Effect of Inspiratory Muscle Training (IMT) On Aerobic Performance in Young Healthy Sedentary Individuals

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Introduction

Maximal aerobic capacity of an individual is evaluated on the basis of maximal oxygen uptake (VO2max). It is dependent on the optimum functioning of various systems such as the respiratory system, circulatory system & neuromuscular system. Respiratory system also has been identified as a limiting factor in aerobic capacity of an individual; which is clinically observed as respiratory muscle fatigue and/or hyperventilation (Boutellier U & Büchel R et al, 1992; Boutellier U, Piwko P, 1992) During high intensity exercise fatigue of respiratory muscles have a cumulative effect along with already fatigued peripheral muscles contributing to increased perception of breathlessness i.e. how hard the exercise feels further limiting the exercise performance. Apart from the respiratory system, the musculoskeletal system plays a crucial role in aerobic conditioning including lung ventilation. Respiratory muscles like all other peripheral muscles are skeletal
muscles. They improve in their function in response to training. At the same time lack of activity also deconditions them. The cardiovascular fitness reflected by aerobic capacity in sedentary individuals is reduced than normal.

Hence, we proposed that IMT (inspiratory muscle training) in normal healthy sedentary individuals can be used as one of the ergogenic aids in improving aerobic performance. Hence, we hypothesized that during increased demand in ventilation such as when exercising; there is high probability that improved respiratory muscle strength would improve the aerobic capacity and exercise tolerance. To examine this hypothesis we assessed the aerobic capacity & exercise tolerance during a progressive exercise test before & after a 4 week of respiratory muscle training program.

Material & Methods

Study Design:
This was a randomized controlled study. Fifty healthy college students of both sexes (17 males, 33 females) of mean age 22.3±2 were selected in this study. All participants were informed of the nature of the study and written consent was taken prior to the study. At the initial screening, physical activity status of all individuals was determined through Physical Activity Readiness Questionnaire (PAR–Q). The participants were equally divided into 2 groups. The training group of 25 participants was required to complete a 4-week supervised program of IMT. The participants performed no other form of exercise training during this study period. The control group did not participate in any form of training (n=25). The independent variables were age & gender and were equally distributed between the 2 groups. The dependent variables measured were inspiratory muscle strength, aerobic capacity, exercise performance & exercise tolerance levels. The study was approved by the ethical committee of the institution & according to the Helsinki Declaration prior to beginning.

Subjects:
The participants were divided randomly in 2 groups by random number table. 25 participants in training group and control group respectively. Participants between the age of 18-25 years & within normal PI max values of 91±25cm H2O were included. Participants with any history of chronic airflow limitation like asthma or any neuromuscular condition were excluded. All participants were non smokers. The training was mainly focused on young healthy individuals to avoid influence of any age-related degenerative changes or associated respiratory conditions.

Materials:
PI max equipment. The reliability & validity was checked at the institutional level.

Procedure:
This study was conducted at a tertiary care centre. The sample size was calculated before starting the study. The random allocation sequence was generated by the random number table. This was a single blinded study. A care provider enrolled the participants and assigned participants to the respective interventions. The researcher assessing the outcome measures was blinded after assignment to interventions. Prior to the intervention, the inspiratory muscle strength was determined by the MIP values. Following this, the training group was given IMT for 4 weeks.

Inspiratory muscle strength- The simplest scientific measurement of the inspiratory muscle strength is maximum inspiratory (PImax) mouth pressures. Each participant’s MIP was determined using PI Max equipment. Participants were instructed to exert maximal inspiratory effort against a closed valve gradually after a forced expiration and to maintain it for 1 second. The nose was plugged during the test procedure to avoid leakage of exhaled air. The participant was asked to look at the needle of the device for a visual feedback. Three consecutive efforts were recorded allowing 1- minute pause between each effort. The mean value of the three readings was taken as the final
IMT Protocol- IMT was given with an elastic resistant bands (theraband) tied firmly circumferentially around the thorax at the xiphisternal level. The xiphisternal level was selected as the thoracic expansion at this level of the ribcage is maximum. The subject was asked to exert their MIP and sustain the MIP for 5 seconds. The resistance was gradually increased depending on perception of individuals’ inspiratory muscle effort by progressing from yellow to green theraband. 5 sets of 6 breaths each with a rest period of 4–6 seconds after each set was given twice a day, 6 days a week for 4 weeks.

Figure I: Anterior view of the elastic band (theraband) tied to lower thoracic cage at the xiphisternal level. The participant was asked to expand the ribcage maximally against the resistance of the band at this level.

Figure II: Lateral view of elastic band tied to the lower thoracic cage to resist the bucket handle movement of ribs & hence strengthening the inspiratory muscles.

Exercise test- A progressive incremental multistage 20m shuttle run test was performed before & after IMT. The exercise test was continued till the stage of exhaustion. The estimated VO2max correlating to the shuttle run test performance was calculated.

Respiratory effort during exercise: At completion of the shuttle run each participant score of breathlessness on a modified Borg scale of 6–20 was measured. The subject was told to estimate the perception of breathlessness on the scale at the end of the test performance.

Primary outcome measures: Shuttle run test, estimated VO2max and Borg scale.

Secondary outcome measures: Peak heart rate & respiratory rate.

Statistical analysis: All the baseline values (table I) reported as mean difference (SD) of MIP, SRT & estimated VO2max, RR, HR were comparable between the two groups and hence analyzed using t-test. Paired t-test was used to analyze pre and post values after 4 weeks (intra group). Unpaired t-test was used to analyze the difference between training and control group (inter group).

12th version of SPSS software was used. A p value of less than 0.05 was considered significant.

Discussion

In the above study effect of IMT on inspiratory muscle strength and aerobic performance was assessed. The participants were given 4 weeks of IMT. Pre and post training, aerobic capacity, exercise performance and exercise tolerance was assessed by estimated VO2max, shuttle run test and Borg scale respectively. After the IMT, aerobic capacity and exercise performance significantly improved however the exercise tolerance (RPE) did not show significant improvement.

In our study, IMT training improved respiratory muscles strength significantly in the training group. We expected the increase in inspiratory muscle strength to allow us to examine the effects of respiratory muscle strengthening on aerobic capacity, exercise performance & tolerance.

During inspiration, with the descent of diaphragm, first the vertical diameter increases. As the descent continues, the transverse & A-P diameter increases; thus making 3-dimensional expansion. The circumferentially tied theraband uniformly resisted the act of inspiration indirectly resisting the action of diaphragm & associated synergists like the intercostals thus helping in its strengthening. The post training improvement in MIP reflected the improvement in strength of the inspiratory muscles. Strengthening of any skeletal muscle is primarily based on the overload principle. Hence we expected that progressive resistive strengthening of the inspiratory muscles will improve the lung ventilation influencing the ventilatory system to efficiently contribute in overall increase in aerobic capacity.

Previous papers have shown that the respiratory system is not stimulated by whole body exercise. Recent evidences suggest that inspiratory muscle training along with limb exercise can be more effective in reducing rate of perceived exertion and improving exercise performance in athletes, increase inspiratory muscle strength and endurance and improved pulmonary function.

IMT training improved aerobic capacity which was reflected by improvement of post training SRT. SRT reflects the overall aerobic capacity of the cardiovascular and respiratory systems and the ability to carry out exercise for prolonged time. Maximal oxygen uptake (VO2max) reflects the oxygen delivery to the exercising muscles by the cardiovascular system. Because of the
The above results showed that specific training of the inspiratory muscles enhanced aerobic capacity and exercise performance in healthy individuals. However, there was no significant improvement in exercise tolerance.

**Bibliography**


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