Original Paper DOI: 10.5604/20831862.1019886 Biol. Sport 2012;29:297-301

THE EFFECT OF A 6-WEEK INDIVIDUAL ANAEROBIC THRESHOLD BASED PROGRAMME IN A TRADITIONAL ROWING CREW

Accepted for publication 27.05.2012

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ABSTRACT: The purpose of the present study was to analyse a 6-week IAT (individual anaerobic threshold) based work load programme in a subelite rowing crew. 15 male rowers performed a 6-week IAT based work load distributed in 2, 2, 3, 3, 3, 2 sessions per week. To assess each rower's IAT training zone, the Stegmann method (22) was used. This training programme was framed in the 6-week precompetitive mesocycle (specific training period). Before and after this training programme the crew was tested in order to analyse the effects of the IAT stimuli programme. These tests were conducted at a starting work load of 100 W and increased by 40 W every 2 min until volitional exhaution. An improvement was found in cardiovascular efficiency and blood lactate concentration ([LA]) buffering capacity during all the work loads in the post-IAT training programme test (100, 140, 180, 220 and 260 W) ($p<0.05$). After 3 min recovery, significant differences were not observed in [LA] (NS). We conclude that the proposed training programme improves cardiovascular efficiency and [LA] buffering capacities but not the short-term recovery in a subelite traditional rowing crew.

KEY WORDS: rowing, training, heart rate, lactate threshold, individual anaerobic threshold

INTRODUCTION

Traditional rowing on a fixed seat is mainly characterised by the number of the crew (13 oarsmen + 1 cox) and singular biomechanics. The rower is seated and leans on the boat in two spots: the ischial region and feet soles. Due to this peculiarity the lower limbs play an important role in the first phase of paddling, making an isometric contraction, whereas the upper limbs, especially the arms, have dynamic activity during the whole cycle. These types of boats usually take part in races with an average duration of 20 min (3 nautical miles), usually at sea. The length of competition is framed in what is called the long endurance strength I disciplines, between 10 and 30 min. Some other characteristics of traditional rowing races are the total number of strokes, the mean time, velocity of the boat, and mean force and power per stroke [12].

During a modern rowing competition, anaerobic alactic, lactic as well as aerobic capacities are stressed to their maximum [9]. Therefore, the training of successful rowers has to be built up with a focus on aerobic training with the proper relationship of strength training and anaerobic training [23]. Intense endurance training above the anaerobic threshold may be important for improvement of $\dot{V}O_2$max during the competitive season, but should not amount to >10% of the training volume [15]. Rowers are adapted to this effort by a large muscle mass and high metabolic capacities [23]. Physiological parameters such as oxygen uptake and blood lactate concentration ([LA]) seem to be the best predictors of individual anaerobic threshold (IAT) and performance in modern rowing for decades [6,11] but we have not found intervention-based studies for traditional rowing.

It is generally accepted that [LA] threshold identified during incremental exercise or during prolonged exercise at constant workload (maximal lactate steady state or MLSS), is a valid index of endurance capability [8]. Based on this concept, the anaerobic threshold (AT) serves as a predictor in determination of work load that can be performed by oxidative metabolism [21,26]. The AT, also termed the 4.0 $mmol \cdot l^{-1}$ threshold (AT4), and IAT as suggested by Stegmann et al. [22] appear to be the concepts of AT most commonly used in rowing ergometry [25]. IAT is defined by the following equation by Stegmann et al. [22].

$$\left|\frac{dn(t)}{dt}\right| = Em = Mc \cdot \Delta C_{Em}$$

where t = tEm (point of time during exercise with stepwise increasing work loads describing the IAT), dn(t)/dt = rate of diffusion in $mmol \cdot l^{-1} \cdot min^{-1}$, Em = maximal rate of elimination in $mmol \cdot l^{-1} \cdot min^{-1}$, Mc = membrane constant in min^{-1} and ΔC_{Em} = lactate gradient at the IAT in $mmol \cdot l^{-1}$.

This equation defines the point of time and work load where the maximal rate of elimination is in equilibrium with the rate of diffusion and was used to set up the training zone for each rower.

The aim of the present study was to evaluate the effects of 6 weeks of IAT based work load ergometry training on rowing performance in a group of subelite traditional rowers.

MATERIALS AND METHODS

Subjects. 15 male (mean ± S.D. aged 25.8 ± 4.3 years; weight, 80.7 ± 11.5 kg; body fat, 15.3 ± 4.7) (See Table 1.), subelite rowers of the Spanish National Rowing Championship 2nd Division were voluntarily tested before and after IAT-based work load intervention. Apart from these 15 participants, 4 rowers were previously excluded due to injuries. Participants signed an informed consent form conformed conforming to the standards set by the Declaration of Helsinki (2008) and the Data Protection Law of Spain (LOPD, 15/1999). This study was approved by the Ethical Committee of Zierbena Rowing Club.

Intervention

6-week IAT- based training programme was performed by participants. IAT zone was set according to Stegmann et al. [22] procedures distributing the training sessions as follows:

TABLE 1. CHARACTERISTICS OF THE PARTICIPANTS

N	Before		After	
15	BM	BF	BM	BF
1	65.0	7.2	65.0	6.9
2	70.8	15.6	70.7	16
3	78.3	15.4	78.5	13.8
4	76.5	7.1	76.2	6.8
5	73.5	17.0	71.5	14.5
6	69.5	11.9	70.1	12.6
7	106.7	23.9	102.1	22.7
8	84.6	17.2	84.0	16.4
9	74.9	16.9	74.0	16.3
10	91.5	14.3	92.5	15.6
11	88.4	22.5	85.3	19.2
12	66.6	11.1	65.8	7.5
13	87.5	15.7	86.3	14.5
14	84.8	16.8	83.5	15.5
15	92.2	17.1	90.0	15.0
Mean ± SD	80.7 ± 11.5	15.3 ± 4.7	79.7 ± 10.6	14.2 ± 4.4

Note: N: Subject. BM: body mass (Kg), BF%: body fat mass (%)

Before each IAT training session each rower performed a standardized warm-up protocol, consisting of 7 min of self-paced rowing exercise. Resting periods between IAT sessions were at least 48 hr. This alternation of easy and hard training days is consistent with cross training principles of rowing training [24]. This intervention was framed in the 6-week precompetitive mesocycle (specific training period) where the development of the optimum expression of all skills and fitness peak are sought [10]. This type of periodisation of training has also been used by modern rowing coaches in world class oarsmen [17].

TABLE 2. IAT WORK LOAD DISTRIBUTION DURING THE 6 WEEKS OF INTERVENTION

WEEK	IAT TRAINING SESSIONS PER WEEK	WORK LOAD LENGTH AT IAT (MIN)
1	2 (Tuesday and Thursday)	20´
2	2 (Tuesday and Thursday)	20´
3	3 (Tuesday, Thursday and Saturday)	30´
4	3 (Tuesday, Thursday and Saturday)	30´
5	3 (Tuesday, Thursday and Saturday)	30´
6	2 (Tuesday and Thursday)	20´

Test procedure

Continuous progressive stagered loads until volitional exhaustion tests were performed under laboratory standards [2]. The initial work load was 100 W and was increased by 40 W every 2 min until volitional extenuation. After each work stage the test was interrupted for 30 s for blood sampling. HR was monitored during the test and for 3 min after exercise. All measurements were conducted on a Concept 2 Ergometer (Morrisville, Vermont, USA) adapting,a non-moving seat called a “bancada”. This was designed to neutralise their leg hyperextension in order to reproduce as exactly as possible the biomechanics of traditional rowing.

Blood lactate concentration [LA]

Capillary blood samples (20 µl) were taken from the hyperaemic ear lobe at the beginning, during the 30 sec breaks between the work stages (every 2 min) and 3 min after testing. [LA] was analysed by the enzymatic method with the YSI 1500 lactate analyser (Sport Yellow Springs Instrument, OH, USA).

Heart rate

Heart rate was measured by a Polar Team Advantage Monitor (beat-to-beat system) during the whole test and until 3 min after finish it (Polar Electro OY, Kempele, Finland).

Statistical analysis

Wilcoxon and Friedman tests were used to determine intra individual mean differences. The differences in moment of intervention (before vs after) for each rower were assessed by Student's two-tailed t-test (for paired samples). The results for continuous variables are given as means ± SD. Data analyses were performed with the SPSS 17.0 statistical software (SPSS, Chicago, Il, USA). P values < 0.05 were considered to be statistically significant.

RESULTS

HR values were found to be lower after the IAT training programme (see Table 3). In the first stage the cardiovascular response is lower compared with following ones, with a slight but significant difference at a work load of 100 W (128 ± 8 vs 121 ± 11 bpm). As workload increased, the differences between means reached the highest peaks with the highest at a work load of 260 W (187 ± 8 vs 182 ± 11 bpm) ($p<0.0001$) at maximal exercise. After 3 minutes of recovery, the HR also decreased, showing a significant change (109 ± 8 vs 102 ± 10 bpm).

[LA] follows the same pattern as HR does. After the IAT training programme, this parameter's values were found to be lower, showing significant differences in all the stages of the test except after 3 minutes of recovery. There was no significant difference between [LA] before vs after the training programme after 3 minutes of recovery (see Fig. 2).

DISCUSSION

The objective of the present study was to evaluate the utility of the IAT-based work load programme in a traditional rowing crew. We speculated that after training for 6 weeks in this working zone, metabolic response as well as cardiovascular response could be improved and subsequently be advantageous in order to face the competition cycle in the best condition possible. The goal was to test directly the hypothesis that this steady state of [LA] for each rower, per se, was a key factor in eliciting a training response. Therefore comparisons were made before vs after the IAT-based training programme for 6 weeks. The results showed that the performed training programme is an effective training stimulus. At work loads of 140 W, the differences between before and after intervention tests on HR were significant (145 ± 9 vs 138 ± 9 bpm), suggesting that an improvement in HR economy was obtained. However, HR economy was not found to be an important predictor of rowing success in other studies [5]. In the second stage of the test, the change could be explained by the cardiovascular adaptation to the training programme showing this improvement on resting HR and light exercise intensities <75% of the $\dot{V}O_2max$ [4]. Another change occurred at maximal exercise just before exhaustion, (187 ± 8 vs 182 ± 11 bpm). This is consistent with previous studies where the athletes improved their $\dot{V}O_2max$ capacity following IAT-based programmes [16]. This improvement can also be related to cardiac adaptation in the oarsmen population. In rowers, internal diameters of the heart enlarge and the highest values for left ventricle end-diastolic diameter are 65 mm, while the ventricular shape is not altered after several years of training [19]. Furthermore, the demand for a large stroke volume in addition to overcoming the high blood pressure at the beginning of each stroke [3] is manifested in a heart size comparable with the largest hearts among elite athletes. This enhancement

TABLE 3. RESULTS OF ROWING TEST BEFORE AND AFTER INTERVENTION

N		Heart rate [bmp]	LA [mmol · l⁻¹]
100 W	B	128 ± 8.0	1.5 ± 0.4
	A	121 ± 11.2*	1.0 ± 0.2*
140 W	B	145 ± 9.3	2.1 ± 0.7
	A	136 ± 9.0*	1.4 ± 0.4*
180 W	B	161 ± 9.2	3.7 ± 1.0
	A	152 ± 12.3*	2.5 ± 0.6*
220 W	B	174 ± 9.5	6.8 ± 1.6
	A	166 ± 9.8*	4.8 ± 1.1*
260 W	B	187 ± 8.0	10.9 ± 3.2
	A	182 ± 11.1*	8.7 ± 2.1*
3´ Recovery	B	109 ± 8.2	10.8 ± 3.4
	A	102 ± 10.7*	10.2 ± 2.3

Note: values are mean±SD; LA - lactate acid concentration; B - before intervention, A - after intervention; * significantly different than before intervention at $p<0.05$

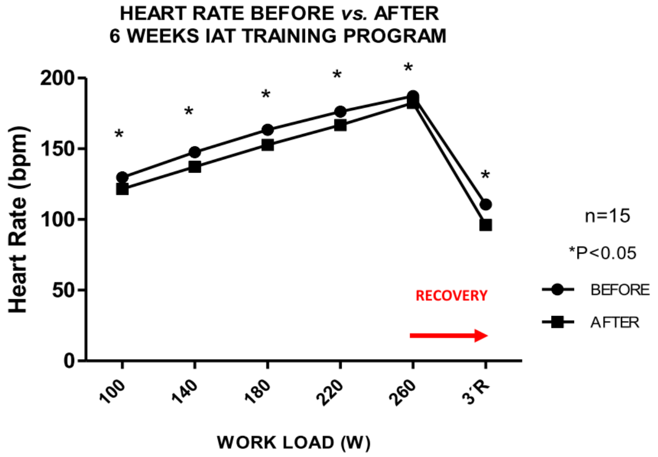

FIG. 1. COMPARISON OF HR MEANS BEFORE VS AFTER 6-WEEK IAT TRAINING PROGRAMME

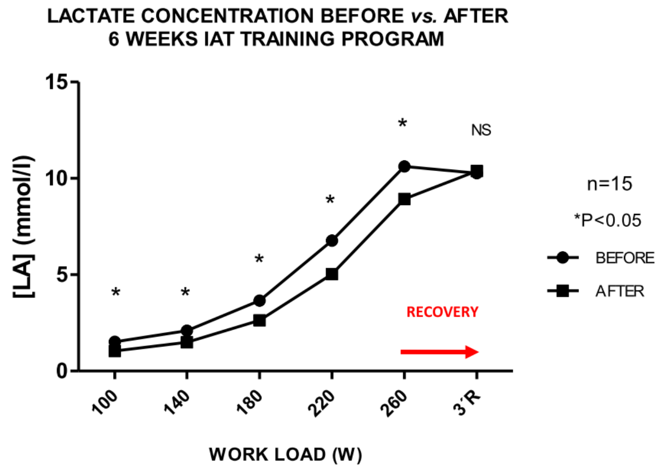

FIG. 2. COMPARISON OF [LA] MEANS BEFORE VS AFTER 6-WEEK IAT TRAINING PROGRAMME

in cardiovascular activity has also been reported in other sport disciplines [18], even though is has never been related to specific IAT training programs. After 3 min of recovery, the differences in HR are still significant, confirming the cardiovascular improvement shown in previous studies [13].

On the other hand, the differences in [LA] during all the stages of the test (100 W to 220 W workloads) are significantly reduced comparing before and after intervention. Higher [LA] buffering capacity has been reported in different endurance sports after similar interventions [20] and suggests that an improvement in glycolytic metabolism might have occurred due to the working programme. This improvement in aerobic fitness is comparable to other studies employing short-term (4–9 weeks) training programmes [1,7]. In the current study, after 3 min of recovery these differences are not statistically significant, showing surprisingly high [LA] values (10.8 ± 3.4 vs 10.2 ± 2.3 $mmol \cdot l^{-1}$) (NS). The singular biomechanics of traditional rowing, with less muscle mass involved than modern rowing, could explain this low lactate removal. Certain removal sites become relatively ineffective in removing LA due in part to reduced blood flow, as was observed in other studies [13]. In other research works, the ability to remove LA is related to elite oarsmen performance [16], whereas this study is based on subelite rowers. There is a good agreement that, within limits, an active recovery promotes the removal of blood lactate better than resting recovery strategies. This would need further research in the traditional rowing field. However, these results are consistent with modern rowing scientific works where the kinetics of lactate are described in rowing [21].

CONCLUSIONS

The present study concluded that a 6-week IAT work load based training programme could improve cardiovascular efficiency and [LA] buffering capacities in subelite traditional rowers, especially at submaximal and maximal intensities of training but does not have effect on [LA] removal after exercise. Thus, this study provides relevant information to coaches to improve intense aerobic capacity and lactic acid tolerance for training. However, this endurance training should not amount to >10% of the training volume [14]. Important limitations of the present study may be the lack of a control group to compare with, and, given the lab based conditions of the study, water research could possibly provide more relevant information for coaches in this specific discipline of rowing.

Acknowledgements

The authors would like to thank the Zierbena Arraun Taldea rowing club and their coaches and doctors for their cooperation and participation in this study.

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