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THE EFFECT OF SPECIALLY PROGRAMMED EXERCISE ON THE DEVELOPMENT OF CARDIORESPIRATORY ENDURANCE AND LACTATE ADAPTABILITY OF ELITE SOCCER PLAYERS

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Abstract The aim of this research are define a cardiorespiratory endurance level and lactate adaptability before and after the experimental treatment based on programmed exercising as well as to define of different level of functional capabilities of initial and final measuring before and after the experimental treatment. Sample of respondents covered by this study consisted of 25 senior soccer players, who are members of the first team of FC Red Star, a member of the Serbian First League. For the sample of predictive variables, a set of 3 variables was applied in order to cover the area of functional abilities. Eight weekly micro cycles are experimental treatment aimed at the development of functional and motor abilities of the respondents. As the data processing method, in addition to the basic statistical procedures, multi-variant methods of data processing were applied. By analyzing of results, which present the differences in functional abilities between the initial and final measurement at the multivariate level, it can be stated that there are statistically significant differences in the majority of variables. Based on the results of this research it can be concluded that the presented specially planned and programmed system of exercise significantly contributes to the development of cardio-respiratory endurance and lactate abilities of players.

Key words: exercise, cardiorespiratory, endurance, lactate, soccer

INTRODUCTION

The performance of the most complex and intense soccer movements is under the influence of adequate and high quality training process. Players develop the foundation of abilities, knowledge and skills that enable them to perform almost perfect kicks, receive the ball while sprinting, kick the ball with a precision, sprint aggressively and change direction many times.

Modern soccer has set high demands to the players, sport experts and coaches [15], which have caused significant transformations and enrichment of the content of training process and given enormous importance to the conditional preparation of soccer players in the broadest sense of the term [7].

The quality of the soccer performance is multifactorial. Research in modern, elite soccer suggest that the most important moments of the match occur during the high intensity activities that must be repeated many times [22]. Conditional training should be directed toward projected values consistently with quality and purpose of a competition [17].

In the process of improvement of specific soccer abilities, a training of simultaneous development of aerobic and anaerobic system is crucial [8]. New competences propose sintezy training and small-sided soccer games [13] as a best way of development of energy systems [4].

Guided by knowledge and principles of modern soccer, we set the problem of this study as an attempt to confirm the effect and suprasumming contribution of this programmed exercising, aiming at the development of abilities and characteristics mentioned, under assumption of positive reflection on functionality and effectiveness on competitive conditions of a soccer play [20].

Functional characterstics of an organism indicate direct influence on the size and character of showing working capabilities during physical activity. Skeletal muscles use energy created through aerobic

and anaerobic processes. Aerobic energy is releasing itself through deconstructing of adenosine tri phosphate, creatine phosphates or carbohydrates until creation of pyruvate during the process of glycolysis, which make lactates [16]. Quantity of adenosine tri phosphate in skeletal muscles is enough to provide maximal muscular contractions lasting 1-2 seconds. Usage of the whole quantity of creatine phosphates prolongs the time of maximal musle contraction for 4 to 6 seconds more. Release of energy from phosphagen sources is complete and without lactate production, and therefore this part is called non lactate anaerobic ability. Energy produced from anaerobic glycolysis provides additional energy lasting longer than 5-10 seconds, but shorter than 1-2 minutes, together with the increase of lactate concentration in the blood. Therefore this part is named lactate anaerobic ability [24]. Evaluation of non-lactate and lactate anaerobic ability of an organism is named by a term anaerobic strength. Anaerobic strength names energetic capacity of an organism in which energy is created from energetic matter without simultaneous oxygen consumption [2].

Aerobic processes comprise mechanisms of re-synthesis of adenosine tri phosphate with simultaneous oxygen consumption. In regular circumstances 90% of the total quantity of adenosine tri phosphate re-synthesizes in aerobic processes, together with enzyme involvement, is placed in mitochondric cells. Quantity of energy made through aerobic processes is 10 times larger than energy produced by anaerobic glycolysis. Lever glycogen, fat and amino acids can be used together with reserves of muscle glycogen, as energy substrata in skeletal muscle cells during physical activity [1].

Cardio-respiratory endurance is connected to development of capabilities of cardiovascular and respiratory system in order to maintain oxygen deliverance to muscles, engaged during lasting physical activity, as well as with muscles ability to obtain necessary energy from aerobic processes [11]. Therefore, the terms cardio-respiratory and aerobic are sometimes used as synonyms.

Some adaptive processes are developing in the inner part of the muscles, providing efficient transport, oxygen usage and energy substrata. Other important changes are developing in the cardiovascular system, enhancing circulation to muscles and inside them [8].

Most scientists who study physical activity consider maximal oxygen uptake (VO_{2max}), sometimes called maximal aerobic strength or generally maximal aerobic capacity, to be the most objective laboratory measure of maximal cardio-respiratory endurance. Respiratory system is subdued to specific adaptation during durability training in order to bring your efficiency to a higher level. Cardio-respiratory efficiency is considered to be the most important component of physical readiness according to majority of published papers and textbooks from a sport science field. It is a main defense of an athlete from exhaustion. Maximal oxygen uptake VO_{2max} is the best sign of aerobic ability of an organism [23], with reference to functional ability of cardiovascular system, respiratory system and ability of tissues to use oxygen. Maximal oxygen uptake VO_{2max}, presents the highest oxygen quantity that an organism can uptake during one minute of maximal intensity strain. VO_{2max} value depends on time and durability of strain and can be measured by direct methods or assessed by indirect ones. Aerobic and anaerobic lactate paths are not alternatives [9]. They are closely connected mechanisms functioning in parallel and to one another, and are used depending on the level of physical activity. It is mostly provided by aerobic way, during physical activity of lower intensity but creation of lactate is not completely abandoned. Small amounts of lactate are created and immediately removed from muscles by blood [16]. In case the intensity of strain is enhanced, e.g. by changing the speed of running, removal of lactate cannot follow increased the creation of lactate anymore and the level of lactate in blood starts to grow. This point is called lactate threshold.

Lactate threshold represents transformation from initial straight lactate curve to sloping part, but there is no unique attitude about its defining. Lactate threshold is most often defined as:

- breaking point – the highest level of maximal oxygen uptake that can be measured during physical activity before measuring lactate concentration increase in blood. It happens just before increase of lactate in blood, which can be noticed when lactate in blood is shown in relation to maximal oxygen uptake value. This phenomenon is also called lactate breaking point and aerobic threshold.
- difference in lactate concentration, valuing more than 1 mmoL/L - maximal oxygen uptake value that can be measured during physical activity related to concentration of lactate in blood, which is 1 mmol/L above base concentration line of lactate in blood.
- difference in lactate concentration, valuing 2.5 mmoL/L - maximal oxygen uptake value that can be measured during physical activity related to concentration of lactate in blood, which is 2.5 mmol/L above base concentration line of lactate in blood.
- increased accumulation of lactate in blood that can be specified during physical activity related to concentration of lactate in blood, which is 4 mmol/L above base concentration line of lactate in blood.

Defining of a cardiorespiratory endurance level and lactate adaptability before and after the experimental treatment based on programmed exercising and defining of different level of functional capabilities of initial and final measuring before and after the experimental treatment is the aim of a research.

METHODS AND MATERIALS

PARTICIPANTS

Sample of respondents covered by this study consisted of 30 senior soccer players, who was members of the first team of FC Red Star, a member of the Jelen Premier League – Serbian First League at season 2011/2012. The criterion implies that the players taken into consideration have been subjected to testing of maximal oxygen uptake ($VO_{2\ max}$) and lactate threshold (LT_1), followed by making an effect on their development with isolated treatment of programmed exercising. It is a treatment of development of functional abilities under the influence of programmed training [12].

PROCEDURE

For the sample of predictive variables, a set of 3 variables was applied in order to cover the area of functional abilities:

1. Shuttle run test, for indirect testing of aerobic – anaerobic abilities (FSHUT),
2. Multi step test on treadmill, for direct testing of cardio-respiratory endurance – oxygen uptake (VO_{2max}) and threshold lactate specification by measuring of lactate concentration in blood (FVST),
3. Conconi test, for indirect specification of lactate threshold (FCON).

MEASURES

MAXIMAL MULTI STEP TEST ON A TREADMILL

$VO_{2\ max}$ value is directly measured (Cosmed`s FitMate Med) together with constant monitoring of heart frequency (Polar Pro Team System) and automatically registered value of cardiovascular and respiratory parameters every 15 seconds. Room temperature was ranging from 21^{O}C to 23^{O}C, air humidity was 55-60 %. Values of artery blood pressure are measured before and after the test.

Arrangement of variables is shown depending on how functional mechanisms are engaged in hierarchical physiologic model of activation [10], so that one test minimally has an impact on the other. Special attention is also given to questions of strain and motivation [15]. For the needs of testing direct oxygen uptake the most sophisticated treadmill has been used, Runrace competition HC 1200 (Technogym, Italia) with software support, which enables data to be shown on the computer screen constantly, and can be automatically memorised for the needs of further analysis.

LACTATE THRESHOLD ASSESSMENTS

For defining lactate thresholds, the data on the level of lactate in capillary blood, have been used (measured in mmol/L), in the end of every phase of step-continuing test. Samples of capillary blood are taken from hyperemic lobe, by the usage of special test strips. Specifying enzyme defined value of lactate concentration immediately follows acquiring of a sample by a lactate analyzer Lactate Scout, EKF SensLab, Germany. Sensitivity and validity of lactate concentration measuring by the use of analyzer Lactate Scout, EKF SensLab, is scientifically proven [24].

PROGRAMME OF EXPERIMENTAL METHOD

We were guided by the most important theoretic principles as well as by methodology of sport training in our endevaours to most adequately and in a most quality way make the effects of programmed training and develop players' functional abilities through incorporation of experimental program. This experimental programmme is in fact one of the phases of preparation period, during macro-cyclic annual plan and work program.

Planning and programming of conditional preparation of soccer players presents only one part it and cannot be observed isolated. It makes integral part with other forms of preparation where there must be clear respect of training laws and principles [14].

We isolated the preparation phase from the combination of short-term form of training, planning and programming with block period and with reference to annual macro-cyclic work plan, formed of 2 cyclic periods of competition between which there is another preparation phase divided into blocks.

We analysed it in detail and represented it endeavouring to fulfill the plan and program in most quality and adequate way during programmed exercising, aiming at development of motor ability of soccer players [25]. Experimental program is presented in Table 1.

Table 1. Structure of experimental program - presented in figures

Phase	Number of Days	Number of Matches	Number of Trainings	Training Hours
Preparation	60	10	78	100

After medical and sport diagnostic treatment in the first period of preparation phase and learning about level of abilities, we divided program into 3 parts:

- general preparation phase lasting 3 weekly micro cycles
- specific preparation phase lasting 2 weekly micro cycles
- situational preparation phase lasting 2 weekly micro cycles

These eight weekly micro cycles are actually an experimental treatment aimed at the development of anthropometric characteristic, functional and motor abilities of the respondents [5, 20].

Table 2. Structure of experimental program - presented in training structure

	$VO_{2\ max}$ Training	Lactate Adaptation and Toleration Training	SAQ Training	Force and Power Training
Number of Trainings	20	15	12/5	12
Minutes per positions	1800±90	1100±100	500±60	100±120
Day/Week	20/4	15/4		
Methods	Continual Interval Synthesis Integral Situation (small-side games)	Interval Synthesis Integral Situation (small-side games)	Ballistic Plyometric Integral SAQ	Circuit Training Progressive Repetition Maximum Repetition (Stress) Dynamic Repetition (Stress) Pliometry

Table 3 are presents the results of initial and final values for functional (cardio-respiratory endurance) and lactate values and performances at a tested sample of football players.

Table 3. Mean value of cardio-respiratory endurance and lactate metabolism parameters before and after programmed training

Before Programmed Training (Initial)	VO_{2max} (ml/kg/min)	LT1 (U/min)	V/LT_1 (km/h)	HR_{max} (b/min)
	58.48 ± 7.4	154.0 ± 8.0	14.5 ± 1.5	191.0 ± 9.0
After Programmed Training (Final)	VO_{2max} (ml/kg/min)	LT1 (U/min)	V/LT_1 (km/h)	HR_{max} (b/min)
	63.89 ± 7.3	165.0 ± 8.0	16.0 ± 1.0	198.0 ± 7.0

STATISTICAL ANALYSIS

As the data processing method, in addition to the basic statistical procedures, multi-variant methods of data processing were applied: Descriptive statistics - mean value (MEAN) and standard deviation (SD); Multivariate analysis of variance (MANOVA), for determining the differences between the initial and final measurements at the multivariate level; Univariate analysis of variance (ANOVA), for determining the differences between the initial and final measurements at the univariate level. SPSS 19.0 statistical program was used for the statistical analyses of the data and the significance level was taken as $p<0.05$.

RESULTS

Table 4 presents the results of the differences in functional abilities between the initial and final measurement at the multivariate level (MANOVA). Analysing the table, it can be concluded that there are statistically significant differences (WL Value = 0.8355, F = 3.68, p= 0.017). That means that the experimental treatment in general influenced the alterations in the functional area of the respondents.

Table 4. Multivariate analysis of variance – functional abilities

Test	Value	F	Effect	Error	p
Wilks Lambda	0.8355	3.68	3	56	**0.017**

Table 5 presents the results of the differences in used variables for functional abilities between the initial and final measurement at the univariate level (ANOVA). Analyzing the table, it can be stated that there are statistically significant differences between all explored variables at statistically significant level (FSHUT, F = 9.41, p= 0.003; FVST, F = 10.85, p= 0.002; FCONC, F = 4.39, p= 0.040). That means that the experimental treatment in general influenced the alterations in the all test for assessment of functional abilities.

Table 5. Univariate analysis of variance – functional abilities

Variables	In/Fi	N	Mean	SD	F	p
FSHUT	Initial	30	13.01	1.10	9.41	**0.003**
	Final	30	13.90	1.16		
FVST	Initial	30	58.17	5.81	10.85	**0.002**
	Final	30	63.27	6.18		
FCONC	Initial	30	166.03	8.08	4.39	**0.040**
	Final	30	170.17	7.17		

Figure 1 shows the results of the endurance test protocol, before and after a special programmed endurance training, as a practical presentation of the changes in the tested endurance performance of the football players.

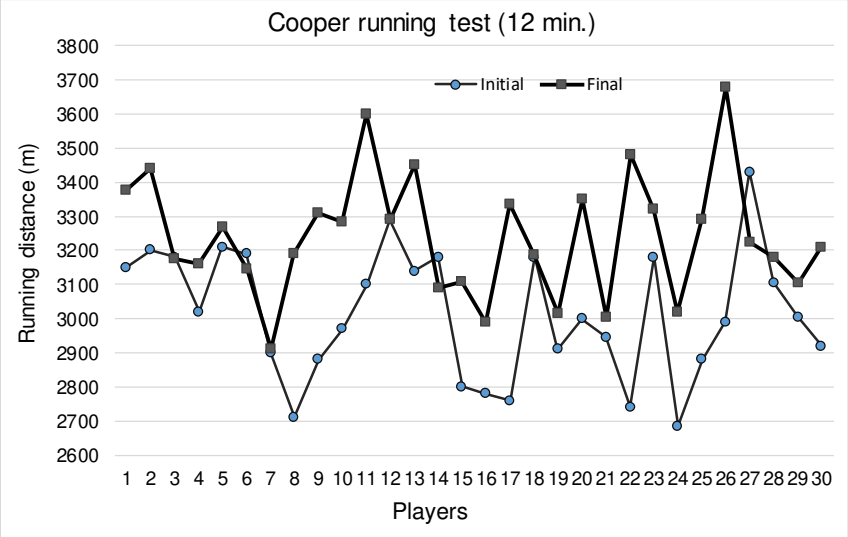

Figure 1. Results of endurance test protocol, before and after special programed endurance program

DISCUSSION

Analysing Table 4., which presents the differences in functional abilities between the initial and final measurement at the multivariate level, it can be stated that there are statistically significant differences in the majority of variables (Shuttle run test – for indirect testing of aerobic-anaerobic abilities, FSHUT, Multi - step test for direct testing of cardio-respiratory endurance – of oxygen uptake, VO_{2max}, and direct determining of anaerobic threshold by measuring lactate concentration in blood, FVST, and Conconi test for direct determining of anaerobic threshold, FCONC), meaning that the experimental treatment affected positive changes of the functional abilities of the respondents [3].

Based on the established results, it can be concluded that under the influence of the applied experimental training program, the following improvements occurred between the initial and final testing: FSHUP by 6.84%, FVST by 8.77% and FCONC by 2.49%. In the same time if we consider Cooper test results as actual endurance performance level, we can conclude that tested football players improved it from 3014 ± 189 m for Initial, to 3240 ± 180 m till Final test (Figure 1). The given improvement was at the level of 225 m (Min - Max, -205 to 740 m), i.e. 7.8% in relative values (Min - Max, -6.0 to 27.0%).

In an effort to understand and emphasize the importance of this research, we conclude that the essential importance of this work lies in the absolute applicability of experimental procedures in the methodic and methodology of football teams and in individual training programs for the development of explored parameters in elite football players. Development of the mentioned abilities and performances, present essential factors of adequate physical fitness considering aerobic endurance, which influence the success in modern top football.

CONCLUSIONS AND PRACTICAL APPLICATION

Based on the results of this research and the set aim, it can be concluded that the presented specially planned and programmed system of training (exercise) significantly contributes to the development of cardio-respiratory endurance and lactate abilities of players (delay of lactate threshold manifestation in relation to heart frequency), so the specific preparatory mesocycle training structure can be considered completely acceptable.

As such, this model of specially planned and programmed training in soccer can serve to soccer coaches and experts as a guide and manual on possible directions and effects in work methods and methodology in their clubs.

The needs for exactness and validity of future studies on similar topics impose the necessity of a larger number of analyzed matches (respondents), different technical-tactical requirements and qualitative levels of competition, in order to confirm correlations and interdependencies of given parameters on a large sample and impose them as a standardized analytical-diagnostic tool in the methodology of working in football.

In an effort to scrutinize and emphasize significance of this kind of a research, we reach the conclusion that the essential importance of this papers lies in an absolute applicability of the experimental procedures in the methodology of soccer teams and in individual training programs for the development of the mentioned abilities and characteristics, as essential factors influencing success in modern-day soccer.

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