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Original article

Elevation training mask in respiratory muscle strength and thoracoabdominal expansion in athletics practitioners

Máscara de treinamento elevado na força muscular respiratória e expansibilidade toracoabdominal em praticantes de atletismo

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ABSTRACT

Introduction: Exposure to moderate or high altitudes promotes physiological changes in all systems of the human body, mainly cardiovascular and respiratory. The elevation training mask (ETM) was developed with the function of simulating respiratory conditions at moderate and high altitudes. **Objectives:** The objectives of this study were to evaluate the effects of ETM on respiratory muscle strength and lung expansion in athletics practitioners. **Methods:** This is a prospective and longitudinal study. The sample was non-probabilistic, composed of athletics practitioners. The individuals were divided into an Intervention Group (IG) that used ETM (LiveUP Sports) and a Control Group (CG) that did not use it. Study outcomes were maximal inspiratory pressure and maximal expiratory pressure, lung expansion by axillary, xiphoid, and abdominal cirtometry. **Results:** The peripheral oxygen saturation (SpO_2) decreased in the pre- and post-intervention of both groups. The CG showed higher values in the variables xiphoid cirtometry, abdominal cirtometry, MIP and MEP. Different GI results, significant only in xiphoid and abdominal cirtometries. **Conclusion:** The high training mask does not improve the thoracoabdominal expansion and the strength of the ventilatory muscles of athletics practitioners.

Keywords: muscle strength; resistance training, athletes; exercise.

RESUMO

Introdução: Exposição a altitudes moderadas ou elevadas promove alterações fisiológicas em todos os sistemas do corpo humano, principalmente cardiovascular e respiratório. A máscara de treinamento elevado (MTE) foi desenvolvida com a função de simular condições respiratórias em moderadas e grandes altitudes. **Objetivos:** O objetivo deste estudo foi avaliar os efeitos do uso da MTE na força muscular respiratória e na expansibilidade tóracoabdominal em praticantes de atletismo. **Métodos:** Trata-se de um de um estudo prospectivo e longitudinal. A amostra foi não probabilística composta por praticantes de atletismo. Os indivíduos foram divididos em Grupo Intervenção (GI) que utilizou a MTE e Grupo Controle (GC) que não a utilizou. Os desfechos do estudo foram pressão inspiratória máxima e pressão expiratória máxima, expansibilidade toracoabdominal pela cirtometria axilar, xifoidiana e abdominal. **Resultados:** Houve redução da saturação periférica de oxigênio (SpO_2) no pré e pós-intervenção de ambos os grupos. O GC apresentou maiores valores nas variáveis cirtometria xifóide, cirtometria abdominal, PImáx e PEmáx. Resultados GI diferentes, significativos apenas nas cirtometrias xifóide e abdominal. **Conclusão:** A máscara de treinamento elevado não melhora a expansão toracoabdominal e a força dos músculos ventilatórios de praticantes de atletismo.

Palavras-chave: força muscular; treinamento de força; atletas; exercício físico.

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Introduction

Exposure to moderate (1300 to 2400 m) or high altitudes (above 2500 m) promotes physiological changes in all human body systems, mainly cardiovascular and respiratory. This occurs due to the decrease in barometric pressure in these places where the levels of partial pressure of oxygen (PpO_2) are reduced, causing low supply and decreased consumption, as well as drops in central and peripheral saturation [1,2].

Exercises performed at these high altitudes lead to a reduction in PpO_2, temperature, and air density, making marathon runners less resistant to high-speed movements. Under these conditions, high-performance athletes lose minimal aerobic power performance during races. The organism undergoes changes to adapt to the environment when practicing specific training at simulated altitudes [3].

The elevation training mask (ETM) was developed to simulate respiratory conditions at moderate and high altitudes [4]. It has already been used by Mixed Martial Arts, running, cycling, and bodybuilding athletes, as it is a simple piece of equipment with few contraindications. Its use is indicated in individuals with high cardiovascular performance [5].

There is a divergence in the literature about the effect of ETM and the results of respiratory variables with its use [4,6,7]. Thus, this study aimed to evaluate the effect of ETM on respiratory muscle strength and thoracoabdominal expansion in athletics practitioners.

Methods

Type of study

It is a prospective and longitudinal study carried out in a public sports center located in a city in the central region of Brazil, held from September to November 2019, composed of a non-probabilistic sample of athletics practitioners.

Inclusion criteria

Individuals aged between 13 and 24 years; enrolled in running training sessions who delivered physical fitness exams; training frequency of at least twice a week; athletics practice for more than three months; signing of the Free and Informed Consent Term, being signed by the legal guardian when under 18 years of age.

Exclusion criteria

Individuals with a training time of fewer than three months were excluded; subjects who did not attend or had a frequency $< 85\%$ and who did not submit the cardiological physical fitness exams.

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Data collect

All athletes underwent two assessments (pre and post-intervention), consisting of personal data, vital signs, axillary, xiphoid, and umbilical 3-point cirtometry and manovacuometry. Vital signs: heart rate, respiratory rate, and systemic blood pressure were collected in all training sessions before and after the end by the same examiner in the reserved space next to the running track. Athletes remained seated at rest for 3 minutes before checking in a chair with back support.

Training protocol

The individuals were divided into Intervention Group (IG) that used the ETM (LiveUP Sports) and Control Group (CG) that did not use it. Twelve training sessions were held twice a week for 45 consecutive days.

Of the 12 sessions, the first three were performed at 914 m, from the fourth to the sixth session at 1829 m, from the seventh to the ninth at 2743 m, and from the tenth to twelfth at 3658 m. The training lasted one hour.

In the first session, the IG underwent an adaptation process, in which he used the mask at rest for 10 minutes to adapt to the instrument. The training of the two groups was identical, following the planning of the team of runners. For the safety of the research participants and possible cases of intolerance or adverse effect of the ETM use during training, a rescuer with oxygen support and a defibrillator were made available at the scheduled training times.

Used tools

The instruments used were: Ventcare analog manovacuometer to measure respiratory muscle strength; Milward body measuring tape 150cm to perform cirtometry; Nonin model GO2 Achieve pulse oximeter to manage and monitor oxygen saturation; premium aneroid sphygmomanometer; and 3M Littmann® Classic II stethoscope to measure blood pressure.

Manovacuometry was used to assess respiratory muscle strength through measurements of maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP). To perform the MIP, an expiration was requested to the residual volume and, after placement of the nasal clip, an inspiration with maximum force. The performance of the MEP started with inspiration until the total lung capacity and, after placing the nasal clip, an expiration with maximum force. Three measurements of each measure were performed, adopting the highest value.

The cirtometry was performed with the athletes standing and the examiner in front of them. The thoracic perimeters were measured in three regions of the chest: (1) axillary perimeter, with the measuring tape passing through the axillary cavities at the level of the third rib; (2) xiphoid perimeter, passing the tape over the xiphoid process at the level of the seventh costal cartilage; (3) umbilical perimeter, passing over the umbilicus. First, the athletes take a deep inspiration and exhale all the inspired air, and then follow the measurements of maximum inspiration at the level of total lung capacity and maximum expiration at the level of residual volume in the three cited regions, with three measurements in each and eligibility of the best numerical variation.

Pulse oximetry was performed with the oximeter in contact with the skin of the index fingers of each athlete, waiting for a 2-minute interval with the device and recording the value at the end of this time. For the blood pressure measurement, the athletes were placed in a sitting position, with both feet flat on the floor and their backs straight, supported on the back of the chair.

Independent outcomes/variables

The study outcomes were: MIP and MEP, thoracoabdominal expansion by axillary, xiphoid, and abdominal cirtometry. The independent variables were: age group (< 18/18 to 25 years); sex (male/female); sport modality (endurance/sprinter); training time (< 24 months/> 24 months); exercise frequency (x/week); heart rate (HR/bpm), respiratory rate (RR/ipm); systolic blood pressure (SBP/mmHg); diastolic blood pressure (DBP/mmHg) and peripheral oxygen saturation (SpO_2/%).

Data analysis

Data were analyzed using the *Statistical Package of Social Sciences* (SPSS 23.0). The demographic profile and vital signs characterization of the athletes in the IG and CG were performed using absolute and relative frequency for qualitative variables, while mean and standard deviation for quantitative variables. The homogeneity of the athletes' profiles in both groups was verified using Pearson's chi-square tests. Data normality was verified using the Shapiro-Wilk test. The t-student test was used to compare the means between the groups studied, while the t-paired test was used for the analysis before and after in the two groups.

Ethical aspects

The work was approved by the Ethics and Research Committee of the *Pontifícia Universidade Católica de Goiás* under number 3,626,289.

Results

The initial sample consisted of 20 athletes. However, four individuals were excluded from the research due to lack of assiduity in training, two from the CG and two from the GI. Therefore, 16 participating athletes remained.

Table I demonstrates the profile characterization of the athletes in the study and the homogeneity between the variables analyzed.

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Table I - Profile characterization of athletes in the control and intervention groups (n = 16)

	Groups n (%)		Total	p*
	Control	Intervention		
Age group				
< 18	4 (50.0)	4 (50.0)	8 (50.0)	1.00
18 a 25	4 (50.0)	4 (50.0)	8 (50.0)	
Gender				
Female	2 (25.0)	5 (62.5)	7 (43.8)	0.13
Male	6 (75.0)	3 (37.5)	9 (56.3)	
Sport				
Resistance	3 (37.5)	5 (62.5)	8 (50.0)	0.31
Sprinter	5 (62.5)	3 (37.5)	8 (50.0)	
Training time				
≤ 24 months	4 (50.0)	3 (37.5)	7 (43.8)	0.61
> 24 months	4 (50.0)	5 (62.5)	9 (56.3)	
Exercise frequency				
3x	4 (50.0)	3 (37.5)	7 (43.8)	0.61
4x	4 (50.0)	5 (62.5)	9 (56.3)	

*Pearson's chi-square; n = absolute frequency; % = relative frequency

Table II characterizes the mean vital signs in the control and intervention groups, after the 12 training sessions, with no statistically significant differences between the groups.

Table II - Characterization of vital signs in the control and intervention groups after the training sessions (n = 16)

	Groups (Mean ± Standard deviation)		
	Control	Intervention	p*
HR (bpm)	80.88 ± 16.75	73.13 ± 10.59	0.2
RR (ipm)	17.00 ± 1.93	18.25 ± 3.37	0.3
SBP (mmHg)	116.25 ± 5.18	112.50 ± 10.35	0.3
DBP (mmHg)	78.75 ± 3.54	75.00 ± 9.26	0.3
SpO_2 (%)	97.75 ± 0.71	98.25 ± 0.46	0.1

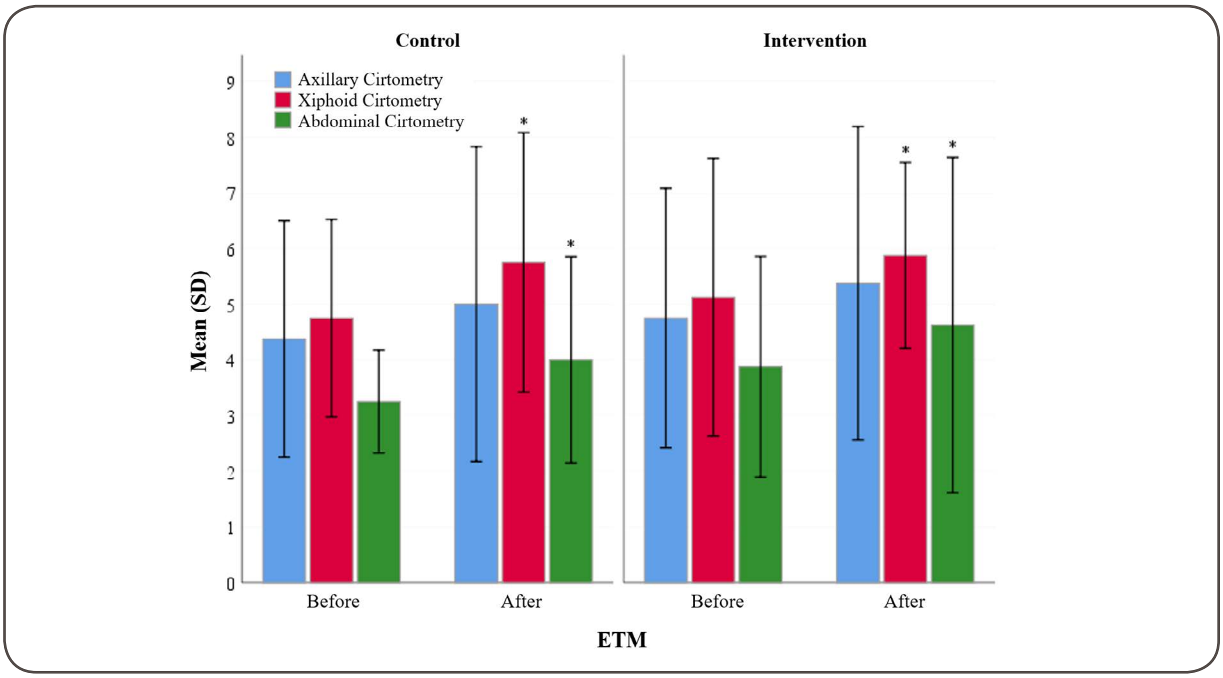
*t Student Test

The evaluation of cirtometry and manovacuometry in the CG and IG before and after the twelve training sessions showed statistically significant differences in the CG, both in xiphoid and abdominal cirtometry and in MIP and MEP. In the IG, only in the xiphoid and abdominal cirtometry (Table III). (Figures 1 and 2).

Table III - Evaluation of cirtometry and manovacuometry in the control and intervention groups before and after training (n = 16)

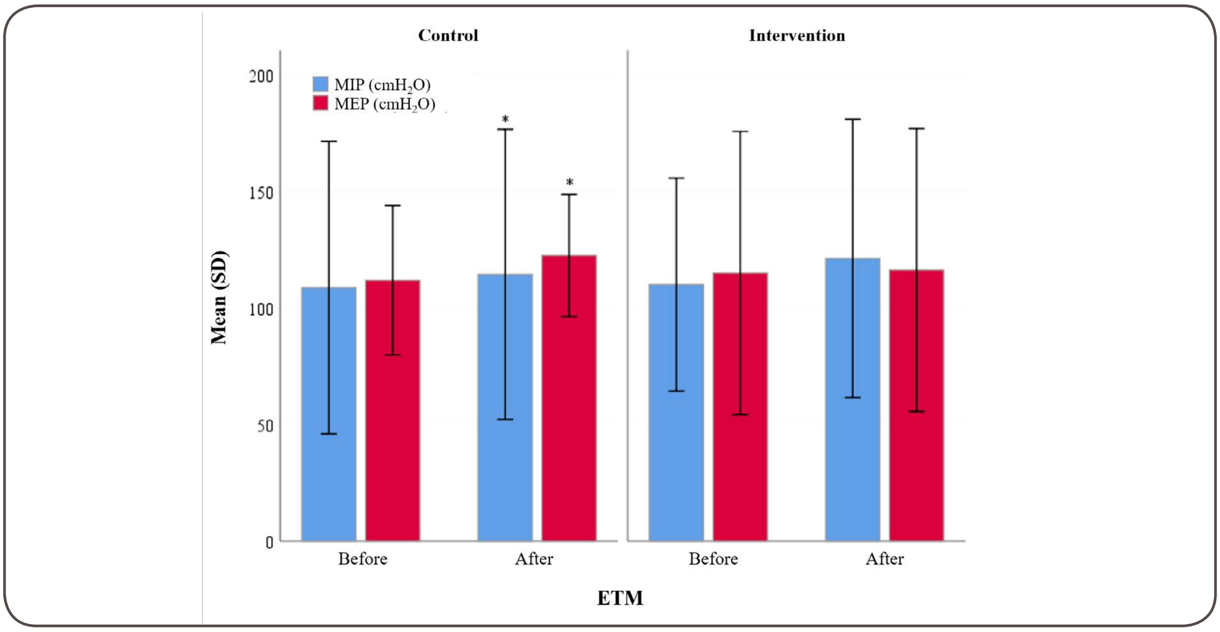
	Control (M/SD)		p*	Intervention (M/SD)		p*
	Before	After		Before	After	
Axillary cirtometry	4.38 ± 1.06	5.00 ± 1.41	0.14	4.75 ± 1.16	5.38 ± 1.41	0.14
Xiphoid cirtometry	4.75 ± 0.89	5.75 ± 1.16	0.02	5.13 ± 1.25	5.88 ± 0.83	0.02
Abdominal cirtometry	3.25 ± 0.46	4.00 ± 0.93	0.02	3.88 ± 0.99	4.63 ± 1.51	0.04
MIP (cmH_2O)	108.75 ± 31.37	114.38 ± 31.10	0.04	110.00 ± 22.83	121.25 ± 29.85	0.16
MEP (cmH_2O)	111.88 ± 16.02	122.50 ± 13.09	0.02	115.00 ± 30.36	116.25 ± 30.33	0.51

* Paired t-test; M= mean; SD= standard deviation



*p = 0,05

Figure 1 - Initial cirtometry values and after conclusion of the 12 training sessions in the control and intervention groups



*p = 0,05

Figure 2 - Initial manovacuometry values and after conclusion of the 12 training sessions in the control and intervention groups

Discussion

The results of this study report no differences between the groups regarding the use of ETM in athletics practitioners. Specific training based on the physiology of the sport itself can already be decisive in the differences found in both cirtometry and manovacuometry, and not only due to the use of ETM.

Divergent and scarce are the studies that evaluated the use effects of this ETM instrument, and this study becomes essential regarding the analysis of the variable thoracoabdominal expansion by cirtometry [8].

Kwitschal *et al.* [9] reported a difference only in MIP after the ETM usage, suggesting a considerable improvement in the inspiratory muscles within eight weeks. In this study, in the assessment of basal cirtometry before and after using the mask, there was no difference, although the group showed an improvement, which may be associated with a small sample. The authors suggest that the increase in inspiratory resistance offered by the mask triggers an improvement only in thoracic mobility, requiring additional studies with a larger sample and longer use of the ETM.

Sellers *et al.* [10] evaluated the effectiveness of ETM on the physical fitness of reserve officers, and the results showed no significant aerobic and anaerobic adaptations. This was because the ETM was used only during the maximum and submaximal capacity tests, with a small sample and evaluation in a short period. It had no effect in training simulating altitude, despite differing from the variables studied in the present study. The authors suggest the need to incorporate training with greater scientific evidence with the use of ETM.

Elmarakby *et al.* [11] found no significant differences between the groups of athletes when assessing respiratory muscle strength, endurance, and aerobic capacity at a 12-week interval when comparing the ETM to two respiratory training devices, which corroborates our findings. The authors suggest that the device should be used to minimize respiratory fatigue and improve exercise performance, maximizing its positive effects in high-intensity training.

Munhoz *et al.* [12] found that thoracoabdominal expansion and pulmonary function did not exceed the normal range expected by the athletes' high aerobic capacity, confirming our results by proving that the ETM did not produce significant effects on the aforementioned outcome. The lack of data regarding the interval and duration of this study suggests the need to carry out additional studies between these variables and the use of ETM.

On the other hand, Hartz and Moreno [9] showed that thoracic mobility and muscle strength in handball athletes in inspiratory muscle training were shown to be at better levels in 12 weeks, which confronts our findings of the ETM not producing the desired effects. Thus, comparing the presented study, it can be understood that the training time is a determining factor for the divergent results between the studies.

Our study had the sample size and a short time interval as limitations, which may have interfered with the outcomes studied, generating a possibility of type II error. Other points to be highlighted would be the non-randomization of athletes in the study groups, without randomness in their allocation, as well as possible selection bias in the choice of participating athletes. On the other hand, the presence of a control group allowed the comparison of the data obtained to expand the scientific knowledge of the topic addressed.

Conclusion

The ETM use did not change the thoracoabdominal expansion and respiratory muscle strength in athletes practicing athletics.

Academic affiliation
This article represents the Course Conclusion Paper by Scarlatt Jordanna Pereira Silva, supervised by Professor Luciana Carvalho Silveira at *Pontifícia Univeresidade Católica de Goiás* in Goiânia.

Potential conflict of interest
No potential conflicts of interest relevant to this article have been reported.

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Authors' contribution
Research conception and design: Silva SJP, Silveira LC, Utida VHS, Alcântara EC, Filho MAB; **Obtaining data:** Silva SJP , Silveira LC; **Data analysis and interpretation:** Silva SJP, Silveira LC, Pádua HT, Filho MAB, Fernandes MR; **Writing of the manuscript:** Silva SJP , Moraes YCS , Pádua HT, Filho MAB ,Silveira LC; **Critical review of the manuscript for important intellectual content:** Fernandes MR.

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