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Resting biochemical parameters throughout 12-day training period at mild altitude (2300 m)

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Summary

Introduction. The study was carried out to investigate changes in selected morning biochemical blood parameters in female judo players during their 12-day training camp at mild altitude, 2300m above sea level.

Material and methods. Elite female judo players (n=12) were studied on the selected days of altitude training period, which lased 12 days. The athletes lived and exercised on 2300m above sea level. That training was undertaken after 1-month detraining period. Plasma kreatine kinase (CK) glucose (G) and urea (U), and hematocrit (Hct) were assessed in the morning of the selected day of the training period. At the beginning (the 2nd 3rd and 4th day) females realised trainings of less intensity than that usually performed during retraining at see levels.

Results. After first night sleep at altitude, the levels of G, CK and U, and values of Htc were lower compared to those recorded on the next days. Significant correlations was found between G and CK on the first day of the camp (r=0.641*, n=12) as well as during the whole period consisted of 7 monitored days (0.587*, n=84). Body mass was correlated with basal plasma CK (the first day, r=0.940*, n=12) and on the whole period (r=0.911*, n=84). The decrease of blood volume during successive days manifested itself as the rise of Hct. During the whole period, G and U were less fluctuating variables than CK. That suggests lower substantial variation of metabolism but higher changes of muscle soreness.

Conclusions. Altitude training resulted in progressive dropped plasma volume and moderate fluctuations of measured variables.

Introduction

The partial pressure of atmospheric oxygen lowers itself with rising altitude. Oxygen deficit causes impairment of human physical ability even among well endurance-trained athletes. For instance, in elite marathon runners competing on 4000-5000 m above see levels their mean time of run on 42km compared to that at see level is longer by approximately 35%. [1]. In contrast to that, 2-fold lower altitude had minor impact (by 5%) on running time to exhaustion, but this parameter positively correlated with maximal oxygen uptake [2]. Over the last decade altitude training became very attractive, and it id scheduled as 2- or 3-week training camps located above 2000-2500m above sea level in mountains. In 1997 Levine B.D., and Stray-Gundersen J. formulated the advice for endurance-trained athletes, who want to improve their aerobic capacity. It sounds "living high-training low" (LHTL). The authors postulate to perform training sessions at somewhat lower altitude, but post training recovery and night sleep are recommended on higher altitude. That paradigm is based on the results of three various protocols study, where 3 groups of runners were undertaken 2-week trainings according to the schedules as follows: group A realised way: "living high (2500m)-training low (1250m), group B: "living high-training high" , group C "living low-training low". After that, only group A demonstrated significant improvement in running time (shorter by 13.4 sec compared to the baseline) on 5-kilometers run [3]. The later observations confirmed effects of LHTL strategy for improving of physical performance, especially endurance-trained athletes [4-9]. These advantages occur mainly due to increments of maximal oxygen uptake determined after return to sea levels resulting in favourable changes in haematological parameters. It is hard to establish whether mentioned beneficial effects are more contributed to living or training under hypoxic condition. Probably the both these factors are important, however, it was showed, that period of repeated training sessions in normobaric hypoxia at a simulated altitude (2750m) did not improve aerobic or anaerobic performance at normoxia [10]. Moreover, it is worth to note, that some athletes do not positively response to altitude [11], and altitude of 2650m may cause disturbance of nocturnal sleep among athletes of worse tolerance to hypoxia [12].

So far no studies were reported regarding effects altitude training in strength-velocity trained athletes, for instant, in combat sport performers. The highest level of aerobic capacity seems not very important in that sport events, nevertheless, after 1-month detraining period, first retraining period is oriented on improving endurance, and later on specific psycho-motor skills, as well as on strength and velocity. For that reason the question whether altitude training may be favourable or risky for combat sport athletes is to be determined, for environmental condition for trainings in various sports disciplines are distinguished. One may expect, that inadequate ambient condition, like temperature, humidity, oxygen content in atmosphere may incise risk of detrimental effects on performance and lead to development of underperformance syndrome, similarly as heavy trainings with inadequate recovery impairs psycho-motor skills, as was observed in judo players [13]. Hence, coaches have to monitor physiological and biochemical responses to altitude training. This study aimed to examine reaction of selected morning blood parameters (capillary blood glucose, creatine kinase and urea, considered as useful indices of training adaptation to altitude training among female judoists.

Material and methods

The group (n=12) of elite lowlanders female judo players aged 24±2.1 years and body mass, 48-135 kg, who were not earlier exposed to altitude, undertook altitude training after 1-month detraining period (on January). The athletes arrived from sea level on the training camp located on 2300 m above see levels and housed together for 12 days, where they lived and trained. After 32h initial acclimatisation (Day 1) females started their training on the 2nd day in the afternoon (16:00pm). During the camp training activity was of slightly graded, loads were increased, but intensity remained low. The first capillary blood samples were taken in the morning after the first night rest at altitude and it was considered as a basal state. Next morning samples were obtained on 3rd , 4th , 6th 7th 9th and 12th day of the camp. Plasma glucose (G), urea (U), creatine kinase activity (CK) and hematocrit (Hct) were determined immediately after sampling with using commercial kits (DR LANGE, GERMANY). Since CK showed lack of normal distribution, log-transformed data were used for statistical calculation. The differences between days and subjects were analysed by two-way ANOVA (day x subject), followed by post hoc analysis with using Newman-Keulus test.

The protocol of this research was approval by Ethical Commission at Institute of Sport.

Results

The results of analysed parameters and differences between their means recorded on the days of the training period are presented in Table1.

The all measures showed significant changes on examined days, however the relative magnitudes of those fluctuations were vary with respect to the variable. CK demonstrated the highest variation throughout training period. Its mean activity reached high value on the 3rd , i.e after two training sessions performed on the 2nd day. Later CK activity dropped markedly from higher values recorded on 6th day to lower (but not baseline) on the second part of training period. It is worth to noting, that 3rd day of the camp was characterised by significant lower blood volume, and that status was maintaining over the whole period, despite drinking water or other beverages were available ad libitum. At the end of the period (on 9th and 12th day) urea demonstrated somewhat higher levels compared to those on the earlier days. Linear significant ($p<0.05$) correlations were found between G and log CK, on the first day of the camp (r=0.641*, n=12), as well as during the whole period consisted of 7 monitored days (0.587*, n=84). Moreover, baseline log CK was correlated with baseline U (r=0.610*). Body mass correlated with baseline G (r=661*), baseline U (r=0.630*, and baseline log CK (r=0.940) as well as with all (n=84) log CK (r=0.911*). Between-day relative variations of parameters expressed as

Tab. 1. The mean values of resting blood parameters, G, CK, U, Hct and relative plasma volume (PV) on the selected days of training period at mild altitude (2300 m above sea level) in female judoists (n=12)

Prameters	Day 1	Day 3	Day 4	Day 6	Day 7	Day 9	Day 12	Between D differences
G (mmol/L)	**3.6±0.4**	**4.4±0.4**	**4.3±0.3**	**4.4±0.3**	**4.5±0.3**	**4.4±0.4**	**4.0±0.3**	
Differ from	3-12	1,12	1	1,12	1,12	1,12	1,3,6,7,9	significant
CK (U/L)	**40±20**	**168±168**	**125±129**	**186±174**	**177±117**	**96±46**	**69±34**	
Differ from	3-9	1	1	1	1,12	1	7	significant
U (mmol/L)	**4.6±0.4**	**4.5±0.4**	**4.3±0.8**	**4.4±0.4**	**4.7±0.4**	**5.1±0.5**	**5.6±0.9**	
Differ from	12	12	12	12	12	-	1,3,4,7	significant
Hct (%)	**42.1±3.2**		**47.3±5.8**	**47.2±4.3**			**48.7±6.0**	
Differ from	4,6,12	-	1	1	-	-	1	significant

coefficient of variation (CV%) was the highest for CK and amounted 46.3%, while CV% for G and U were markedly lower, 7.1% and 7.5% respectively. Summarising, all blood parameters fluctuated significantly throughout training period. Mean CK values on recorded successive days were only somewhat related to training loads in a previous days. The magnitude of mean CK increment following first light training session performed on D2 was inadequately huge, that was not observed earlier on sea level.

Analysis of variance revealed also between-subject differences regarding mean individual parameters. That analysis of between-subject variability for CK, G and U are presented in Table 2.

Mean individual CK values demonstrated huge between subject-variation. The higher means CK were found in athletes of heavy weight categories (+72 kg). Within-subject variability may be expressed as coefficient of variation (CV%) calculated according to the following formula CV% = (SD/Mean) x 100%.

Within-subject variability of CK was also very high since an individual mean is often comparable with its SD. Its CV% ranged from 26.9% in subject K to 60.5% in subject G. Lesser within-subject variability were found for glucose (CV% from 7.1 in subject J to 12.1% in subject C. In contrast to glucose on creatine kinase urea showed no significant differences between subjects, and marked within-subject variation (CV% from 6.3% in subject K to 41.9 %) in subject E. At the first glance, subject K demonstrated the lowest variation of all determined blood parameters over the whole period. Between-subject variability calculated from individual mean CK values and expressed as CV% amounted 76.4%. Obviously, that value is higher than the highest within-subject one recorded in subject G.

Discussion

The main finding of our study is that blood parameters were very useful for monitoring biological responses to altitude training. We assumed that markedly dropped glucose, elevated creatine kinase and urea show temporary worse overnight recovery from training underwent a day before. Lowered (below 3.5 mmol/L) blood glucose indicates disturbances in regulatory processes being under control of selected hormones (cortisol, growth hormone, glucagons, adrenaline and insulin). No such case was observed over the period. Elevated resting urea may suggest increased muscle protein breakdown (proteolysis). That occurs during recovery following very exhausting, long lasting exertion, like triathlon competition [14], single intensive interval anaerobic training [15], during 2-week exhausting endurance training period [16], after single soccer match [17] and ultra marathon cycling [18]. Elevated urea over baseline value indicated imbalance in homeostasis of protein turnover, it means increased rate oh catabolic process. Surprisingly, in our study that state appeared at the and of training camp (12th Day), when CK activity, marker of induced by exertion muscle soreness was normalised. The reason for that is unknown. We may speculate, that for such phenomenon may be responsible hormonal system, which maintains anabolic-catabolic equilibrium, or something was wrong with renal function.

As to CK behaviour, its individual responses to the first training session (on Day2) of very low intensity were unexpected. Majority of examined subjects did not earlier demonstrate such CK rises in response to retraining on normoxia. We may suspect, that at mild altitude the rise of CK is affected not only by exertion, but also by hypoxia. Our suggestion is support by authors, who reported initial increase in CK activity in triathlon athletes exposed (without training activity) on mild hypoxia (1860m) over 36h after arriving to the altitude camp [19]. Our study on differences between-subject mean CK values indicated so-called various individual patterns. Each individual CK pattern is manifests itself as a typical mean higher or lower CK recoded on numerous repeated investigations. Likewise other authors reported higher between- than within-subject variability of CK activity in blood as result of genetic factor regulating that parameter at rest and its response to exertion [20-22].

The observed elevated Hct on Day 4, by 12.4% as compared to initial on Day1, may be resulted in reduced plasma volume (dehydration ?) as well as stimulatory effect of hypoxia on increased creation of red blood cells. However, it is impossible to distinguish the contributions of these two factors without additional measures.

Tab. 2. Twelve individual Mean ± SD plasma values of CK, G and U obtained from 7 measures (Days)

Subjects	CK (U/L)	Differ from others	G (mmol/L)	Differ from others	U (mmol/L)	Differ from others
A (48kg)	36±11	E,G,H,I,L	4.1±0.3	-	4.7±0.8	-
B (54kg)	85±45	G	4.3±0.5	-	4.5±0.9	-
C (59kg)	100±52	G	4.1±0.5	G	4.7±0.9	-
D (61kg)	49±17	E,G,H	4.3±04	-	4.4±0.5	-
E (66kg)	191±107	A,D,K,G	4.3±0.4	-	4.3±1.8	-
F (72kg)	100±58	G	4.2±0.3	G	4.7±0.2	-
G (135kg)	385±233	(A-L),G	4.8±0.4	K,L,C,F	5.8±0.8	-
H (90kg)	165±112	A,L,G	4.2±0.5	-	4.7±0.5	-
I (66kg)	122±73	A,G,H	4.2±0.4	-	5.2±1.2	-
J (74kg)	94±41	G,	4.2±0.3	-	4.3±0.8	-
K (62kg)	52±14	E,G,H	3.9±0.4	G	4.8±0.3	-
L (52kg)	97±39	A,G	4.1±0.3	G	4.6±0.8	-

Conclusion

1. Determination of morning blood glucose, urea and creatine kinase appeared to be useful tool for altitude training monitoring.
2. Since "living high-training low" may induced temporary higher changes in blood chemistry, and may be bigger challenge than training on the sea level, addition studies on the other physiological indices merit further investigations.

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