Role of muscle relaxation in the correction of vestibulo-respiratory reactions in athletes

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Abstract

The aim of the study was to study the possibility of using muscle relaxation as a means of correcting the negative influence of vestibular loads on the function of external respiration of wrestlers. For 81 athletes-wrestlers (men) (19.41±1.66 years), the parameters of the tone of paravertebral muscles (TPM) of the reflexogenic vascular zones of C3-Th8 segments and the indices of spirometry at rest, after presentation of a vestibular load (Series-1), after the combined action of active traction rotational muscle relaxation (ATRM) and vestibular load (Series-2) were studied. It was shown that vestibular loads increase the tone of the cervical muscles in wrestlers by 4.72-11.54% ($p<0.05$). After the combined action of ATRM with vestibular loads, there was a significant decrease in myotonus at the VG15 point: up to 19.12% ($p<0.001$). In Series-2, the constants of the respiratory system significantly increased: vital lung capacity (VC) by 4.55% ($p<0.01$), maximum lung ventilation (MVV) by 6.55% ($p<0.01$) with a decrease in frequency respiration RR by 26.41% ($p<0.001$) and an increase in respiratory volume by 15.19% ($p<0.01$), which indicates an increase in the efficiency and effectiveness of breathing under conditions of vestibular loads. The method can be used in training process, sports medicine and physical rehabilitation.

Keywords: *respiratory system; vestibular load; muscle tone; athletes.*

Introduction

The problem of increasing the level of adaptation of the organism to various extreme factors is an urgent problem of sports physiology. An increase in vestibular stability in sports is of particular interest, because the vestibular analyzer, being one of the most ancient sensory systems, has a direct effect on the extrapyramidal and pyramidal systems of motor activity control, as well as on the visceral systems: respiratory, cardiovascular etc. [1].

The adaptation of athletes to specific sports loads significantly depends on their autonomic status, and, consequently, on the activity of the sympathetic and parasympathetic divisions of the autonomic nervous system. At present, various ways of directed influence on the regulation of autonomic tone are known. At the same time, pressor and physiotherapeutic effects are used on the C3-Th8 segments, which are cardio-respiratory projections of Zakharyin-Ged [2].

One of the methods contributing to the normalization of myo-visceral reflexes of the spinal cord, correction of muscle tone in the C3-Th8 segments is traction muscle relaxation: targeted effect of specially selected physical exercises, under the influence of which, stretching of the paravertebral muscles is carried out [3]. However, the question of the influence of ATRM on the adaptation of the muscular and respiratory systems of athletes-wrestlers to vestibular loads has not been studied enough.

The aim of the study was to study the possibility of using muscle relaxation as a means of correcting the negative influence of vestibular loads on the function of external respiration of wrestlers.

Material and Methods

Participants

The study involved 81 men (average age of 19.41±1.66 years), engaged in freestyle and Greco-

Table 1. Changes in muscle tone values (myotones) in segments C3-Th8 under the action of vestibular load (first series) and its effect in combination with active muscle relaxation (second series) (n=81)

Points	first set			second set		
	baseline	vestibular load	Δ%	baseline	ATRM + vestibular load	Δ%
VG15	26.0 (25.0-27.0)	29.00 (25.0-27.0)	11.54 ♦♦♦	25.68±1.78	20.77±1.97	-19.12 ***
TR15 dexter	57.77±2.31	60.50±2.22	4.72 ***	56.68±2.42	47.14±3.28	-16.84 ***
TR15 sinister	58 (55.0-60.0)	60.0 (58.0-62.0)	3.45 ♦♦	58.50±2.30	50.82±3.30	-13.13 ***
V46 dexter	57.91±2.58	60.27±1.49	4.08 ***	57.95±1.79	48.91±2.11	-15.61 ***
V46 sinister	57.91±2.62	60.36±1.65	4.24 ***	58.14±2.29	49.86±2.29	-14.23 ***

Note: VG15, TR15, V46 – points of myotonus measurement; dexter and sinister: right and left;

*, **, *** – P<0.05, 0.01, 0.001 respectively, Student's t-test;

♦, ♦♦, ♦♦♦ – P<0.05, 0.01, 0.001 respectively, Wilcoxon's W test.

Roman wrestling with 10 years of sports training experience (weight category up to 76 kg), without cardiovascular and respiratory pathology. All participants were informed about the purpose and risks of the study before they signed the written consent, and the studies were carried out in conformity with the Declaration of Helsinki.

Procedures

All athletes underwent two series of examinations (Table 1). In the first series (Series-1), the effect of vestibular loads on the functional state of the muscular and respiratory systems was studied. All examined young men were subjected to vestibular loads according to the Voyachek method [1].

The second series (Series-2) of surveys was carried out 2 weeks after the first; the same 81 people were re-examined. Before vestibular loads young men performed a set of physical exercises aimed at ATRM of the muscles of C3-Th8 segments (ATRM), which consisted in the fact that for 15 minutes in certain fixed poses the athlete performed a two-phase movement: 1) at first, stepwise increasing ATRM with the longitudinal direction of the fibers; 2) then, at the maximum of longitudinal stretching, an active rotation of the trunk was carried out to the right and to the left, effectively stretching the rotator muscles under conditions of reduced resistance of the longitudinal muscles [3].

In both series, using NOVOTEST myotonometer (Russia), the value of muscle tone was measured at point VG15, and at symmetrical paravertebral points: TR15 and V46, which are localized in the cervicothoracic spine.

With the help of the medical diagnostic complex "SFERA-4" (Ukraine), spirometric studies were carried out. The following parameters were determined: respiratory rate (RR), vital capacity (VC), tidal volume (TV), respiratory minute volume (VE), inspiratory reserve volume (IRV), expiratory reserve volume (ERV); maximal voluntary ventilation (MVV), forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV1); Tiffeneau index (FEV1/VC); MVV-VE is the breathing reserve; heart rate (HR) and Hildebrant's ratio (Q = HR/RR).

Statistical Analysis

Statistical data processing was carried out using STATISTICA 10.0 software package (StatSoft Inc., USA), using parametric (Student's t-test) and nonparametric (Wilcoxon's W-test) criteria. The nature of the distribution of the values of quantitative traits was assessed using Shapiro-Wilk test. The median (Me) was used as a measure of the central tendency, and the lower (Q1) and upper (Q3) quartiles (25th and 75th percentiles) were used as scattering measures. Comparing the samples with a normally distributed trait, the arithmetic mean (M) was used as a measure of the central tendency, and the standard error of the arithmetic mean (m) was used as a scattering measure. $P<0.05$ was considered as statistically significant.

Results

It was found that in athletes, under the action of vestibular load and under the combined action of active muscle relaxation with vestibular load, myotonus indices and the function of external respiration change. However, these changes are multidirectional. So, under the action of the vestibular load, the myotonus at the VG15 point increased most significantly: up to 11.54% ($p<0.001$). After the combined action of active muscle relaxation with vestibular load, there was a significant ($p<0.001$) decrease in myotonus at VG15 point: up to 19.12% (Table 2).

Under the influence of vestibular load, the following changes in external respiration function occurred:

Table 2. Changes in the values of spirometry indicators in athletes under the action of vestibular load (first series) and its effect in combination with active muscle relaxation (second series) (n = 81)

Parameters	first set			second set		
	baseline	vestibular load	Δ %	baseline	ATRM + vestibular load	Δ %
spirometry indicators						
pulmonary volumes						
TV (l)	0.84±0.37	0.79±0.31	-5.44	0.73 (0.52-1.06)	0.95 (0.69-1.24)	30.31 ♦♦♦
IRV (l)	2.15 (1.85-2.55)	2.08 (1.92-2.42)	-3.35	2.23±0.48	2.28±0.52	2.05
ERV (l)	0.77±0.40	0.70±0.37	-9.17	0.71 (0.62-0.38)	0.70 (0.55-0.96)	-2.32
pulmonary capacity						
VC (l)	4.17 (3.87-4.68)	4.17 (4.09-3.83)	0.18	4.29 (4.16-3.76)	4.36 (3.91-4.86)	1.47 ♦♦♦
IC (l)	2.95 (2.67-3.23)	2.93 (2.90-2.71)	-0.56	3.03±0.53	3.23±0.52	6.41 **
RR (in/min)	18.92±3.44	21.52±4.15	13.75 ***	19.40 (16.56-23.79)	15.96 (15.03-19.20)	-17.71 ♦♦♦
MVV (l/min)	70.00 (42.00-124.50)	62.00 (32.50-119.00)	-11.43 ♦	66.50 (37.50-102.50)	118.50 (97.00-147.00)	78.20 ♦♦♦
V_E (l/min)	13.68 (11.54-17.45)	15.22 (12.65-19.55)	11.31	13.76 (12.11-16.87)	13.76 (11.66-17.19)	0.04
MVV-VE (%)	78.50 (72.00-87.50)	72.50 (58.00-84.00)	-7.64 ♦♦	75.00 (62.00-83.50)	87.00 (82.50-91.00)	16.00 ♦♦♦
pneumotachometry indicators						
FVC (l)	4.07 (3.74-4.66)	4.06 (3.71-4.47)	-0,.8 ♦	3.98 (3.68-4.46)	4.20 (3.78-4.57)	5.31 ♦♦
FEV1 (%)	3.64 (3.35-3.94)	3.57 (3.30-3.89)	-1.86	3.52±0.54	3.72±0.49	5.70 *
respiratory function indices						
FEV1/VC (%)	85.50 (80.00-91.50)	85.00 (80.50-91.50)	-0.58	83.06±12.18	83.42±7.79	0.43
Q (c.inu.)	3.24±0.72	2.66±0.51	-17.82 ♦♦♦	3.20±0.87	3.55±0.74	10.88 **

Note: respiratory rate (RR), vital capacity (VC), tidal volume (TV), respiratory minute volume (VE), inspiratory reserve volume (IRV), expiratory reserve volume (ERV); maximal voluntary ventilation (MVV), forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV1); Tiffeneau index (FEV1/VC); MVV-VE is the breathing reserve; heart rate (HR) and Hildebrant's ratio (Q = HR/RR). *,**,*** – P<0.05, 0.01, 0.001 respectively, Student's T-test; ♦, ♦♦, ♦♦♦ – P<0.05, 0.01, 0.001 respectively, Wilcoxon's W-test.

RR increased by 13.8% (p<0.001), MVV decreased by 11.43% (p<0.05), MVV-VE decreased by 7.64% (p<0.01), FVC decreased by 0.18% (p<0.05), Q decreased by 17.82% (p<0.001) (Table 3). The effect of the combined action of active muscle relaxation with vestibular load manifested itself in a significant decrease in comparison with the initial RR level: by 17.71% (p<0.001).

These changes were accompanied by an increase in TV by 30.31% (p<0.001), VC by 1.47% (p<0.001), IC by 6.41% (p<0.01), MVV by 78.20% (p<0.001), RR by 16.0% (p<0.001), FVC by 5.31% (p<0.01), FEV1 by 5.71% (p<0.05) and an increase in Q values by 10.88% (p<0.01) (Table 2).

Discussion

The results show that the vestibular load and its combination with active muscle relaxation have a multidirectional effect on the functional state of the muscular and respiratory systems of athletes. Background studies of the spirogram of athletes indicate a high level of their physical development: good condition of the lung tissue, normal chest mobility, sufficient strength of the respiratory muscles and good airway patency. The initial indicators of myotonometry indicate the presence of hypertonicity of the paravertebral muscles in the cervicothoracic spine, since wrestlers pay increased attention to training these zones [3].

In the course of the work, it was revealed that the vestibular load increases the tone of the cervical muscles even more, which is confirmed by a number of studies [3]. Noteworthy is the fact that VG15 point is most sensitive to the vestibular load ($p<0.001$). This point is located between I and II cervical vertebrae, above the posterior border of hair growth. McCall A.A., Miller D.M., Yates B.J. showed that the greatest flow of impulses to the lateral vestibular nuclei comes precisely from the structures of the neck-osteo-ligamentous, articular and muscle receptors [4]. The action on this point of acupuncture methods leads to an improvement in the condition of the vestibular apparatus.

Attention is drawn to the pronounced degree of the negative effect of vestibular load on the function of external respiration of athletes. In our studies, the use of vestibular load led to a clear mismatch in the activity of the visceral systems, which manifests itself in a significant decrease in Q. Obviously, this change is the cause of a decrease in the reserve breathing capacity, breathing reserve and an increase in RR, which were accompanied by a tendency towards a decrease in FVC (Table 2). The observed changes negatively affect the efficiency of respiration, and, given the decrease in HR, are the result of activation of the parasympathetic division of the autonomic nervous system.

The effect of active muscle relaxation on the function of external respiration of athletes is manifested in the opposite way. There was an improvement in the coordination of the autonomic nervous system divisions (Q growth), which was accompanied by HR stability. Obviously, as a result of this, in athletes compared with the initial level, despite the effect of vestibular load, there was a significant decrease in RR with an almost unchanged VE level. An increase in the efficiency of external respiration is also indicated by an increase in VC, FVC, MVV and respiratory reserve (Table 2).

Conclusion

Vestibular loads lead to an increase in muscle tone in the C3-Th8 segments, as well as to a decrease in the efficiency and economy of the external respiration system. The implementation of the ATRM complex significantly reduces the negative effect of vestibular loads on the respiratory functions of wrestlers.

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