Biology of Sport, Vol. 23 N°1 , 2006

CHANGES OF CHOSEN BLOOD PARAMETERS IN FOOTBALL PLAYERS IN RELATION TO APPLIED TRAINING LOADS DURING COMPETITION

Z. Jastrzębski
Dept. of Physiology Academy of Physical Education, Gdańsk, Poland

Abstract. Researches were conducted on 20 football players of the I league. Athletes won the Polish Cup Finals and partook in the UEFA Cup play-offs during the research period. Respective anthropometric features were as follows: age 24.4±3.65 years; body height 182.3±5.22 cm; body mass 79.5±6.46 kg. Examinations were performed thrice: at the beginning (beginning of March), in the middle (end of April) and at the end (middle of June) of the playing period. Examinations concerned levels of the chosen biochemical parameters of blood in the three micro cycles of training. Blood samples for (RBC), (Hgb), (HCT), 9ALAT) and (AspAT) were taken in the middle (Wednesday) of the each micro cycle. Samples for (CK) and (LDH) were taken each day from Monday to Friday. The restitution time from the match end and the first blood sample taking (for CK and LDH) amounted to 36 h in each series. Levels of RBC, Hgb, HTC and WBC were marked according to the standard methods with the Corning Company apparatus. Determinations of CK, LDH, ALAT, AspAT were made with the spectrophotometer type EPOLL-200 and POINTE-SCIENTIFIC reagents in the temperature of 37°C for CK (physiological norm up to 166 IU/I) and 30°C for LDH (physiological norm 50-166 IU/I). Physiological norm for ALAT amounted to 38 IU/I and 40 IU/I for AspAT. The training loads were recorded in every discussed micro cycle. Results were elaborated with the Statistica V. 5.0 software. Obtained results prove the changeability of the blood biochemical parameters especially those determining the after effort fatigue during the practice micro cycle. For example, the CK activity after the 36 h restitution of athlete i.e. on Monday examinations was high (697.4 U/L). It is the three times as large as the physiological norm (third examination series). However, taking into consideration the whole week micro cycle the gradual decrease of its level was noticed reaching 241.7 U/I on Friday. It was the effect of the proper choice of training loads during the cycle. (***Biol.Sport 23:85-96, 2006)***

Key words: Football - Training micro cycle - Training loads - CK and LDH activity

---

Reprint request to: Dr Zbigniew Jastrzębski, Dept. of Physiology, Academy of Physical Education, Wiejska 1, 80-336 Gdańsk, Poland
E-mail: jassibi@poczta.onet.pl

Introduction

Football as any other team game belong to a remarkably a-cyclic as considering motion sport discipline. In sport competition following efforts can be seen: with aerobic metabolic, anaerobic-non-acidilactic and anaerobic-acidilactic changes. An important role in motorial behaviours of footballers during competition and connected with it muscles twitches play both concentric and eccentric muscle retractions. Many authors [1,4,5,13] claim that eccentric twitches are one of factors eliciting mechanical injuries of working muscle tissue.

Many studies discuss the physical exercise influence on the activity of creatine kinase, lactate dehydrogenase and other enzymes in athletes' blood. On the other hand, there are only few works analyzing training loads especially in relation to training cycles. Large loads and their improper distribution for example in a micro-cycle range may cause homeostasis disturbances what as a conclusion may lead to constant fatigue symptoms. Creatine kinase and lactate dehydrogenase as well other blood components activity may point a large after effort fluctuations and can maintain for many hours after the effort [1,4,10,18].

The basic training cycle in football during competition is a week micro-cycle determined by time between matches. The proper training load is a crucial element keeping up the effort capacity formed in a preparatory period and not allowing for creation of disadvantageous fatigue changes.

The aim of this work was the analysis of dynamics of chosen blood parameters changes in football players elicited by applied loads during 3 week micro-cycles of competition period. There was assumed that the level of examined parameters is changeable dependently on occurring after effort fatigue processes elicited by applied training loads.

Materials and Methods

Players of extra class football team Amica Wronki in number of 20 took part in the experiment. All athletes played matches in full time competition of I (11 players) and III (9 players) league. The whole Amica Wronki team contained 28-30 players. Eight of them did not participate in matches in fool time or attend the study trice at random causes. The team, at discussed time, was the Polish Football Cup champion and partook in the UEFA Cup competition. Examined subjects played football professionally.

Athletes age amounted to: 24.4±3.65 years; body height to: 182.3±5.22 cm and body mass to: 79.5±6.46 kg.

The research was conducted in 3 series: at the beginning (beginning of March) in the middle (end of April) and at the end (half of June) of the II round of 2000/2001 league playing season.

Laboratory measurements encompassed chosen biochemical blood parameters during the above micro-cycles. Blood samples were taken in the analytic laboratory form Monday to Friday, unfed, in mornings. The amount of red blood cells (RBC), haemoglobin (Hgb), white blood cells (WBC), percentage hematocrit amount (HCT), alanine amino-transferaze (ALAT) and asparagine amino-transferaze (AspAT) in the middle (Wednesday) of discussed training cycles as well as the creatine kinase (CK) and lactate dehydrogenase (LDH) activities in every day of respective micro cycles were analysed. The time between the game finish and first blood sample taking for CK and LDH analysis equalled 36 restitution h.

Values of RBC, Hgb, HTC and WBC were marked according to standard methods and Corning company apparatus. Denotations of CK, LDH, ALAT and AspAT were done with the EPOLLZO spectrophotometer and POINTE-SCIENTIFIC reagents in temperature of 37^0C for CK (physiological norm to 166 IU/I) and for AspAT (to 40 IU/I) [9].

Training loads were registered in every micro cycle day from Monday to Sunday. Identical set of exercises was applied to athletes in every training micro cycle. They were recorded on the basis of computer programme: Treob-4 with the use of training means for football players. Exercises quantity and quality was presented in percents regarding to the effective time of its performance. The training means recording was based on the analysis of each exercise realised in one training unit. According to authors of the Treob-4 programme following energetic exercises were found: 1 - sustaining (HR- heart retraction 130-140r/m); 2 – aerobic (HR – 160-180 r/m); 3 – mixed (HR>180 r/m); 4 – anaerobic-acidilactic (HR>190 r/m); 5 – anaerobic- non-acidilactic (HR – 150-160 r/m). The above ranges of heart retraction were helpful in the general estimation of training load with the regard of energetic fields. Next, the individual ranges of heart retraction were determined on the basis of conducted earlier studies over the physical capacity (effort trial with gradual fatigue accrue) where the every athlete lactic threshold (AT- Anaerobic Threshold) was calculated. Heart retraction frequency was registered during each training unit on the telemetric Sport-tester, Polar-Advantage gauge in averaging for 5 s time periods. As regards the exercises specificity (information field) they were divided into: I – versatile, II – oriented, III – special [16].

The Statistica V 5.0 software was used as for the result analysis. Basic statistics (average values, standard deviation, maximal and minimal values) were counted. The significance of differences between averages was determined according to the Anova programme and RIR-Tuckey test. Differences at the level of $p<0.05$ were accepted as significant.

Results

Table 1
Percentage amounts of football players training loads in every day of the week micro cycle during competition in relation to the effective time of its duration

Week day	Energetic field					Exercises energetic field		
	1	2	3	4	5	I	II	III
Mon.	21.4%	42.9%	34.3%	-	1.43%	30.0%	14.3%	55.7%
Tues.	62.9%	21.4%	-	12.9%	2.86%	62.9%	-	37.1%
Wed.	47.5%	6.25%	37.5%	7.5%	1.25%	18.8%	-	81.2%
Thu.	21.4%	42.9%	28.6%	-	7.14%	21.4%	21.4%	57.1%
Fri.	50.0%	16.7%	26.7%	-	6.67%	33.3%	-	66.7%
Sat. (match)	-	9.0%	90.0%	-	1%	9.0%	1.0%	90.0%
Sun.	100%	-	-	-	-	100%	-	-

Exercises energetic area – 1-maintaining, 2-aerobic, 3-mixed, 4-anaerobic-acidilactic, 5-anaerobic-non-acidilactic.
Exercises information field – I-versatile, II-directed, III-special [16].

The one week training micro cycle in examined footballers was carefully planned. The percentage values of training loads presented in Table 1 concern the realisation of training plan in every discussed micro cycle. Character of applied loads was typical for tournament period. In the first day of micro cycle the energetic character of effort in football players was based on aerobic and mixed work. The biggest loads were applied in the second and third day of training. The largest part of exercises during this period were – anaerobic-lactic in the energetic field and special exercises for the information area. The last two days of micro cycle were concentrated on a special exercises with high locomotion dynamics i.e.: anaerobic-non-lactic effort (Table 1).

The statistically significant growth of biochemical blood parameters (RBC, HCT and HGB) was noticed in II and III examination ($p<0.05$; Table 2).

Table 2
Averages of blood haematological indices in examined footballers in 3 examination series: at the beginning (1), in the middle (2) and at the end (3) of the competition period

Study	Value	RBC $10^6/mm^3$ (3.8-5.8)	HGB g/dl (11.0-16.0)	HCT % (35.0-50.0)	WBC $10^3/mm^3$ (4.0-10.0)	ALA T IU/l (≤38)	AspAT IU/l (≤40.0)
1	X	4.86^{*1-3}	14.4^{*1-3}	42.4^{*1-3}	5.76	20.4	35.8
	±SD	0.32	0.79	2.55	1.07	3.98	7.48
	Max	5.36	15.8	46.0	8.9	27	53-
	Min	4.20	13.1	37.9	4.6	14	21
2	X	4.91^{*2-3}	14.6^{*2-3}	42.2^{*2-3}	5.64	19.4	33.4
	±SD	0.29	0.89	2.52	1.16	4.30	6.90
	Max	5.40	15.6	46.0	8.9	27	48
	Min	4.32	14.0	37.9	4.1	12	21
3	X	5.47	15.9	47.7	5.935	19.45	32.4
	±SD	0.56	1.36	4.43	1.19	4.83	6.35
	Max	6.51	18.6	54.5	9.1	27	43
	Min	4.58	14.0	40.3	4.1	12	21

*differences statistically significant by $p<0.05$

The dimension of CK and LDH index should be considered in two levels. 1 – comparing of their average values in series of 3 examinations (each day separately); 2 – study over the changes dynamics measured in every micro cycle i.e.: from Monday to Friday.

At the first level only two cases presented some crucial differences between average results – CK recorded on Monday (I and III examination series) and on Thursday (I and III series) ($p<0.05$). Any differences in level of LDH between examination series were found.

At the second level of CK and LDH analysis the highest averages were recorded during Monday exercises and the lowest while Friday. Differences were significant in many cases and considered 3 examination series (Table 3).

Table 3
Average CK and LDH values in football players in 3 examination series: at the beginning (1), in the middle (2) and at the end (3) of the competition period and in following days of 3 week micro cycles: Monday I; Tuesday II; Wednesday III, Thursday IV; Friday V

Study	Value	CK I IU/l	CK II IU/l	CK III IU/l	CK IV IU/l	CK V IU/l	LDH I IU/l	LDH II IU/l	LDH III IU/l	LDH IV IU/l	LDH V IU/l
1	X	449.8^{*1-3}	338.9	290.8	242.8^{*1-2}	220.6	149.5	129.3	110	105.7	94.2
	±SD	258.8	177.7	118.2	99.9	94	15.4	14.7	15.6	13.9	9.4
	Max	1069	752	437	395	368	175	155	155	135	110
	Min	121	114	107	112	69	115	102	102	76	69
		*CK; I-III,II-IV,I-V					*LDH; I-II,I-III,I-IV,I-V,II-III,II-IV,II-V,III-V				
2	X	646.8	508.2	420.3	341.8	274	149.7	128.9	108.1	107.4	95.5
	±SD	381.1	336.5	225.9	146.7	117.9	15.6	13.6	16.9	10.4	11.1
	Max	1800	1630	1052	672	543	173	155	138	125	110
	Min	200	185	190	175	137	115	109	84	88	65
		*CK; I-IV,I-V,II-V					*LDH; I-II,I-III,I-IV,I-V,II-III,II-IV,II-V,III-V				
3	X	697.4	481.9	364	294.3	241.7	147.9	129.2	108.2	105.8	94
	±SD	268.6	254.3	153.5	132.7	115.1	19.3	14.4	16.8	12.5	10.8
	Max	1350	1100	663	669	647	175	155	138	125	110
	Min	200	185	168	132	115	115	102	84	76	65
		*CK; I-II,I-III,I-IV,I-V,II-IV,II-V					*LDH; I-II,I-III,I-IV,I-V,II-III,II-IV,II-V,III-V				

*differences statistically significant by $p<0.05$
Physiological norm for: CK (≤166 IU/I) and LDH (50-166 IU/I)

The dynamics of these parameters changes is presented in Figs. 1 and 2.

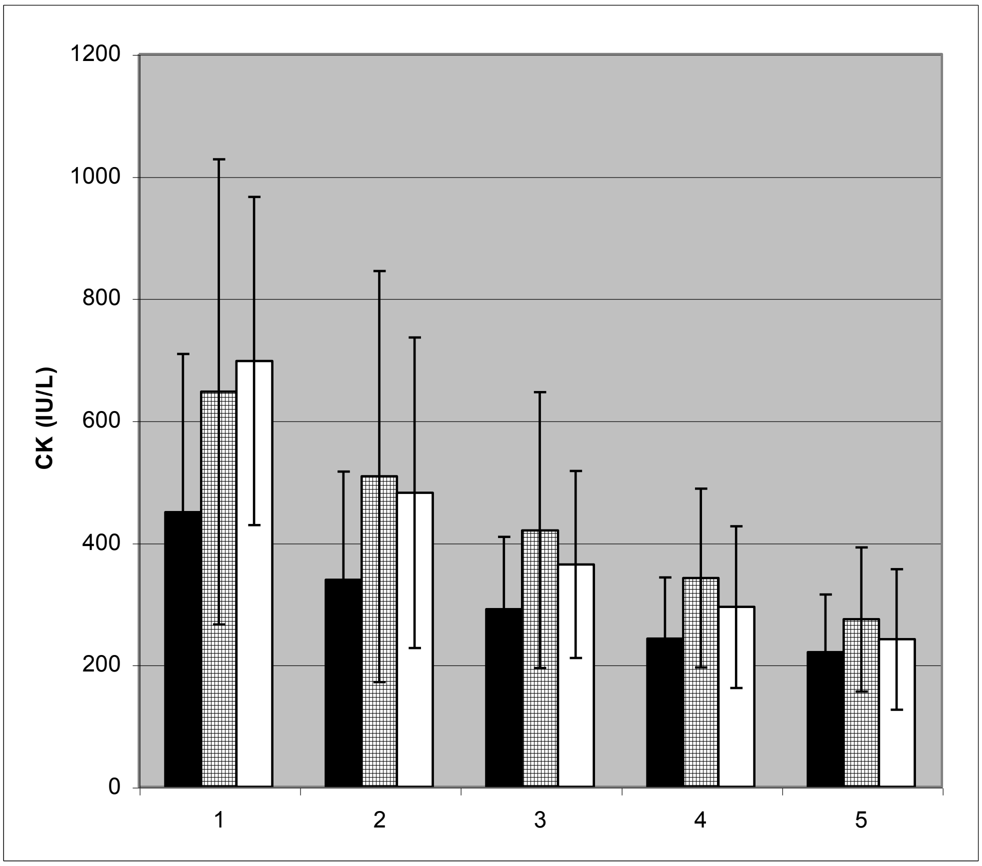

Fig. 1
Dynamics of CK changes in footballers in 3 examination series: at the beginning (1), in the middle (2) and at the end (3) of the competition period
One week micro cycle days: 1-Monday, 2-Tuesday, 3-Wednesday, 4-Thursday, 5-Friday

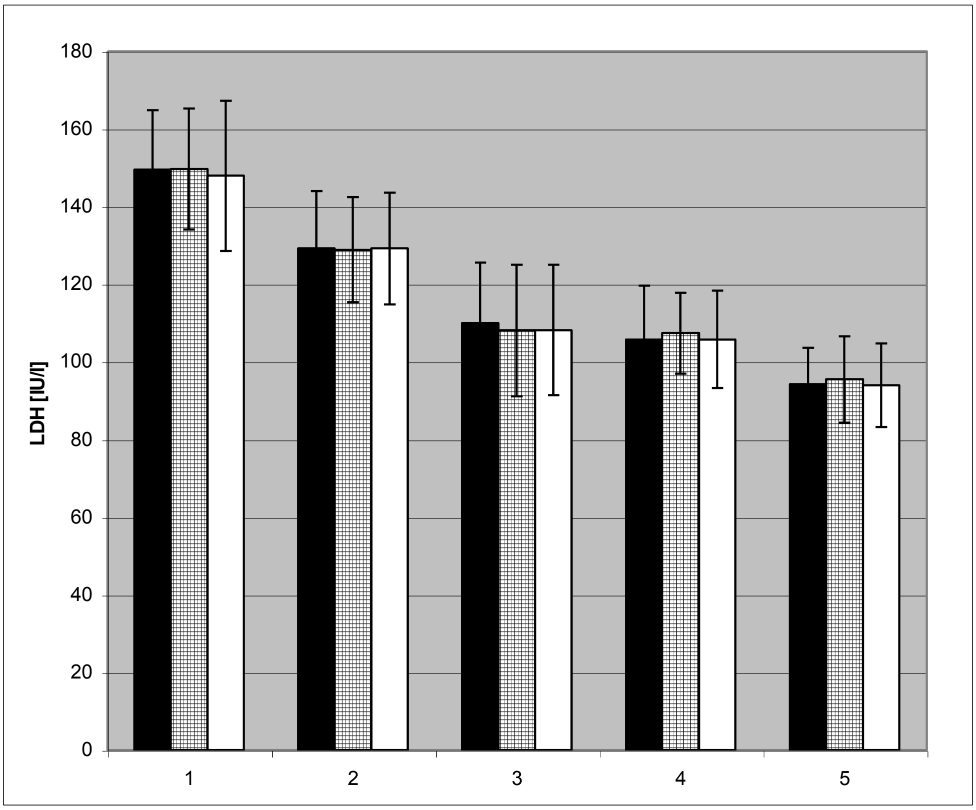

Fig. 2
Dynamics of LDH changes in footballers in 3 examination series: at the beginning (1), in the middle (2) and at the end (3) of the competition period
One week micro cycle days: 1-Monday, 2-Tuesday, 3-Wednesday, 4-Thursday, 5-Friday

Discussion

The competition period in football has its own specificity. All training and organising actions are subordinated to league contest. The trainer task is elaboration and realisation of training loads in week micro cycles as for players were prepared for competition optimally. Established in examined footballers training loads programme set up the general and special maintenance of athletes' condition in the technical-tactical and efficiency sphere (Table 1). This foundation was verified, especially as regards large exercises intensities, by the level of biochemical and haematological indices in blood measured in chosen micro cycles. It was assumed that with proper composition of training means in following micro cycle days values of measured indices should be approaching to the established normative qualities [18].

The usability of blood parameters (CK, LDH, RBC, HGB, HCT, WBC, AIAT and AspAT) measurements for after training effects control was widely discussed in references [2,3,4,8,10,18]. The researches considered most frequently individual disputes and singular studies on chosen athlete groups during training periods [8,10,11]. Papers discussing levels of mentioned above parameters in relation to training micro cycles controlled in constant manner are on the rare side [14,15]. In the accessible references any research describing football players especially with training micro cycles and applied loads consideration were found. It is connected with the organisational difficulties during competition and in professional teams in particular.

Sitkowski *et al.* [15], Hubher-Woźniak *et al.* [6], Lutosławska *et al.* [10] state that the CK and LDH level in blood serum after physical effort depends on its intensity and obtains the highest level after 18-24 h. Moreover, it can be determined by the effect of fatigue accumulation and the effort adaptation degree.

Gledhill *et al.* [3], Wochyński *et al.* [18] claim that the volume of some blood biochemical and haematological parameters may evaluate precisely the degree of athletes adaptation to effort or inform about the metabolic employment of respective organs during physical effort.

The CK value observed in football players after 36h of rest i.e. in Monday examination may be considered as high. Its concentration exceeded physiological norm thrice (III series of examinations; Table 2; Fig. 1). Worth mentioning are also large values of standard deflections in relation to the arithmetical average and low minimal CK values in examined athletes in every day of micro cycle. The latter amount regard random players although taking into consideration the playing position of footballers it was observed mostly in back players. Trainers during competition applied the “stop-watch” and “for-stop-watch” game tactics i.e. back players passive in the middle part of the defence field. Similar results attained Jastrzębski [8] in Junior Polish Football Representation after Sidney Olympics elimination in the year 2000 (CK 581.3±382.8 U/I). Interesting may be the fact that at the end of playing period athletes reached the highest CK values and they were significantly different from results in I and II examination series. It can be expected that such a result was the effect of growing fatigue during competition period. It is connected with the fact that in football teams, even in so called professional, the main part of a whole forms a group of 12-15 players. They are present in most of games in full playing time. The after effort fatigue processes are rarely compensated with the effective relaxation as a consequence, in the finishing part of the tournament symptoms of objective and subjective fatigue can be seen. The same phenomenon was observed in our research however, changes were not protracted. The micro cycles optimisation was the crucial element of training process not allowing such changes [7]. Hence, the every day CK analysis was one of the most important actions. This parameter presented diminishing tendency in respective micro cycle days and the lowest value was noted on Friday. Such dependencies confirmed itself trice in each micro cycle. Differences between CK averages were statistically significant what suggest large dynamics of resting after extreme playing effort. Therefore, gained results make rational the statement saying that planning and realisation of training loads during discussed training units were close to the optimal. Even higher values of CK gained in Fridays' examinations do not restrict the positive evaluation of realised training plan as they regarded most of all not practicing individuals (Table 3).

The LDH activity is also frequently used for the analysis of after effort fatigue processes. Many authors confirm the LDH and CK activity growth as a consequence of efforts with, dominating in football training, aerobic-anaerobic metabolic changes [1,6,7,10,13].

The similar in comparison to CK though not identical dynamics of LDH activity changes was noted in athletes participating in our research. LDH activity differences were particularly essential as regards the one week training micro cycle. It alludes very effective resting after extreme playing effort despite applied training loads. On the other hand, any statistically significant changes of LDH level were found in three examination series during the same week days. It may be assumed then that statistically crucial variations of CK level in examination series (regarding mostly after match values – Monday) could be accompanied by changes of the muscle tissue integrity what seems to be characteristic for football. Next, high effectiveness of the restitution, proved by statistically significant variations of CK and LDH activities during respective micro cycle days, may be the manifestation of not permanent fatigue modifications during all competition period (Table 3; Figs. 1 and 2).

An important element of physiological functions control in athletes are results of blood haematological indices and some enzymes characterising functions of internal organs engaged by physical effort (liver-ALAT, AspAT). They are the reflection of after effort and adaptive changes [2,3,4,11,18]. This indices dimensions observed in examined football players are within the physiological norms accepted in scientific references [2,3,9]. Nevertheless, worth mentioning are statistically significant changes of RBC, HGB and HCT during I and III as well as II and III examination series ($p<0.05$). In III examination series this parameters values were in some athletes higher than accepted physiological norms. Many authors claim that values of HCT over 50%, HGB 16-18g/dl and RBC 6.0ml/cm^3 are the effect of organism dehydration or using of erythropoietin for blood doping [2,3]. Higher than 50% hematocrit value was found in 5 examined subjects. It was probably the result of organism drainage after effort and high atmospheric temperatures during last series of examining. It is accepted that growth of HTC over 2% may lead to the total athletes efficiency drop for about 10%. The control of this parameter has therefore large application meaning what was used during the training work. Another important aspect of training is its individualisation. It consist of purposeful training tasks and detailed analysis of measured blood parameters in respective footballers. Physiological norms deviations were seen in maximal values of: haemoglobin 18.6 g/dl; AspAT 63.0 IU/I; hematocrit 54.5% (Table 2). It is frequently connected with the momentary indisposition of athlete elicited by mechanical injury (contusion), his/her negligence in the sphere of diet or training overwork (CK level over 1000 IU/I in few days measurement). Blood biochemical variables measurement is not an easy task especially in numerous sport teams. That is why the individual recording of signalised objective or subjective fatigue processes are conducted in each athlete.

Basing on presented results it can be assumed that blood biochemical parameters amounts are the reflection of training intensities applied in week micro cycle and are the highest after the football match. Moreover, the properly constructed plan of training loads allows the effective restitution what in consequence leads to the gradual diminish of CK and LDH in blood during following days of micro cycle.

References

1. Clarkson P.M., M.E.Dedrick (1988) Exercise-induced muscle damage, repair, and adaptation in old and young subjects. *Med.Sci.* 43:91-96

2. Ekblom B. (1996) Blood doping and erythropoietin. The effects of variation in hemoglobin concentration and other related factors on physical performance. *Am.J.Sports Med.* 24:40-42

3. Gledhill N., D.Warburton, V.Jamnik (1999) Hemoglobin, blood volume, cardiac function and aerobic power. *Can.J.Appl.Physiol.* 24:54-65

4. Hortobagyi T., T.Denahan (1989) Variability in creatine kinase: Methodological, exercise, and clinically related factors. *Int.J.Sports Med.* 10:69-80

5. Hübner-Woźniak E., W.Sendecki (1990) Plasma creatine kinase and MB isoenzyme following training in wrestlers. *Biol. Sport* 7:305-314

6. Hübner-Woźniak E, W.Sendecki, R.Świerad, D.Ćwikowski (1994) Zmiany aktywności kinazy kreatynowej w osoczu w treningu zapaśników. *Trening* 1:132-136

7. Hübner-Woźniak E., G.Lutosławska, W.Sendecki, A.Dentkowski, J.Drozd, T.Sawicka (1995) Changes in the activites of selected marker enzymes in plasma of recreational bodybilders. *Biol.Sport* 12:225-231

8. Jastrzębski Z. (2001) Serum creatine kinase (CK) activity in Polsh Olimpic Team football players, during a playing period: no relation to maximum power test. *Med. Sportowa* 12:14-16

9. Kaplan, L.A., A.J.Pesce (1989) Clinical Chemistry: Theory, Analysis and Correlation. C.V. Mosby Co., St.Louis, 921 pp.

10. Lutosławska G., W.Sendecki, I.Wojcieszak, J.Pośnik (1988) Effects of exercise on plasma creatine kinase and lactate dehydrogenase activity in women kayak paddlers. *Biol.Sport* l5:187-193

11. Lutosławska G., W.Sendecki (1990) Plasma creatine kinase MB and lactate dehydrogenase isoenzymes in response to ironman thriathlon competition. *Biol.Sport* 7:219-230

12. Lutosławska G., K.Buśko, E.Hübner-Woźniak, M.Kłosowski (1999) Wpływ treningu o dużej intensywności na stężenie kwasu moczowego i aktywność kinazy kreatynowej we krwi. *Wych.Fiz.Sport* 4: 24-28

13. Manfredi T.G., R.A.Fielding, K.P.O'Reilly, C.N.Meredith, H.Y.Lee, W.J.Ewans (1991) Plasma creatine kinase activity and exercise-induced muscle damage in older men. *Med.Sci.Sports Exerc.* 23:1028-103

14. Rodak Z., J.Pucsuk, S.Z.Boros, L.Josfai, A.W.Taylor (2000) Changes in urine 8-hydroxydeoxyguanosine levels of supermarathon runners during a four-day race period. *Life Sci.* 66:1763-1767

15. Sitkowski D., G.Lutosławska, J.Pośnik, M.Brzuchalski (1995) Relationship between plasma creatine kinase activity and aerobic performance indices in elite kayakers during a training microcycle preceding World Championships. *Biol.Sport* 12:3-13

16. Sozański H., D.Śledziewski D. (1995) Obciążenia treningowe: dokumentowanie i opracowywanie danch. RCMSzKFiS, Warszawa.

17. Stathis C.G., M.A.Febrraio, M.F.Carey, R.J.Snow (1994) Influense of sprint training on human skeletal muscle purine nucleotide matabolism. *J.Appl.Physiol.* 76:1802-1809

18. Wochyński Z., J.Majda., K.A.Sobiech (1998) Zmiany wskaźników biochemicznych i hematologicznych u lekkoatletów pod wpływem treningu wytrzymałościowo-szybkościowego. *Wych.Fiz.Sport* 3:39-47 (in Polish, English abstract)

Accepted for publication 5.07.2004