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

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- Abstract: Background: Respiratory muscles like all other skeletal muscles improve their function in response to training. The principles of progressive overload and specificity of training apply to respiratory muscles also. Inspite so many studies on effect of RMT (respiratory muscle training) on athletes and other respiratory conditions, there is lack of literature on RMT in healthy individuals.
 - Methods: 50 subjects were divided in 2 groups (25 each): training and control group. The training group was given 4-week inspiratory muscle training program while the control group did not participate in any form of training. IMT was given with an elastic resistant band tied around the thorax at the xiphisternal level. 30 breaths twice a day, 6 days a week for 4 weeks was given. Outcome measures: shuttle run test (SRT) and estimated.
 - Conclusion: Specific inspiratory muscle training shows significant improvement in aerobic capacity.
 - Keywords: Inspiratory muscle training, aerobic capacity.
- Thesis Question: Does specific Inspiratory muscle training improves aerobic performance
- Thesis Answer: Specific training of the inspiratory muscles enhanced aerobic capacity and exercise performance in healthy individuals. However there was no significant improvement in exercise tolerance

THESIS SUMMARY

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

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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 & Mathods

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 agerelated 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

measurement.

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 advised to take deep breaths and expand the chest against the resistance of the theraband. When MIP readings were taken, the participants were asked to remember the feel of it. They were also given adequate number of trails before starting IMT. The participants were 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 V O2max, 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.

Observation & Result

All the subjects repeated the shuttle run test after 4 weeks. All the subjects in training group completed the study. A confidence interval (CI) of 95% was considered for all the outcome measures & both the groups. The effectiveness of muscle training was demonstrated by increase in the MIP values in the training group significantly. (p<0.05). The estimated effect size (EES) for this group was 0.64.

Intra-group pre and post training values of Shuttle run test (SRT) performance in training group showed significant improvement.(p<0.05) (0.54 EES). The V O2max increased from significantly (p<0.05) (0.55 EES) in training group. But

even in the control group SRT significantly increased (p<0.05) (0.01 EES), but the associated V O2 max did not show a statistically significant change (p>0.05) (0.00 EES).

However, inter-group analysis of SRT and estimated V O2max between the training & control group using unpaired t test demonstrated a statistically significant improvement in SRT in the training group as compared to control group (p<0.05). At SRT completion, Borg scale of rate of perceived exertion (RPE) was not influenced by IMT. The RPE values remained significantly unchanged in training group (0.31 EES) and control group (p>0.05) (0.08 EES). The peak respiratory rate i.e. RR and heart rate in the training group reduced (p<0.05) (1.01 EES), (p<0.05) (0.16 EES) which showed significant cardiovascular conditioning. There was no significant improvement seen in the control group in RPE, maximal heart rate & respiratory rate.

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 V O2max, 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 suggests 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 (V O2max) reflects the oxygen delivery to the exercising muscles by the cardiovascular system. Because of the

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linear relationship between oxygen consumption and running velocity strong correlations exist between running performance in SRT and V O2max .V O2max based on the SRT performance also showed a statistically significant improvement. The delay in reaching peak threshold of lactate concentration & improved channelization of oxygenated blood flow to the limb muscle from cardiovascular & respiratory system can be the contributing factors. IMT may potentially reduce metabolic requirements of the inspiratory muscles during intense exercise thereby reducing lactate accumulation. This reduces the stimulation of diaphragm metaboreceptors and increases the threshold for activation of the metaboreflex. As a result the vasoconstrictor effect of the metaboreflex diminishes, directing the blood flow & improved O2 availability to the limbs.

During the progressive exercise test, the minute ventilation & the work of breathing increases resulting in increased effort of breathing. With IMT we expected a reduction in this sensation of respiratory effort and hence exercise tolerance. However in the present study Borg Scale for Rating of Perceived Exertion (RPE) scores the training group or the control group remained unchanged. This can be contributed to a short duration of training of 4 weeks. In fact, hyperventilation commonly occurs over time during prolonged heavy exercise because of accessory respiratory muscles recruitment . The changes in muscle recruitment patterns may lead to mechanical inefficiency of breathing. This may significantly limit exercise performance and increase may the work of breathing. During high-intensity exercise; the respiratory muscles consume $\sim 10-15\%$ of the total O2max which suggest that the respiratory system could V potentially limit V O2 max . Thus, respiratory effort adds to the peripheral working muscles fatigue. The sensation of breathlessness further prevents the individuals' exercise tolerance. In contrast to our results, in a study at a given work load while IMT did decrease RPE while expiratory muscle training did not decrease RPE. The cardiovascular adaptations or conditioning such as reduction in the peak heart rate and respiratory rate were observed in this study. A short duration of 4 weeks of training also has shown apparent cardiovascular conditioning.

Study limitations: The amount of resistance applied to the inspiratory muscles through the elastic bands is very subjective. It depends on the individuals' effort to take a deep breath. Also, the sample size was small when done on normal healthy individuals. The study can be further done to generalize the effect to a bigger population.

Clinical Message

Inspite of the limitations stated above, the technique of IMT is very simple and can be used in various clinical settings without requiring any specific training equipment. IMT can be applicable to a vast population including long term bed ridden patients, as part of general fitness program & rehabilitation program to improve the cardiopulmonary endurance of the people. The focus on IMT is still not into vogue & needs to be emphasized.

Conclusions

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.

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