered the most number of kilometres during a match, 10.9 km (16). The Croatian midfielders had somewhat higher values VO_{2max} (mL kg min^{-1}) than the attackers (58,45 mL/kg min-1), and the defenders (mL kg min^{-1}), which might be a proof of correlation between VO_{2max} and the distance (km), that the players cover during the match (12). The differences between the midfielders, defenders and attackers in the passed distances and VO_{2max} may be attributed to the different tasks of the players within the team. Midfielders move more than attackers and defenders. In the phase of attack, midfielders take a ball to the opponents' half, whereas defenders, in most cases, make a slight shift towards, while attackers wait for the ball from midfielders. In the phase of defence, attackers stand, the midfielders run back and defenders wait for players of the opponent team. It is known that defenders perform sprints from 1 5m more frequently (16), than the midfielders and attackers do. Defenders have to be quick and react quickly in order to be able to stop attackers, to which it is possible to attribute the differences of defenders in relation to attackers and midfielders. Maximal running speed and the percentage of maximal oxygen consumption at ventilatory threshold indicated did not differ between the positions. Also there were no limitations from ventilatory lung function as expected in any of the players.

During a soccer game, a sprint bout occurs every 90 seconds (1, 14). In the endurance context of the game, each player performs around 1000 mainly short activities (1, 4, 14). To recover quickly from such activities, during a soccer game, players need to posses good level of conditioning abilities, mainly VO_{2max}. Also the rate of lactate removal depends on lactate concentration, activity in recovery period and aerobic capacity. The players with higher VO_{2max} may have lower blood lactate concentration because of an enhanced recovery from high intensity intermittent exercise through: increase aerobic response; improved lactate removal and enhance phosphcreatine regeneration (15).

The defenders were the tallest and the heaviest player in the team. Anthropometry of elite soccer players indicates that defenders, goalkeepers and attackers are players used as a target for winning possessions of the ball with the head tend to be taller than players in other positions (17, 20). On the contrary, the players deployed in midfield and on the wings tend to be smaller in size then those in other positional roles. These generic values have but limited use for competitive purpose when the variability within a given soccer team is large. A coach may modify his team configuration and playing style to accommodate individuals without the expected physical attributes of conventional playing roles, provided they compensate by superior skills and motivation.

Conclusions

The line specific quality is evident and needs to be recognized and integrated within planning and programming of physical fitness training. Aerobic abilities of Croatian soccer players are within reported values for soccer player, but still in the lower range for midfielders. Therefore, the Croatian soccer players, especially the midfielders should improve aerobic fitness, which might contribute to the overall better match performance.

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