Comparative assessment of the strength and endurance of the respiratory muscles in skiers and wrestlers

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Abstract

Objective of the study was to compare the maximal inspiratory strength and endurance of inspiratory muscles in athletes engaged in different types wrestling and skiing.

Methods and structure of the study. The maximal inspiratory pressure (MIP) was measured in athletes of wrestlers and skiers, as well as in volunteers without special physical training before and after incremental cycling exercise "to exhaustion".

Results and conclusion. The highest values of the maximal inspiratory pressure were found in athletes of skiers (155.4±9.9 cm H_2O), whose training is aimed at developing the aerobic capabilities. At the same time, the strength of inspiratory muscles decreased both in the control group of subjects (by 12%), and in athletes-skiers (by 8%) and wrestlers (by 11%) after incremental cycling exercise "to exhaustion", which is probably due to the development of inspiratory muscles fatigue. Specific training of the respiratory muscles can be an effective method for the increase in strength and endurance in both wrestlers and skiers, as well as in healthy physically active people.

Keywords: *maximal inspiratory pressure, incremental exercise, respiratory muscle fatigue, wrestlers, skiers*

Introduction. The reserve capabilities of the human inspiratory muscles significantly exceed the requirements to ensure adequate gas exchange at rest and have a significant “margin of safety” to maintain high levels of pulmonary ventilation during heavy and prolonged physical exertion in accordance with the metabolic demands of the body [8]. However, with high-intensity and prolonged muscle loads, fatigue of the respiratory muscles may develop more, which may be one of the limiting links in achieving maximum sports results [2, 5, 12]. “Working hyperpnoea” is accompanied by a significant increase in the load on the athlete’s respiratory muscles, the work of breathing to overcome elastic and resistive resistance increases, and the effort of the respiratory muscles necessary to create and ensure high velocities of gas flows in the respiratory tract increases many times over. Prolonged work of the respiratory muscles in such intense conditions can cause a decrease in its contractility and, ultimately, contribute to limiting the athlete’s maximum performance [4]. In this regard, conducting a comparative assessment of the functional reserves of the respiratory muscles of athletes of different specializations and different skill levels is very important to justify the introduction of additional targeted training of the respiratory muscles into the general training programs of athletes.

Objective of the study was to compare the maximal inspiratory strength and endurance of inspiratory muscles in athletes engaged in different types wrestling and skiing.

Methods and structure of the study. The experiment involved 20 young male athletes training strength (wrestlers of various types of martial arts) and endurance (skiers). All athletes had qualification categories from 1st sports category to master of sports. The con-

trol group included 10 physically active young men – university students who did not have special sports training. All participants were informed in detail about the methods used, the sequence of research and gave written consent to participate in them. The studies were conducted in accordance with the provisions of the Declaration of Helsinki on research involving human subjects and were approved by the local Ethics Committee. The athletes and student volunteers invited to participate in the study were of the same age category, had similar anthropometric data, did not have tobacco addiction, and did not take any pharmaceutical drugs at the time of the study. All participants in the experiment performed a load of increasing power on a bicycle ergometer "Schiller" (Switzerland). The work began with a load of 1 W/kg and every 2 minutes its value increased by 0.5 W/kg. The work continued until it was impossible to maintain the specified pedal speed (60-70 rpm) and the subject refused to continue. At rest, before the start of the bicycle ergometer test and immediately after its completion, the maximum strength of the inspiratory muscles was determined. The strength of contractions of the respiratory muscles was assessed by the amount of oral pressure created during maximum voluntary inspiratory (MIP) efforts with the airways blocked. The maneuver was performed based on the level of residual lung volume. MIP measurements were performed using a portable RPM device (FusionCare, UK) in accordance with the recommendations for respiratory muscle testing developed by the American Thoracic and European Respiratory Societies (ATS/ERS) in 2002 [1]. Soft latex mouthpieces connected to disposable antibacterial filters from the equipment manufacturer (FusionCare, UK) were used. Such mouthpieces fit tightly into the oral cavity and prevent even minimal air leakage when performing forced inspiratory maneuvers [10, 13]. Measurements were taken in a standing position at least 5 times with breaks of 1 minute; the maximum MIP value achieved was taken into account. Statistical data analysis was carried out using the Microsoft Excel statistical software package. Data are presented as mean ± error of mean (m ± SE). When comparing differences in indicators, Student's t-test and the non-parametric Wilcoxon test were used. Differences were considered statistically significant at $P<0.05$.

Results of the study and discussion. All study participants were of the same age category and had no significant differences in anthropometric parameters. The maximum strength of the inspiratory muscles was significantly higher than the control in all groups of athletes, and the highest MIP values were noted in the group of skiers and reached 155.4 cm of water column, which is 44.3% higher than the control (see table).

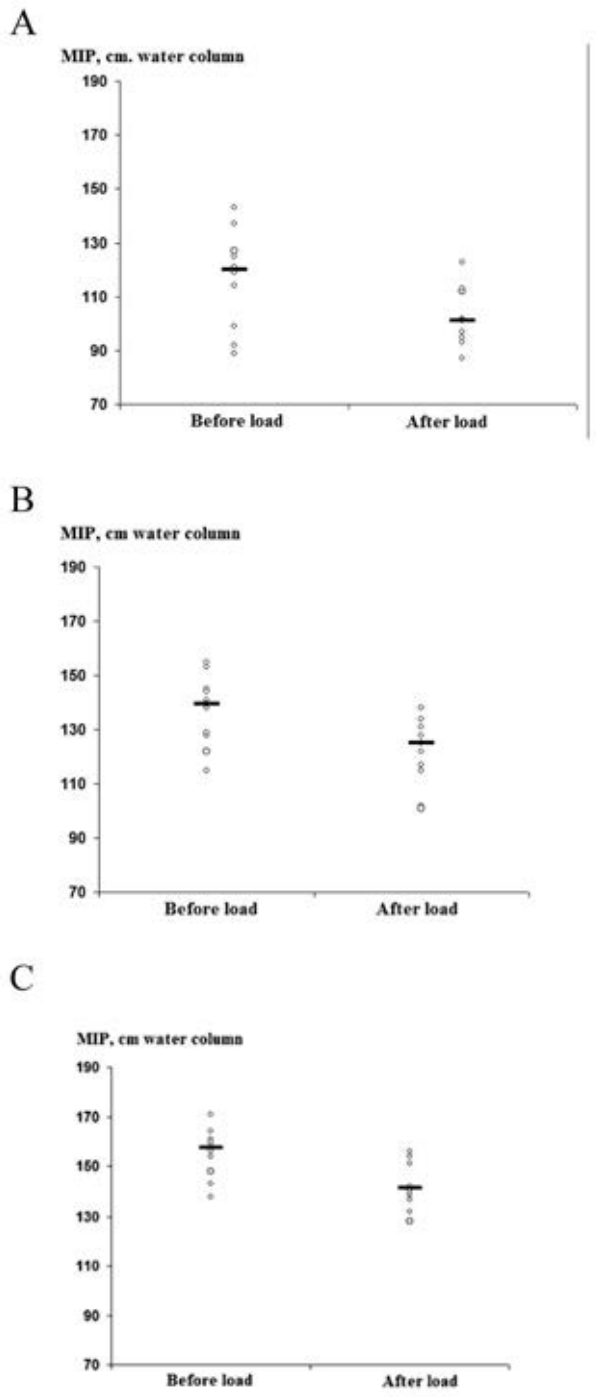
The results obtained showed that the maximum strength of the inspiratory muscles of endurance athletes is significantly higher than that of strength athletes and the general population of men of the corresponding age. These data are consistent with previously obtained information about higher values of maximum inspiratory pressure in highly qualified athletes: rowers [6] and swimmers [11]. The specific training of endurance athletes is aimed at developing the aerobic capabilities of the body, which are provided by the cardiorespiratory system. "Working hyperpnoea" is also the most important mechanism for training the respiratory muscles, which, in turn, promotes adaptive changes in the external respiration system, ensuring an improvement in the dynamic indicators of its function. At the same time, the results of our study showed that after performing a muscle load of increasing power, MIP values decreased both in the control group of volunteers (by 12%), and in the groups of martial artists (by 11%) and skiers (by 8%) (see drawing).

Similar data were obtained by other authors when studying changes in maximum inspiratory pressure in track and field athletes, runners and cyclists [7]. The authors found a decrease in MIP values after exer-

Functional characteristics of athletes and untrained volunteers before and after performing a load of increasing power "to failure"

Indicators	Control		Wrestlers		Skiers	
	Before load	After load	Before load	After load	Before load	After load
MIP, cm of water column	116,6±5,8	102,4±4,9*	137,0±4,1	121,6±4,03*	155,4±9,9	143,0±9,6*
$W_{max,}$ W		188,5±7,1		232±8,8#		255,8±9,1##
V_E, l	11,1±0,4	71,1±6,9	9,9±0,5	92,7±7,2#	11,6±0,3	122,9±8,2##

MIP, cm water column – maximum inspiratory pressure, Wmax, W – maximum power of the work performed; VE, l – minute ventilation value
** – p<0.05 relative to values within groups; # – p<0.05 ## – p<0.01 relative to control*



Maximum inspiratory pressure values and median values before and after bicycle ergometric load of increasing power in untrained volunteers (A), martial artists (B) and skiers (C) ($p<0.05$)

cise to failure by 13% and 17%, respectively, in athletes involved in athletics and cycling. A decrease in the strength of contractions of the inspiratory muscles after exercise is the main criterion for the development of their fatigue. Current evidence suggests that respiratory muscle fatigue triggers the activation of the "respiratory muscle metaboreflex," resulting in sympathetically mediated vasoconstriction of actively working locomotor muscles. This leads to a redistribution of blood flow towards the respiratory muscles, which require increased oxygen supply. This redistribution of blood flow and limitation of energy supply to intensely contracting locomotor muscles accelerates their fatigue, thereby contributing to refusal to continue working [8, 3]. At the same time, it should be noted that the total power of the work performed was maximum in the group of skiers (Table 1) compared to martial artists and the control group. At the same time, the degree of decrease in MIP values after stress testing in skiers was less than in wrestlers and untrained volunteers. These data allow us to conclude that the strength and endurance of the inspiratory muscles are highest in cross-country skiing athletes compared to wrestlers and the control group.

Conclusions. The most powerful functional reserves of inspiratory muscles have been identified in cross-country skiers, whose training is aimed at developing the aerobic capabilities of the body. At the same time, after performing a load of increasing power "to failure," the strength of the inspiratory muscles decreased both in the control group of subjects and in athletes training strength and endurance, which is likely due to the development of fatigue of the inspiratory muscles. Specific training of the respiratory muscles can be an effective method of increasing their strength and endurance in both martial arts athletes and skiers, as well as in healthy physically active people.

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