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AEROBIC PERFORMANCE OF YOUNG FOOTBALL PLAYERS IN THE PREPARATORY PERIOD

Key words: soccer, training of teenagers, Multistage Shuttle Run Test, anaerobic threshold, PWC_{170}, VO_{2max}.

ABSTRACT

A contemporary approach to sport training requires a constant inflow of information on the size and rate of adaptive changes taking place in the body of the training footballer. Most studies of this type relate to a small group of professional players. The above problem has been little explored and documented in the case of young players. The aim of this study was to perform a comprehensive assessment of changes in selected indicators characterising aerobic performance in footballers in the preparatory period. The study included a group of 22 junior players from the WKP Lech Poznań football club before and after the basic preparatory period of the 2006/2007 season. In the assessment of aerobic performance the following exercise tests were used: PWC_{170}, the progressive running test to exhaustion – the aim of which is to determine the anaerobic threshold (AT) and establish the threshold running speed, and the Multistage Shuttle Run Test (MST) – a shuttle endurance test which allows to predict the maximum oxygen intake (VO_{2max}). For the analysis of training loads the method developed in the Department of Theory of Sport of the University of Physical Education in Warsaw was used. The significance of differences between two dates of measurements was established on the basis of Wilcoxon's test. The analysis of the results indicates a clear increase in aerobic exercise capabilities of the studied players after the preparatory period. In relation to all physiological indicators, generally statistically significant changes at $p \leq 0.001$ were found. Advantageous adaptive changes in terms of the studied physiological indicators may indicate an effective application of individual training loads and good preparation of the team to the spring starting period in terms of aerobic performance. It seems that individualised (at the level of anaerobic threshold) various forms of continuous and changeable running and appropriately selected – in terms of volume and intensity of effort – auxiliary games at various stages of the preparatory period had the greatest influence on the improvement of effort tolerance.

INTRODUCTION

In a rational management of a process of footballer training a systematic control of loads on the physiological level is necessary. The main task of this control is to establish the effect of training loads on the state of the player's body, in particular to establish the speed, direction and level of exercise adaptation of the body and its individual systems and organs.

The analysis of relations between the load and adaptation gives rise to the need of control and assessment of those physiological indicators which, on the one hand, describe the current state of effort tolerance and, on the other hand, forecast the direction of further adaptive changes [Olszewski

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and Zatoń 2002]. The most diagnostic and most frequently registered indicators in football training are such indicators as threshold running speed, threshold heart rate and maximum oxygen intake. The observation of the above indicators in various stages of the training cycle allows modification of the meso- and microcycles through the selection of optimum structure of applied training loads. The process of planning these loads should be highly individualised. In the practice of football training this principle relates in particular to the preparatory period.

Taking the above into account, the basic aim of this study was to perform a comprehensive assessment of changes in selected indicators characterising aerobic performance in footballers in the preparatory period.

MATERIAL AND METHODS

The study included a group of 22 juniors of WKP Lech Poznań before and after the basic preparatory period for the 2006/2007 season. For the assessment of aerobic performance the following exercise tests were used:

PWC 170 – the essence of which is calculating the PWC_{170} index, which describes the amount of performed work in the subject with the heart rate (HR) of 170 beats per minute (beats/min). The subjects were loaded twice with 5-minute cycloergometric work, one after another without a rest break, with a submaximal intensity selected so that the heart rate (HR) is about 130 beats/min in the first test and 150 beats/min. in the second test. After the test the players rested in a sitting position for 5 minutes. In the last minute of the rest the heart rate was registered. For the loading of the players a Monark E-818 cyclo-ergometer was used. PWC_{170} was determined by extrapolation using software package developed for this purpose [Jastrzębski et al. 2003, Stanisz 1998].

The progressive running test till refusal – the aim of which is to determine the anaerobic threshold (AT) and establish the threshold running speed. The test takes place on the basis of a special protocol and involves an exercise test with an increasing load (a run on an ellipse with a circumference of 250 metres) until the subject refuses to continue [Jastrzębski 2004]. The initial speed of the run is 2.8 $m\cdot s^{-1}$. In order to carry out the test it is necessary to measure lactate blood concentration, heart rate and running time. The obtained indicators of threshold speed make it possible to determine precisely the intensity of the effort in an individual training.

The Multistage Shuttle Run Test – a shuttle endurance test which allows prediction of the maximum oxygen intake (VO_{2max}). Performing this test involves repeated movement at the distance of 20 metres back and forth to the rhythm of sound signals recorded on a special tape. The signals impose a quicker and quicker speed. The participant performs this test as long as he or she is able to run at the required pace. For the purposes of this study the more modern version of Brewer et al. 1988 was used (modified in Australia). The above version (also called a beep tests) makes it possible to determine the achieved level of run (like in the traditional method), but also the number of covered lengths. This in turn, using calculation tables, gives a possibility of more precise assessment of the VO_{2max} level.

For the analysis of training loads the method developed in the Department of Theory of Sport of the University of Physical Education in Warsaw was used [Sozański and Śledziewski 1995].

The results of tests were analysed using basic statistical methods-arithmetic mean and standard deviation. The statistical significance of differences between two dates of measurements was established on the basis of Wilcoxon's test. Differences at $p \leq 0.01$** and $p<0.05$* were adopted as significant.

The participants' biometric characteristics and training experience of the participants were presented in Table 1.

Table 1. Biometric characteristics and training experience of the studied players of the WKP Lech Poznań football club

		Age [years]	Height [cm]	Weight [kg]	Training experience [years]
Test I	$\bar{x}$	17.6	180.3	72.4	8.3
	SD	0.72	5.58	6.68	2.56
Test II	$\bar{x}$	17.8	180.7	72.9	8.5
	SD	0.72	5.83	6.98	2.56

RESULTS

The analysis of the results indicates a clear increase in aerobic exercise capabilities of the studied players after the preparatory period. In relation to all physiological indicators, generally statistically significant changes at $p \leq 0.001$ were found (Tables 2-4).

Table 2. Mean values of PWC_{170} for players of WKP Lech and the results of Wilcoxon's test

		TEST I	TEST II	Wilcoxon's test
PWC_{170}	$\bar{x}$	17.7	20.4	3.55
$[Kgm \cdot kg^{-1} \cdot min^{-1}]$	SD	3.076	3.293	0.0004**

statistically significant $p \leq 0.01$**

Table 3. Mean values of the threshold running speed for players of WKP Lech and the results of Wilcoxon's test

		TEST I	TEST II	Wilcoxon's test
V_{PPA}	$\bar{x}$	3.47	3.69	3.86
$[m \cdot s^{-1}]$	SD	0.285	0.257	0.0001**

statistically significant $p \leq 0.01$**

Table 4. Mean values of maximum oxygen intake for players of WKP Lech and the results of Wilcoxon's test

		TEST I	TEST II	Wilcoxon's test
VO_{2max}	$\bar{x}$	56.7	59.6	3.93
$[ml \cdot kg^{-1} \cdot min^{-1}]$	SD	2.460	2.017	0.0001**

statistically significant $p \leq 0.01$**

DISCUSSION

The basic problem of the preparatory period is developing aerobic performance which is the basis of fatigue and maintaining the form in the starting period. According to Bangsbo and Michalsik [2002] aerobic performance is determined by the aerobic power and capacity. The former reflects the ability to produce aerobic energy at a high speed and is characterised by a maximum oxygen intake; the latter expresses the ability to maintain the high intensity effort for a longer time and is synonymous with endurance.

The above mentioned maximum oxygen intake (VO_{2max}) is generally believed to be the best measure of aerobic performance [Wilmore and Costill 1999]. According to Bassett et al. [2000], the greater oxygen intake, the greater effort tolerance of a player, irrespective of the sport type. The Multistage Shuttle Run Test used in the current study (recently particularly popular with footballers in western Europe) allows for an assessment of the endurance potential of the body with a possibility of prediction of VO_{2max} on the basis of the number of covered lengths. Many works confirm the approximate results of this way of establishing maximum oxygen intake with direct trials. At the end of the preparatory period a significant increase ($p \leq 0.01$, Tab. 2) was noted in the analysed indicator in the studied athletes of WKP Lech, of 59.6 $ml \cdot kg^{-1} \cdot min^{-1}$. Similar values of VO_{2max} at the level of 58.3 $ml \cdot kg^{-1} \cdot min^{-1}$ were also noted by Tyka et al. [2004] for the elite junior team at the Sport Championship School. Reilly et al. [2000], when reviewing the literature devoted to physiological determinants of football of young, highly trained players, presented data which indicate that at the age of 17 VO_{2max} is close to 62.0 $ml \cdot kg^{-1} \cdot min^{-1}$. This is the level noted in professional players in the senior age group [Reilly 1996, Arnason et al. 2004, Shepard 1999].

In the latest diagnostics of the process of training management and in the assessment of exercise adaptation of footballers the so called “anaerobic threshold” (AT) has been used more and more often [Tyka 2004]. In order to establish the anaerobic threshold a number of both invasive and non-invasive methods are used. In the football training practice the most frequently used method is based on marking blood lactate concentration during an exercise test with a gradually growing intensity and establishing using interpolation a load, which corresponds to the level of concentration of LA equal to 4 $mmol \cdot l^{-1}$ (so-called lactate threshold) [Jastrzębski 2004, Śledziewski et al. 2003, Casajus 2001]. Among many established threshold indicators – according to Jastrzębski [2004] – the threshold running speed (V_{AT}) shows the best diagnostic qualities in the assessment of the effectiveness of applied football training. It informs about the dynamics of adaptive mechanisms of the body under the influence of applied training loads. As expected in the current study after the preparatory period a significant increase in the value of this indicator was noted ($p<0.01$, Tab. 3), from 3.5 to 3.7 $m \cdot s^{-1}$. The course of changes presented above was also noted in two groups of 16- and 17-year-old players of SMS – assessed using Conconi's test [Szczerbowski 2000]. The analysed groups of players, after a preparatory period, achieved mean values of V_{AT} of 3.6 and 3.8 $m \cdot s^{-1}$, respectively, similar to those noted in the current study. According to Kindermann et al. [1993], elite footballers should be characterized by a level of threshold values expressed as running speed exceeding 4 $m \cdot s^{-1}$.

A clear improvement in aerobic energetic potential of the studied players is also confirmed by a significant increase ($p<0.01$, Tab. 1) in the PWC_{170} index. In the comparison of mean values of this indicator achieved by our players after the end of the preparatory period (20.4 $Kgm \cdot kg^{-1} \cdot min^{-1}$) to the norms presented by Jastrzębski [2003] for the older-junior category they should be considered good. A significant progress of selected aerobic performance indicators after a preparatory period in young footballers was also noted by Śliwowski et al. [2000], Jastrzębski and Szwarc [2003], Helgerud et al. [2001].

Considering the character of training in the analysed training period a significant volume of loads of the nature of comprehensive work were noted (W), in particular the component (W_2, table 5) which is the basis for the development of general endurance. We believe that these loads determine mainly the development of adaptive processes in terms of aerobic performance of the studied players. It seems that individualised (at the level of anaerobic threshold) various forms of continuous and changeable running and appropriately selected – in terms of volume and intensity of effort – auxiliary games at various stages of the preparatory period had the greatest influence on the improvement of effort tolerance.

It can be concluded that advantageous adaptive changes in terms of the studied physiological indicators may indicate an effective application of individual training loads and good preparation of the team to the spring starting period in terms of aerobic performance. The studied group was characterised by a high general performance as shown by the level of maximum oxygen intake, threshold running speed and PWC_{170} index. Comprehensive studies of aerobic performance used in monitoring of sports training of young football players fully meet the requirements in terms of identification of the direction and scope of changes in exercise adaptation of the studied subjects.

Table 5. The most important components of training loads applied in individual sub-periods of the basic preparatory season 2006/2007 in the group of older juniors of WKP Lech Poznań

	Most important components of training loads
Sub-period of general preparation	W2, S3, W1, S2, W3, W6,
Sub-period of special preparation	S3, W2, S2, S1, W1, W3, S4

REFERENCES

[1] Arnason A., Sigurdsson S.B., Gudmundsson A., Holme I., Engebretsen L., Bahr R., Physical Fitness, Injuries, and Team Performance in Soccer, Med.Sci. Sports Exerc., 2004, 36 (2): 278-285.

[2] Bangsbo J., Michalsik L., Assessment of the physiological capacity of elite soccer players, [in:] Science and Football IV, W. Spinks, T. Reilly, A. Murphy, ed., Routledge, 2002, 53-62.

[3] Bassett D.R., Howley J.R., Howley E.T., Limiting Factors for Maximum Oxygen Uptake and Determinants of Endurance Performance, Med.Sci.Sports Exerc., 2000, 32: 70-84.

[4] Brewer J., Ramsbottom R., Williams C., A progressive shuttle-run test for estimation of maximal oxygen uptake, Br.J.Sports Med., 1988, 22: 141-145.

[5] Casajus J.A., Seasonal variation in fitness variables in professional soccer players, J.Sports Med.Phys. Fitness, 2001, 41:463-469.

[6] Helgerud J., Engen L.Ch., Wisløff U., Hoff J., Aerobic endurance training improves soccer performance, Med.Sci.Sports Exerc., 2001, 33 (11): 1925-1931.

[7] Jastrzębski Z., Obciążenia treningowe i ich wpływ na rozwój sportowy piłkarzy nożnych i ręcznych (Training loads and their impact on sport development of football and handball players), AWFiS, Gdańsk 2004.

[8] Jastrzębski Z., Normy wskaźników w teście PWC_{170} u piłkarzy nożnych i piłkarzy ręcznych różnych grup wiekowych (PWC_{170} index standards for football and handball players of different ages) [in:] H. Sozański, K. Perkowski, D. Śledziewski, ed., Kierunki doskonalenia treningu i walki sportowej (Development of training and sport combat), AWF, Warszawa 2003, 170-174.

[9] Jastrzębski Z., Szwarc A., Struktura organizacyjna i jej wpływ na efektywność szkolenia piłkarskiego na przykładzie Szkoły Mistrzostwa Sportowego w Gdańsku (The organizational structure and its impact on the effectiveness of football training) AWFiS, Gdańsk 2003.

[10] Kindermann W., Gabriel H., Coen B., Urhausen A., Sportmedizinische Leistungsdiagnostik in Fußball, Dtsch.Z.Sportmed., 1993, 44: 232-236.

[11] Olszewski K., Zatoń M., Związki między wielkością i rodzajem bodźców treningowych a zmianami zdolności wysiłkowej (Relationships between the number and type of training stimuli and changes in exercise ability), [in:] M. Zatoń, Z. Jethon, ed., Aktywność ruchowa w świetle badań fizjologicznych (Motor activity in the light of physiological research), AWF, Wrocław 2002, 109-125.

[12] Reilly T., Bangsbo J., Franks A., Anthropometric and physiological predispositions for elite soccer, J. Sports Sci., 2000, 18: 669-683.

[13] Reilly T., eds., Science and Soccer, London: E& F.N. Spon, 1996.

[14] Shepard R.J., Biology and medicine of soccer: An update, J.Sports Sci., 1999, 17: 757-786.

[15] Sozański H., Śledziewski D., ed., Obciążenia treningowe, Dokumentowanie i opracowywanie danych (Training loads. Data recording and processing) Biblioteka Trenera, Warszawa 1995.

[16] Stanisz A., Przystępny kurs statystyki w oparciu o program Statistica PL na przykładach z medycyny (Practical course in statistics using Statistica PL- medicine cases), Stat Soft Polska sp. z o.o., Kraków 1998.

[17] Szczerbowski M., *Test* Conconi'ego w monitorowaniu wydolności tlenowej piłkarzy podczas okresu startowego (Conconi test in monitoring of football players' aerobic capacity during the competitive period), [in:] H. Sozański, K. Perkowski, D. Śledziewski, ed., Trening sportowy na przełomie wieków (Sport training at the turn of the century), AWF, Warszawa 2000, 50-52.

[18] Śledziewski D., Kuder A., Kosmol A., Hubner-Woźniak E., Programowanie obciążeń wysiłkowych w piłce nożnej na podstawie badań diagnostycznych (Programming of training loads in football), [in:] H. Sozański, K. Perkowski, D. Śledziewski, ed., Kierunki doskonalenia treningu i walki sportowej (Directions of improvement of training and sport rivalry), AWF, Warszawa 2003, 83-86.

[19] Śliwowski R., Jastrzębski A., Gołaszewski J., Wpływ obciążeń treningowych na zmiany wybranych wskaźników wydolności fizycznej młodych piłkarzy (The effects of training loads on changes of selected indices of physical capacity of young footballers), S. Drozdowski, E. Wachowski, ed., Wychowanie fizyczne i sport w badaniach naukowych (Physical education and sport in scientific research), AWF, Poznań 2000.

[20] Tyka A., Wybrane zagadnienia z fizjologii sportu – fizjologiczne aspekty piłkarstwa (Selected aspects of sport physiology – physiological aspects of football), Med.Sportiva, 2004, 8 (1): S5-S17.

[21] Tyka A., Bahr A., Oratowski A., Pałka T., Cisoń T., Małek Z., Różnice w poziomie wydolności aerobowej i anaerobowej piłkarzy nożnych drużyny mistrza Polski i elitarnej drużyny juniorów (Differences in aerobic and anaerobic capacity in football players), Med.Sportiva, 2004, 8 (1): S254-S255.

[22] Wilimore J.H., Costill D.L., Physiology of Sport and Exercise, Human Kinetics, Champaign 1999.