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Changes of Lactate Threshold during a Half-Year Training Cycle in "Arka Gdynia" Football Players

Author's Conrtibution
A – Study Design
B – Data Collection
C – Statistical Analysis
D – Data Interpretation
E – Manuscript Preparation
F – Literature Search
G – Funds Collection

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Key words: *football, lactate threshold, heart rate*

Abstract

Background: *The aim of this study was to assess lactate threshold changes during a half-year training cycle in S.S.A. "Arka Gdynia" football team.*

Materials and methods: *The research was conducted on a sample of 17 "Arka Gdynia" Football Club players. The subjects participated in premier league competitions in autumn 2009/10 season. Apart from league matches (17) the players took part in Remes Polish Cup (2 matches). Aerobic capacity tests were conducted at the beginning of the summer preparatory season (test 1-27th June 2009), during the competitive season (test 2-2nd September 2009) and at the beginning of the winter preparatory season (test 3-13th January 2010). The players underwent an incremental running test. Running speed (V/LT) and heart rate (HR/LT) at the lactate threshold were determined.*

Results: *An analysis of mean running speed values at LT intensity in each study confirms that during the first two tests participants achieved the same mean value of the ratio V/LT (3.80 m/s). The last test revealed a regression of the results by 0.17 m/s. The lowest standard deviation (± 0.20 m/s) was observed in the first study, which indicates that the diversity of the group was the smallest.*

Conclusions: *Goalkeepers achieved statistically lower (p<0.05) values of running speed at the intensity corresponding to the anaerobic threshold (V/LT) in relation to field players.*

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Introduction

The linear relationship between an increase in training intensity and lactic acid concentration has been widely known since the beginning of the 20th century [1,2]. Yet later some discrepancy was stated. It was confirmed that after reaching a certain intensity level lactic acid concentration increases rapidly [3, 4] so the chart shows a nonlinear relation. Nowadays lactate threshold (LT) is defined as the highest load volume of dynamic work engaging large muscle groups during which production of lactate and its clearance balance out [5]. The lactate threshold is expressed as an absolute value as well as a relative one of the heart rate, oxygen consumption and running velocity. Many authors [6,7,8,9] claim that lactate threshold constitutes more precise aerobic capacity indicator than VO_{2max} and shows higher sensitivity [10,11]. Running speed at the lactate threshold is an indictor independent from body mass unlike the maximal oxygen uptake (VO_{2max}). It poses a significant fact for subjects of unstable body composition and body size [12,13,14]. Physical work at LT influences significantly adaptation of the respiratory and the circulatory system as well as energy processes in cells during physical effort of a football player [15]. During a football match a player covers the distance of 10–12 km [16,17,18,19,20,21,22] and the mean value of work intensity is between 80–90% of HR_{max} (this value correlates with LT) [23,24,25,26,27,28,29]. Despite such a high load, nearly 90% of energy needs are covered by oxidative processes [16,24]. A high level of aerobic capacity allows accomplishing the task, and the acyclic character of the discipline lets the player rest optimally. Therefore, it seems reasonable to state that the higher work intensity at the LT level, the higher mean value of game intensity of this player without lactate accumulation in his blood [30].

Definite LT not only informs about the player's condition but also creates the chance for training load individualization, which is an important element in the training process regarding not only team games [31,32]. Maintenance of aerobic capacity at a high level is one of the crucial tasks, as it significantly influences the results achieved within a long competitive period. The main advantage of the conducted test is its easiness of determining LT during physical effort. Moreover, the measurements are done during submaximal effort of moderate intensity. What is more, the commonly used LT index in sports diagnostic opens up possibilities of results comparison among different sports [33].

A practical application of LT as an indicator of training load volume contributed to the development of numerous method of determining the individual anaerobic threshold (IAT). This indicator considers also variability of muscle fibers composition and the current metabolic adaptation. In this case LT is determined at lactate balance level which not always corresponds with 4 mmol/l of blood [31].

According to IAT tests methodology, the time of incremental performance spans usually 3 to 5 min. Within this period an individual relation between lactic acid concentration in blood and the heart rate is determined. However, this relation cannot be extrapolated for performance of longer duration. Using only the heart rate to determine a training load volume without blood lactate control can lead to considerable training faults and failures. It is advisable to verify the IAT level in a natural training situation every 4–6 weeks considering the type of period [31,34].

The aim of the study was to analyse lactate threshold changes, determined by running velocity and the heart rate, within a half-year training cycle in premier division "Arka Gdynia" footballers.

Material and method

The research was conducted on a sample of 17 "Arka Gdynia" Football Club players. The subjects participated in premier league competitions in autumn 2009/10 season. Apart from league matches (17) the players took part in Remes Polish Cup (2 matches).

Aerobic capacity tests were conducted at the beginning of the summer preparatory season (test 1 – 27th June 2009), during the competitive season (test 2 – 2nd September 2009) and at the beginning of the winter preparatory season (test 3 – 13th January 2010). Biometric profile of the players is shown in Table 1.

Tab. 1. Biometric profile of “Arka Gdynia” Football Club players

Statistical Value	Test 1		Test 2		Test 3	
	Body height (cm)	Body weight (kg)	Body height (cm)	Body weight (kg)	Body height (cm)	Body weight (kg)
$\overline{X}$ ± SD	181.7 ± 6.7	77.7 ± 6.7	181.7 ± 6.7	77.9 ± 6.9	181.6 ± 6.6	78.1 ± 6.5
min-max	169 – 191	65 – 87	169 – 191	65.4 – 87.5	169 – 191	67 – 88.7

The subjects were submitted to an incremental running test according to Jastrzębski’s method [35, 36]. They performed run at progressively increased speed on a football pitch (synthetic surface) in sequential courses. The initial running speed was 2.8 m/s and increased in each sequential course by 0.4 m/s. After each course blood sample was taken from the finger tip within one minute time. The lactic acid level in blood was determined based on the enzymatic method with the use of spectrofotometer (EPOLL 200) and reagents made by Pointe-Scientific firm. Certain indices were determined based on the test results: running speed (V/LT) and the heart rate (HR/LT) corresponding to the lactate threshold (LT) which were counted according to Beaver’s method [37].

A statistical analysis was done with the use of Statistica 8.0 version. Shapiro–Wilk test and Kolmogorov–Smirnov (K-S) test with Lilliefors’s amendment were applied to check homogeneity of dispersion with normal distribution. In the non-normality case, non-parametric statistics were applied: Friedman test (significance of differences). The Kruskal–Wallis test performed on ranked data and a multiple comparison test were used to verify the hypothesis that the positional role of the players influences the HR/LT and V/LT values. Moreover, Pearson correlation coefficient was calculated for certain parametric variables.

Results

An analysis of the results shows that mean values of the running speed at LT in the first two tests were identical V/AT (3.80 m/s). However, in the third test the value decreased by 0.17 m/s. The smallest value of standard deviation (± 0.20 m/s) was observed in the first test, which means little diversity of footballers’ abilities. The second test revealed larger differences of aerobic capacity (determined by V/LT index) among the players: from 3.3 m/s (goalkeeper) to 4.2 m/s (forward). The lowest value of this index was noted in the third test (3.2 m/s) (see Tab. 2.)

The heart rate at LT indices were similar in consecutive tests in the players and no significant differences were stated (see Figure 1).

An analysis of data revealed statistically significant differences among the results obtained by the subjects within the concerned period (p=0.03). In the third test the players reached significantly lower values than in the other two tests. In these tests (1 and 2) the results reached similar values (see Figure 2).

The study confirmed that the positional role of the players does not influence significantly HR/LT index value. However, speed results at LT (V/LT index) obtained by the goalkeepers were significantly lower than those of the field players. Results of defenders, midfielders and forwards show no significant differences (see Figure 3).

Testing a correlation between variables is essential not only for selection for the sport but also for training individualization. For example, in football, moderately tall players (175–182 cm) are predisposed to play as midfielders and wing backs, as a high level of aerobic endurance is crucial for this positional role. In this study a weak negative correlation between body height and running speed at LT was stated. Therefore, it can be assumed that shorter players obtained higher running speed values at LT level (see Tab. 3).

Tab. 2. Individual results and mean values of HR/LT and V/LT in Arka Gdynia Football Club players in consecutive tests

No	Test 1		Test 2		Test 3		Positional role on the field
	HR (bpm)	V/LT (m/s)	HR (bpm)	V/LT (m/s)	HR (bpm)	V/LT (m/s)	
1.	160	3.8	166	3.4	155	3.2	Goalkeeper
2.	162	3.4	169	3.3	170	3.3	Goalkeeper
3.	166	3.9	165	3.9	170	3.7	Forward
4.	168	4	162	3.8	156	3.6	Forward
5.	170	3.6	168	3.8	172	3.6	Forward
6.	167	3.8	180	4.2	178	3.6	Forward
7.	172	3.4	179	3.8	173	3.6	Defender
8.	160	3.9	167	4	167	4.1	Defender
9.	184	4	183	3.6	184	3.6	Defender
10.	170	4	166	3.8	167	3.6	Defender
11.	166	3.8	166	3.7	168	3.6	Midfielder
12.	168	4	162	3.6	167	3.7	Midfielder
13.	177	3.8	180	3.8	179	3.6	Midfielder
14.	175	3.6	177	3.8	175	3.5	Midfielder
15.	161	4	166	4	160	4	Midfielder
16.	165	3.8	180	4	169	3.7	Midfielder
17.	175	3.8	184	4.1	177	3.7	Midfielder
$\overline{X}$	168.6	3.8	171.8	3.8	169.8	3.63	
SD	6.54	0.20	7.80	0.23	7.83	0.21	
max	184	4	184	4.2	184	4.1	
min	160	3.4	162	3.3	155	3.2	

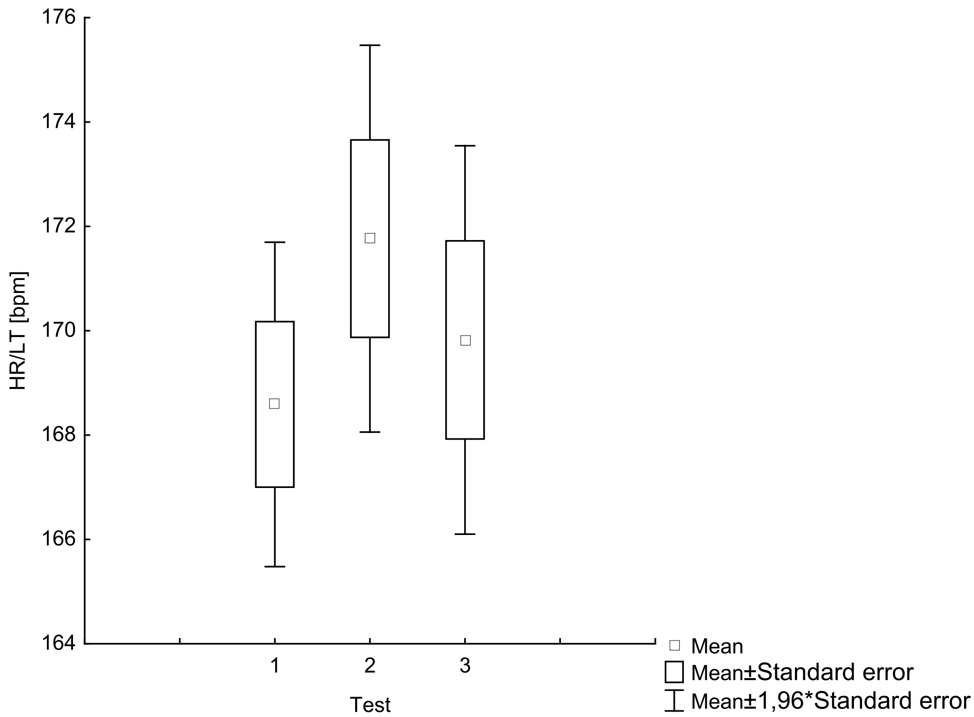

Fig. 1. Mean values and standard errors of HR/LT index [bpm] in tested footballers in consecutive tests

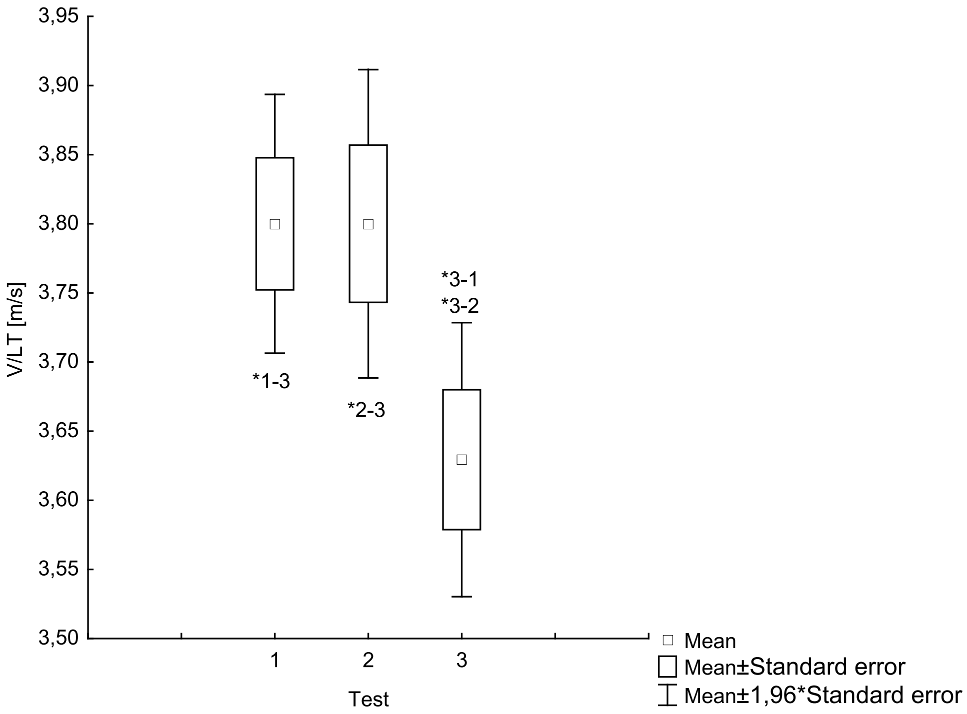

Fig. 2. Mean values and standard errors of V/LT index in footballers in consecutive tests (statistically significant differences at p<0.03)

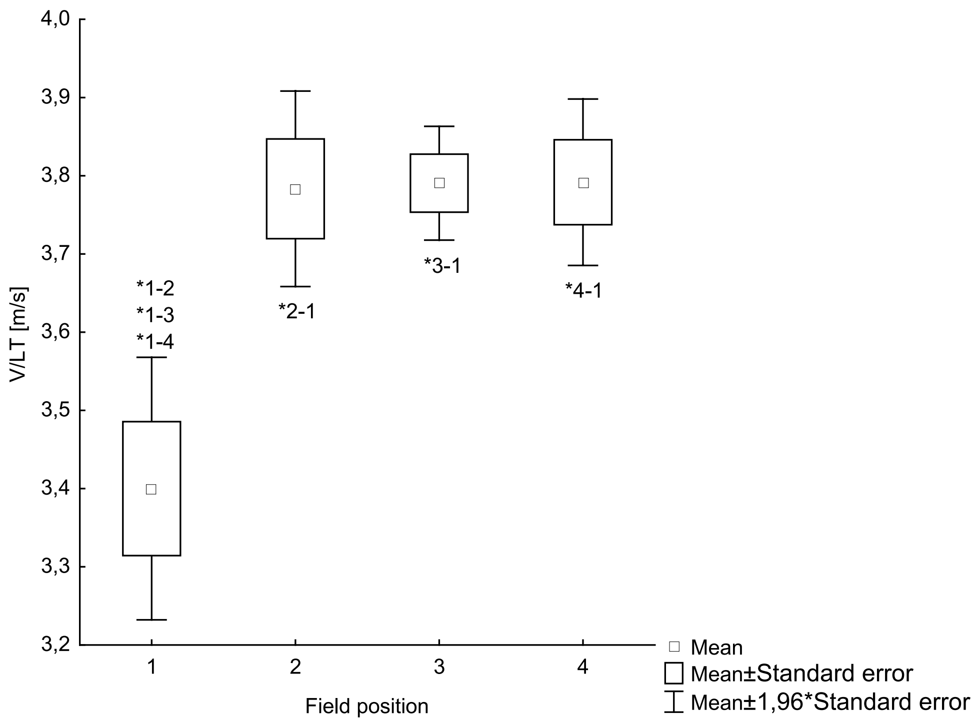

Fig. 3. Mean values of V/LT index in tested football players; 1 – goalkeepers, 2 – defenders, 3 – midfielders, 4 – forwards (* statistically significant differences at p<0.01)

Tab. 3. Pearson correlation coefficient for some biometric and physiological indices of tested football players

	Age	Body height	Body mass	HR/LT	V/LT
Age	1.00	-0.02	-0.09	-0.07	0.09
Body height	-0.02	1.00	0.87*	0.07	-0.29*
Body mass	-0.09	0.87*	1.00	0.10	-0.19
HR/LT	-0.07	0.07	0.10	1.00	0.13
V/LT	0.09	-0.29*	-0.19	0.13	1.00

Discussion

Judging by the results achieved by the footballers within the time considered, it is stated that the subjects showed the highest level of physical abilities at the beginning of the summer preparatory season and at the end of the competitive period. Significantly lower V/LT index was registered after the off-season at the beginning of January. Conversely, HR/LT index shows no significant differences in sequential tests. The study confirmed that aerobic capacity expressed by V/LT index in goalkeepers was significantly lower than in field players. Also a significant negative correlation between body height and running speed at LT was found.

Interestingly, aerobic capacity level at the beginning of the winter preparatory season was significantly lower than at the beginning of the summer preparatory season. The reason for that fact could be the length of the off-season: in summer 2 weeks, in winter 4 weeks.

Specificity of the discipline requires from the players maintaining optimal physical condition during the competitive season lasting over 4 months. The main aim of the preparatory season is multilateral preparation of the players for the league matches. Meanwhile anaerobic capacity and speed should be developed on the solid aerobic foundation, which is the key to success in football [35]. Therefore, reaching and sustaining the highest possible level of aerobic and anaerobic capacity during the whole competitive season should occur as a result of the correct training process. It is obvious that even a high level of technical skills if not supported with a high level of physical capacity leads to a decrease in a player's effectiveness [38,39]. According to Jastrzębski [40] an actual preparation level including physical capacity is a result of specific vegetative alteration occurring in a healthy organism. This phenomenon is caused by a sequence of physical efforts with set frequency and intensity. Yet, due to methodological difficulties, very little research data tracing physical capacity in football players within several seasons are available [11].

Rompa et al. [41] in his study revealed the highest V/LT level (3.36 ± 0.32 m/s) at the beginning of the preparatory season before autumn competition. However, the values of the competitive season and at the beginning of winter preparation were similar (3.80 ± 0.30 and 3.84 ± 0.16 m/s respectively). Zarzeczny et al. [42] tested the physical capacity level in footballers just before and at the end of the competitive season. The obtained V/LT results (V/LT: 3.74 ± 0.40 m/s and 3.70 ± 0.46 m/s; HR/LT: 166.6 ± 10.25 bpm and 166.1 ± 11.23 bpm) were only slightly lower than results obtained in this study. Tests conducted by Zarzeczny et al. were performed on a treadmill, whereas ours on a football pitch. What Di Michele et al. [43] studies revealed confirms that the differences in physical capacity could be even bigger. Results obtained by Arka Gdynia footballers in comparison with those of players tested by Radzimiński et al. [36] at the beginning of the summer preparatory season reached higher values of V/LT (3.80m/s vs 3.63m/s), though results from the competitive season were similar (3.80m/s vs 3.79 m/s). The important fact in the cited study is that the highest physical capacity level (3.91 ± 0.24 m/s) was observed in the tested subject at the end of the competitive season. Tests conducted by Śledziewski [44] on a treadmill also confirm that during a half-year training period the premier division footballers obtain the lowest results at the beginning of the preparatory season (3.62 ± 0.48 m/s). Jastrzębski [35] in his study of the first league players noted the mean running speed value at LT as 3.51 ± 0.23 m/s. This value is diminished by 0.29 m/s in comparison with subjects of the present study. All the comparisons shown above are of high value as all of them concern the players from the same division representing a similar level of sports mastery.

It seems that a high level of V/LT index might result from interval training. Helgerud et al. [24] observed V/LT values in two Norwegian junior football teams during competitive season before and after 8-week interval training (4 x 4 min., 90–95% HR_{max}, twice a week). Running speed at LT index was 3,08 m/s at the initial stage of the experiment and increased up to 3.75 m/s afterwards. It means that footballers tested by Helgerud reached the aerobic capacity level close to Arka Gdynia players. Similar general as well as specific training (small-sided games) was applied by Impellizzeri et al. [44]. In this research increase by 9.7% and 8.9% in aerobic capacity indices was stated. Moreover, a high level of aerobic capacity expressed by running speed at the lactate level assumed as 4 mmol per one blood litre was also reported by McMillan et al. [30]. During the preparatory season the players reached 3.78 m/s value while during the competitive season it increased up to 4.08 m/s and remained stable during the next seven months. Some authors suggest that it proves a correct choice of the training load within the time considered. Ziogas et al. [45] stated that V/LT index is a factor diversifying the players in terms of the league level they play in. Mean V/LT value of second league footballers (3.50 m/s) was substantially higher than the one of the third league players (3.42 m/s). The first league footballers showed significantly higher results (3.67 m/s) than both lower level groups, though.

Mohr et al. [46] revealed that during the match the longest distance is covered by wing backs, midfielders and forwards, while the shortest one by centre back. Similar results regard run at high intensity. This fact could support the conclusion that the highest aerobic capacity should occur in wing backs and the lowest one in centre backs.

The presented study revealed a significant difference between aerobic capacity in goalkeepers and field players. The V/LT values achieved by defenders, midfielders and forwards were comparable. No substantial difference among these players' groups in this study might result from the fact that in modern tactical solutions (Mohr et al. studies in 2003) there is no division of the defenders for wing and centre ones. Midfielders often exchange their position for defenders and forwards for midfielders. Therefore, training loads applied for the players are often at a similar level and do not diversify their physical capacity.

A pattern similar to this study is evident in Gil et al. [47] research, who found the lowest aerobic capacity level in goalkeepers and confirmed no difference among field players.

A statistical analysis of physiological indicators in the players in this study shows a negative correlation between body height and running velocity at LT level. Buresh et al. [8] stated that body mass and body surface correlate negatively with running speed at LT. There was no evidence for this claim found in Arka Gdynia footballers.

Conclusions

The lowest V/LT index values occurred in the players at the beginning of the winter preparatory season. The highest values were achieved at the beginning of the summer preparatory season and during the competitive period.

Tested goalkeepers showed statistically significant ($p<0.05$) lower running speed values corresponding to LT (V/LT) in comparison with field players.

Players of a lower body height values achieved higher running velocity at LT values.

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