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EFFECT OF TRAINING ON BLOOD LACTATE RESPONSES TO SIMULATED 500 M AND 2000 M ROWING IN SCHOOLBOY ROWERS

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Abstract

Introduction. Elite rowers are characterized by high post-exercise blood lactate in response to both simulating and competitive 2000 m distance. However, data concerning training response of blood lactate levels in schoolboy rowers are not available.

Aim of the study. This study was aimed at evaluation of post-exercise blood lactate in adolescent rowers following 500 m and 2000 m distance in two periods of year a training cycle – in March and in June.

Methods. A total of 6 schoolboy rowers volunteered to participate in the study after receiving parental consent. All the subjects performed 500 m and 2000 m all out simulated rowing using the Concept II ergometer (Concept, Vermont, USA). Peak and mean power output, and maximal heart rate were registered during both tests. Lactate was measured colorimetrically in capillary blood immediately after exercise and 3, 5 and 7 min after exercise using Dr Lange commercial kits.

Results. Maximal heart rate, maximal and mean power output did not differ in March and June. In June blood lactate levels following both 500 m and 2000 m distances did not differ in comparison with March. In contrast, total lactate (expressed as sum of lactate levels) and peak blood lactate levels following 500 m and 2000 m distances were markedly lower in June than in March.

Conclusion. Training performed between March and June did not affect power output during simulated 500 m and 2000 m rowing, however depressed blood lactate accumulation. Thus, similar mechanical work was achieved with less metabolic stress.

Key words: schoolboy rowers, blood lactate, simulated rowing

Introduction

Rowing is a strength-endurance sport and competition performance depends on both aerobic and anaerobic power, physical power as well as rowing technique and tactics (1). Elite rowers are characterized by extraordinary high maximal oxygen uptake, pulmonary ventilation, very high percentage of slow twitch fibers both in the upper and lower body and low maximal lactate steady state (MLSS) indicating the importance of aerobic capacity in successful rowing (2-6). On the other hand, there is increasing evidence suggesting that anaerobic capacity may be critical for rowing performance (7-9).

A wealth of studies have focused on rowing technique, anthropometric, physiological and biochemical attributes of highly skilled junior and senior rowers (10-14). Numerous studies addressed training effects on physiological and biochemical variables as well as psychological traits in elite rowers (15-17).

However, according to our best knowledge data concerning either physiological or biochemical responses to sport-specific effort in adolescent rowers, starting regular training are fragmentary.

In younger junior rowers of both sexes aged approximately 17 years four months of training resulted in significant increase in absolute mean power output during simulated 2000 m rowing, however it was mostly due to the elevation in body mass (18). In addition, in male rowers the time of the distance after training was markedly shorter than before training.

In schoolboy rowers aged 14.5 years who trained 4-5 days a week plasma CK activity was elevated above the physiological limits suggesting training-induced muscle damage (19).

Russell et al. (20) have demonstrated that in adolescent rowers 2000 m performance was best predicted by body mass, maximal oxygen uptake and knee extension. On the other hand Ebert et al. (21) have noted that in schoolboy rowers aged approximately 17 years an improvement of 2000 m performance in response to 8 weeks training was achieved despite a decrease in maximal oxygen uptake.

The elevation in blood lactate in response to rowing is greater than after, for example running, however, it depends on the motivation of the oarsmen and is higher after international than after national regattas (4). Nielsen (22) has demonstrated that in top class rowers, winners of Olympic games, blood lactate levels in response to simulated 2000 m rowing equaled 26.2 $mmol \cdot l^{-1}$ and this value has to be recognized as the

highest observed in the sportsmen. Klusiewicz (23) has indicated that blood lactate levels in response to 2000 m laboratory rowing is similar in junior and senior rowers and does not exceed 15 mmol·l^{-1}. Additionally, in high performance senior rowers a better rowing performance on a rowing ergometer is associated with improved lactate exchange and removal (24). Moreover, the ability to row at high relative work rates is correlated with an increased lactate removal ability.

There is no data concerning the effect of training on blood lactate levels in response to all out rowing exercise in schoolboy rowers. Thus, this study was undertaken to evaluate blood lactate response to 500 m and 2000 m simulated rowing in two periods of a year-long training cycle – during specialistic training in March and again after four months of training – in June i.e. during the competitive period.

Materials and methods

Subjects

A total of 6 schoolboy rowers volunteered to participate in the study. The study protocol was approved by their parents. All the subjects were healthy and according to a physician's opinion were able to participate in regular sport training. Training schedule of the participants during 3 months preceding first testing (between January and March) and during 3 months preceding second testing (between March and June) is depicted in Table 1and 2.

Table 1. *Training volume (hours) of schoolboy rowers*

	January-March	March-June
Running	47.7	11.8
Swimming	15.1	–
Gymnastics	3.5	4.0
Games	4.3	6.2
Strength training	24.1	11.3
Ergometer rowing	19.7	4.7
Pool rowing	10.4	5.2
On-water rowing	–	81.4
Total volume	124.8	124.6

Table 2. *Training intensity in two periods of training cycle*

HR (bpm)	January-March	March-June
130-140	40*	65
160-180	24	12
> 180	20	11
> 190	14	10
Interval training	2	2

*percent of total training volume

Exercise protocol

All the participants underwent simulated 500 m and 2000 m all out rowing exercise using Concept II ergometer and damper setting 4-5 (Concept, Vermont, USA) The tests were performed twice – in March and in June, one day apart with 500 m rowing preceding the 2000 m distance. Heart rate during the tests was registered using Polar Sport Tester (Finland). The readings of peak and mean power output and time of the distance were taken from the registration system of the ergometer.

Lactate determination

Blood for the lactate assay was taken from the earlobe into heparinized 10 µl capillaries immediatedly after exercise and 3, 5 and 7 min after exercise ceased. Lactate was determined colorimetrically using commercial kits (Dr Lange, Germany) and LP 400 photometer. Coefficients of variation (CV) of blood lactate determination did not exceed 5%.

Statistical analysis

Data distribution was evaluated using the Shapiro-Wilk test. Two-way ANOVA for repeated measures and post-hoc Tukey test were used for data comparison. Significance was set at $P<0.05$. All calculations were performed using Statistica v.7 (StatSoft, USA). Data are presented as the mean ± SD.

Results

Subject characteristics are depicted in Table 3. Mean and maximal power output as well as time of the distance and maximal heart rate in response to 500 m and 2000 m all out rowing in two periods of a year training cycle are shown in Table 4 and 5. None of the variables significantly differed in March and June.

Table 3. *Physical characteristics of the subjects (mean ± SD)*

	March (n=6)	June (n=6)
Age (yrs)	16.5 ± 0.3	16.8 ± 0.3
Body mass (kg)	90.2 ± 4.2	89.4 ± 6.0
Body height (cm)	191.4 ± 4.2	191.5 ± 4.3
Training experience (years)	1.50	1.75

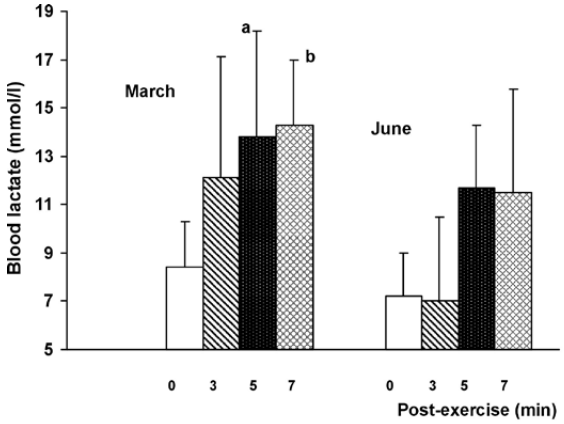
Table 4. *Maximal and mean power output, maximal heart rate and time of the distance during simulated 500 m rowing in schoolboy rowers (mean ± SD)*

	March (n=6)	June (n=6)
Maximal power (W)	589.0 ± 52.9	609.3 ± 69.7
Mean power (W)	524.3 ± 41.8	526.5 ± 42.2
Time (s)	87.5 ± 2.3	87.4 ± 2.4
HR_{max}	182.5 ± 9.7	186.5 ± 3.7

Table 5. *Maximal and mean power output, maximal heart rate and time of the distance during simulated 2000 m rowing in schoolboy rowers (mean ± SD)*

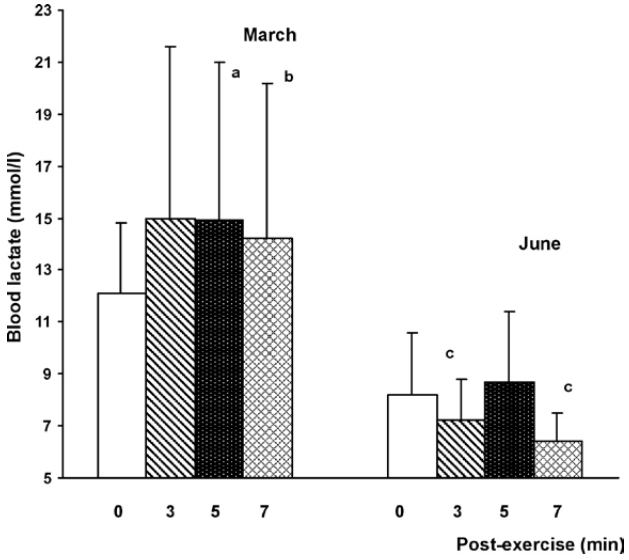
	March (n=6)	June (n=6)
Maximal power (W)	396.0 ± 41.6	397.0 ± 44.2
Mean power (W)	358.2 ± 33.7	352.2 ± 37.7
Time (s)	397.6 ± 12.9	410.0 ± 22.8
HR_{max}	194.0 ± 7.6	195.3 ± 6.7

Blood lactate levels 5 and 7 min after 500 rowing in March were significantly higher than that determined immediately after exercise (P<0.04 and P<0.02, respectively) (Fig.1)). In June blood lactate levels following 500 m rowing were similar at all time points after exercise ceased. Furthermore, post-exercise blood lactate concentrations did not differ in March and June.



[a] significantly higher vs. level immediately after exercise (P<0.04);
[b] significantly higher vs. cessation of exercise (P<0.02)

Fig. 1. *Post-exercise blood lactate levels in response to 500 simulated rowing during two periods of the training cycle (mean ± SD)*



[a] significantly higher vs. completion of exercise (P<).04);
[b] significantly higher vs. completion of exercise (P<0.02);
[c] significantly lower vs. March (P<0.02)

Fig. 2. *Post-exercise blood lactate concentrations in response to simulated 2000 m distance during two periods of the training cycle (mean ± SD)*

In March blood lactate levels 5 and 7 min after 2000 m exercise were significantly higher than those determined immediately after exercise (p<0.04 and p<0.02, respectively) (Fig. 2). On the contrary, in June post-exercise blood lactate was similar at all time points. However, in June blood lactate concentrations 3 and 7 min after exercise were significantly lower than at the same post-exercise time in March (p<0.02).

Total blood lactate expressed as overall sum of lactate (0-7 min) after 500 m distance in June was significantly (P<0.03) lower than in March. Peak blood lactate in June tended to be lower than in March (P<0.06) (Table 6).

Table 6. *Total and peak post-exercise blood lactate concentrations in response to 500 m and 2000 m simulated rowing in schoolboy rowersduring two periods of training cycle (mean ± SD)*

Distance (m)	Blood lactate ($mmol \cdot l^{-1}$)			
	Σ La		Peak La	
	March	June	March	June
500 m	48.6 ± 11.4	37.4 ± 7.9[a]	15.6 ± 3.3	12.7 ± 2.4[b]
2000 m	56.2 ± 19.2	30.6 ± 3.4[a]	17.1 ± 5.0	9.6 ± 2.1[c]

[a] - significantly lower vs. March (P<0.03);
[b] - lower than in March 0 (P<0.06);
[c] - significantly lower vs. March after 500 m distance and vs. June after 500 m distance (P<0.04);

Total post-exercise blood lactate following 2000 m distance in June was significantly lower than in March (P<0.03). Peak blood lactate levels in June wer markedly lower than in March (P<0.04). In addition, in June peak blood lactate in response to 2000 m all out rowing was significantly lower than after 500 m distance (P<0.04).

Discussion

Post-exercise blood lactate concentrations reflect lactate production in the working fast-twitch fibers as well as from its oxidation in non-working slow twitch fibers, working fast-twitch muscle, and gluconeogenesis in the liver and kidneys (25, 26).

Additionally, it is well documented that lactate efflux from the muscle into the bloodstream is not only passive diffusion, but is, at least partially dependent on specific membrane-bound monocarboxylate transporters (MCT) (27, 28).

Thus, the interpretation of the changes in blood lactate concentrations in response to a single exercise and/or to training have to take into consideration complicated mechanism regulating its production, oxidation and efflux.

Despite all these shortcomings blood lactate determination in response to exercise is an important tool in the evaluation of training effects in sport practice.

The elevation in blood lactate concentrations following a single all out exercise bout in sport is recognized as a good measure of anaerobic glycolysis contribution to energy metabolism and tolerance of the muscle to the pH decrease (29). On the other hand, blood lactate response to incremental exercise and maximal lactate steady state (MLSS) are used in assessing lactate threshold or anaerobic threshold and adaptation to prolonged muscular work (30-32).

In the present study four months of training did not affect post-exercise blood lactate levels in response to 500 m simulated rowing. However, the lack of the differences was mostly due to high individual variability in post-exercise blood lactate concentrations in our subjects, much higher then that found by Klusiewicz (23) in junior and senior rowers.

The reason for high variability in blood lactate concentrations in our subjects remains unclear, but two factors have to be recognized as a potential reasons - short training experience of schoolboys rowers and/or genetic background determining low, medium or high response to training (33).

However, when the sum of post-exercise blood lactate was calculated (total lactate levels) it became clear that overall blood lactate in response to 500 m distance was markedly (by 23.1%) lower in June than in March. Similarly, peak blood lactate concentrations in June was significantly (by 18,6%) lower than in March.

Taking into account that time of the 500 distance, peak and mean power output was similar in March and June, but blood lactate level was lower in June than in March, it could be postulated that metabolic stress in June was much less then in March possibly due to increasing contribution of on-water low-intensity rowing training. Thus, it seems feasible that subjects' aerobic capacity was improved leading to either less lactate production and/or more efficient oxidation (34, 35).

According to Garland (36) a 500 m distance during both simulated 2000 m rowing and regatta is covered with highest speed relative to the mean speed developed during all distance.

Our study revealed that four months of training of schoolboy rowers brought about favorable metabolic changes during this distance. Assuming that lactate-induced pH decrease may contribute to muscle fatigue, less overall lactate possibly increases subjects' potential to cover faster the competitive distance of 2000 m (37).

Training-induced changes in blood lactate response were even more evident during simulated 2000 m rowing. Post-exercise blood lactate levels in June were significantly lower than in March, at least 3 and 7 min after exercise ceased. In addition, the sum of lactate levels in June was lower by 45.6% and peak blood lactate lower by 43.9% in June in comparison with March.

Neither time of the distance nor mean and peak power output during 2000 m distance differ in March and June. Thus, our subjects were able to cover the distance with much less lactate-induced metabolic disturbances as e.g. blood pH decrease (38).

Furthermore, taking into account the race profile of simulated rowing and significant increase in rowing speed from approximately 1600 m to the finish (39), relatively low blood lactate at the end of the distance in June may suggest that our subjects were able to increase the speed, however it does not result in increased blood lactate accumulation either due to lower lactate production or to improved clearance (elimination and/or oxidation) (40, 41).

This assumption is in agreement with other data indicating excellent aerobic capacity in rowers and capability to develop high power output at low lactate levels (42,43) and strengthened by findings indicating greater contribution of aerobic energy system during short-term events than traditionally thought (44, 45).

In addition, it is worthy to note that the mean power output during the 2000 m distance and time of the distance in our subjects were similar to that reported for successful junior rowers with longer training experience (approximately 3 years) than our subjects (less than 2 years) (46). Peak post-exercise blood lactate following 2000 m distance in our subjects in March was by 24.8% higher than in junior rowers, but in June – by 30% lower than in successful junior rowers. However, data comparison has to be made with caution, since in the cited study (46) there is no information concerning training period in which junior rowers were tested. On the other hand, our subjects covered 2000 m distance in shorter time (by 16.3 s) than university and club rowers aged 25 years tested by Kennedy and Bell (39). The above data indicates that the participants of the present study represented a high sport level.

Summing up, four months of training in schoolboy rowers did not affect time of 500 m and 2000 m distances and mean and peak power output developed during both efforts. However, it brought about significant changes in blood lactate responses to both distances reflected by lower post-exercise peak and total lactate levels. Thus, during competitive period in June our subjects performed either 500 m or 2000 m simulated rowing with much less metabolic disturbances than in March.

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A – Study Design
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C – Statistical Analysis
D – Data Interpretation
E – Manuscript Preparation
F – Literature Search
G – Funds Collection