

Effect of the pulmonary resistance training device “Elevation training mask 2.0” on physiological parameters and aerobic capacity during a maximal incremental cycling test

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Abstract—*The pulmonary resistance training device “Elevation Training Mask 2.0” (ETM) is widely used in various sports to help athletes gain a competitive edge. It is assumed that ETM simulates hypoxic conditions by creating pulmonary resistance, which can potentially result in arterial hypoxemia and as a result promotes the growth of aerobic fitness. The aim of this study was to investigate the influence of wearing the ETM on acute physiological effects, metabolic stress markers and aerobic performance during a maximal incremental cycling test. Ten physically healthy subjects completed maximal incremental cycling test with the mask and without the mask. Results of the ETM usage include insignificant reduction in peak power output (PPO) by -7.5% and this was accompanied by lower lactate (La^+) values that also did not reach statistical significance. Oxygen saturation (SaO_2) was lower at maximal intensity in comparison with the control condition ($-2.2 \pm 2.3\%$, $p \leq 0.01$), which corresponded to a mild degree of hypoxemia, but did not affect the dynamics of power output at the anaerobic threshold. In conclusion, our findings suggest that wearing the ETM does not produce a hypoxic stimulus great enough to elicit the necessary physiologic responses experienced at true elevation, however, more research is needed to identify the specific physiological mechanisms that are elicited by this device.*

Keywords—*altitude mask, ventilatory training mask, hypoxic mask, aerobic performance, hypoxia, elevation/altitude training.*

decrease partial pressure of oxygen during exercise should cause hypoxic state during exercise purportedly allowing the user to simulate high altitude training [2, 7, 9, 11].

Athletes' responses to training workloads can be considered hierarchically. Training outcomes categorized as acute and immediate encompass changes produced at the cellular and molecular levels. Acute and immediate effects in turn determine cumulative outcomes representing generalized level that summarizes the most integrative training outcomes, which characterize athletes' adaptability, preparedness and readiness for forthcoming workloads [4, 5].

Therefore, before deciding to include in the athletes' training program of an additional tool (here ETM) in order to improve its physical performance in long-term perspective (cumulative effect), it is necessary to understand physiological mechanisms underlying the short-term changes caused by the use of this tool (acute and immediate training effect).

The purpose of this study was to evaluate the effects of the ETM on acute physiological effects, metabolic stress markers and aerobic performance during the maximal incremental cycling test.

I. INTRODUCTION

There are a number of sports disciplines that place high demands on the aerobic performance of athletes, including martial arts, sports games, all-around events and many others [12, 13]. In order to gain a competitive edge, athletes and coaches are constantly looking for ways to enhance performance. The Elevation Training Mask 2.0 (ETM) is a patented pulmonary resistance training device that claims to enhance endurance and maximal oxygen consumption (VO_{2max}), as well as improve lung function. The ETM has different sized openings and flux valves that can be adjusted to increase the resistance of respiration, that limit the amount of air entering the mask, and therefore, the lungs [1]. It is assumed that the use of this mask in order to

II. MATERIAL AND METHODS

Ten physically healthy subjects (9 males and 1 female; 24 ± 3 years and 23, respectively) volunteered to participate in the study. Testing was performed on a stationary bike (Cardio Line, China). The test began at 20 W with a pedaling rate of 80 rpm and was increased by 20 W every 2 minutes until volitional fatigue. Testing procedure was stopped if the subject reduced the required rate of pedaling by more than 5 rpm for 15 seconds. The exercise was performed using the ETM which was set at the highest level of resistance to the flow of inhaled air – a combination of adjustable flux valves called “18000 ft” (5486 meters above sea level) [1].

During the trial oxygen saturation (SpO₂) was monitored continuously using a finger pulse oximeter (MD300 C2). Heart rate, RR intervals and short-term heart rate variability (HRV) data obtained every stage from the Polar RS-800 heart rate monitor. Rate of perceived exertion (RPE) was also obtained and recorded using a Borg Scale of 6-20 [3]. This data was averaged over the last 30 seconds of each load stage. Also, each odd stage of the test for 10 seconds before the end of the current load blood lactate (La⁺) concentration was measured in using a capillary blood sample (Lactate Plus, USA) which indicates the degree of metabolic stress [8].

Participants completed experimental protocol in 2 separate conditions with the use of ETM (mask group) and without the use of ETM (control), that is cross over from one arm of the study to the other and serve as their own control group. Both protocols were performed on the same day with a timeout between workloads of 2 hours (until participants felt a full recovery). To eliminate the effects of pre-fatigue, the sequence of tests varied: five subjects first

performed the exercise with ETM, and then without ETM, the other five vice versa.

III. RESULTS

Data of performance variables measured during the maximal exercise test at the point of volitional fatigue are presented in Table 1. Oxygen saturation tended to be lower in the mask group at the end of the test, but overall SpO₂ was only $2.2 \pm 2.3\%$ ($p \leq 0.01$) lower in the mask group than control group (94.8% versus 97%). These values represent a normal drop in SpO₂ during high intensity exercise [10] and are on the border of normal values and values characteristic of mild arterial hypoxemia. No significant differences were found in the mean heart rate, heart rate variability and RPE score given by participants between the groups. Insignificant reduction in peak power output (PPO) by -7.5% was accompanied by lower lactate (La⁺) concentration ($-1.6 \text{ mmol}\cdot\text{l}^{-1}$) that also did not reach statistical significance. Large variability of results may indicate a great degree of individual response to the use of ETM.

TABLE I. DATA OF PERFORMANCE VARIABLES AT THE POINT OF VOLITIONAL FATIGUE. VALUES REPRESENT MEAN (\pm STANDARD DEVIATION, SD)

Subject	SpO ₂ , %		PPO, %		La ⁺ , mmol·l ⁻¹	
	Control	Mask	Control	Mask	Control	Mask
1	97	96	100	100	8.6	6
2	97	95	100	71	9.3	Not finished
3	97	95	100	100	8.9	8.7
4	96	89	100	100	12.2	10.3
5	97	97	100	83	13.1	Not finished
6	97	97	100	100	9.8	9.4
7	98	95	100	71	6.8	Not finished
8	97	96	100	100	8.3	5.8
9	97	95	100	100	5.8	4.7
10	97	93	100	100	8	5.8
Mean	97 \pm 0,5	94,8 \pm 2,3	100	92.5 \pm 12.5	8.8 \pm 1.9 ¹	7.2 \pm 2.2 ¹

¹ Only subjects who completed the exercise were taken into account in the calculations

IV. DISCUSSION

Peripheral air resistance during inspiration generated by the ETM at the level of «18000 ft» induces mild arterial hypoxemia (95% > SpO₂ > 93%) at the point of volitional fatigue in the exercise with incremental workload. The mild degree of arterial hypoxemia did not affect the dynamics of the power output at the anaerobic threshold, estimated by the lactate concentration of 4 mmol/l and by achieving RR intervals curve of the plateau level in the region of 2-4 ms [6]. Wearing the ETM while participating in a maximal incremental cycling test does not appear to act as a simulator of altitude and its influence on different subjects is ambiguous. Subjects associate failure to continue work with respiratory discomfort. In line with this, wearing the ETM in training settings with the purpose of improving endurance is not supported with conclusive evidence. Further research and development of a battery of tests is needed to predict the effects of this simulator on a particular subject.

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