EFFECTS OF INSPIRATORY MUSCLE TRAINING ON LUNG FUNCTIONS IN LONG AND MIDDLE DISTANCED RUNNERS

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ABSTRACT

Background & Aim: This study aims to investigate and compare the effects of inspiratory muscle training (IMT) on lung functions (LF) in long and middle distanced runners. Studies have shown that IMT has benefits to the cardiorespiratory system whereby it augments the maximal inspiratory volume, forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV1) in people of all different fitness levels. With the addition of IMT into any sports activities or exercise, the LF can improve significantly. Method: 20 recreational runners were recruited in this 4-weeks experimental study. Group 1 undergoes a 5km run while Group 2 had to run 1.5km 3 times a week. Both groups also undergo IMT after every run. 60% maximal inspiratory pressure (MIP) is set in the first two weeks followed by 70% MIP in the last two weeks. FVC and FEV1 were recorded pre-test and post-test. Results: The results have shown that there is no significant difference in IMT on LF in Group 1 (long distanced runners) and Group 2 (middle distanced runners). From the results obtained, FVC was stated at a p-value of 1.142 (p>0.05), and 1.230 (p>0.05) for FEV1. Conclusion: In conclusion, the effects of IMT on LF in long and middle-distance runners are not significant. Despite showing significant improvements in LF within the groups, there was no difference between when comparing the two groups.

***Keywords:** Inspiratory muscle training; Long distanced runners; Lung functions; Middle distanced runners*

Introduction

Engaging in sports activities is some of the ways one can maintain fitness and health in daily lifestyle by reducing the propensity to deal with respiratory diseases (Patel et al., 2017). With respiratory disease being one of the leading causes of death globally, more than 200 million cases of respiratory diseases were reported in the year 2013 (Ferkol, T. and Schraufnagel, D., 2014). Based on the data from the National Health and Morbidity Survey (NHMS), it was reported that approximately 65% of the population in Malaysia was physically active (Teh, C.H., et al., 2014). Regular exercises can help the respiratory system attain adaptive changes in enhancing the respiratory muscles and endurance of an individual. In an experimental study, it has been stated that moderate-intensity exercise provides adequate cardiovascular adaptation and endurance capacity when compared to high-intensity exercises (Soltani, M., et al., 2021).

Based on a recent study by Shoba, Niranjan, and Mane (2013), the differences between FVC and FEV1 were observed in the incongruity of lifestyle. As the connection between the respiratory system and cardiovascular system to physical lifestyle is inevitable, athletes have better LF than sedentary lifestyle individuals. As the respiration rate exceeds the minimal capability of a person during breathing, it may lead to breathlessness and thus diminish exercise capacity. By selecting the suitable type of exercise training, the endurance and respiratory muscles strength shall improve through the enhancement of lung elasticity and alveolar expansion, and better airflow in the respiratory canals (Lazovic et al., 2015).

IMT is known to permit beneficial physiological effects on the CR system in the body. As the respiratory muscle is subjected to a repeated task that loads the muscle fibres, neural conditioning occurs whereby the muscle fibres adapt and progress from a certain pressure. Also, neuromuscular adaptations help in providing better mobility of the respiratory muscles as the activation frequency improves. Thus, it leads to hypertrophy and an increase in maximal respiratory pressure which allows for better exercise capacity and mitigates the risk of attaining respiratory infections (Souza et al., 2014). Besides, IMT delays the occurrence of respiratory muscle fatigue. Respiratory metaboreflex is a reflex known to regulate the cardiovascular system during a strenuous activity whereby the work of breathing (WOB) and cardiac output is decreased leading to an increase in the blood flow of the peripheral limbs (Lomax, Grant, and Corbett, 2011). According to Harms & Craig (2007), the reduction in cardiovascular response was because of the desensitization of the nerve fibres that innervates the respiratory muscles. It could also be due to the constant exposure to collective metabolites linked with IMT that results in the poor responsiveness of the nerve fibres to the chemical stimulants in the CR system.

Recent research was conducted to study the effects of IMT on long distanced runners (Rożek-Piechura et al., 2020). In this study, the long-distance runners depicted a significant increase in lung ventilation and respiratory muscles after 8 weeks of training. The results of this study also showed that IMT on running has reduced the lactate accumulation of the subjects. In an experimental study, 17 elite athletes were required to run in the long and middle distanced program and undergo IMT to understand its effects on running performance (Barnes and Ludge, 2021). This study interprets that not only the performance and endurance increase after running a 3.2 km run but the rate of perceived exertions (RPE) is also reduced. Ergo, dyspnea can be improved by implementing IMT into the running. Nevertheless, IMT is known to enhance the training and LF capacity of middle-distance runners. In a 10-weeks intervention of IMT on middle-distance runners, the maximal oxygen volume and lactic acid threshold had improved greatly (Enoksen, Shalfawi, and Tønnessen, 2011). The running economy of the subjects also improved due to the enhancement of their endurance capacity. Similarly, another study investigated the LF on middle-distance runners in a 0.8km run.

Based on a study conducted by Paiva et al. (2015), when compared incentive spirometry with threshold IMT, the latter displayed a greater improvement in the LF after a month of intervention. In a systemic review, IMT is known to act as an ergogenic tool to enhance an athlete's performance and CR functions (Karsten et al., 2018). Electronic spirometry (ES) is a portable device known to record the dynamic lung volumes which include FVC, FEV1 and FEV1/FVC ratio to scrutinize for any presence of respiratory diseases in a person (Carpenter et al., 2018). Several studies have signified the strong validity and reliability of ES in assessing CR conditions (Ring et al., 2021). Despite the lack of study of ES used by performance coaches and in clinical settings, the use of ES has been slowly gaining acceptance in obtaining LF measurements (Al Rasyid, Sulistiyo, and Sukaridhoto, 2018). According to Enright and Unnithan (2011), at least 60% of the maximal inspiratory pressure (MIP) effort on the IMT is required to project significant improvements in the LF.

The implication of this research was to study the efficiency of threshold IMT when applied in long and middle distanced runners. It is to test the efficacy of the tool in enhancing the LF in these individuals undergoing medium-intensity exercise. This study also implies that IMT should be implemented in different clinical setups to increase CR endurance and reduce susceptibility to CR conditions. Both conditioning and endurance should be fairly prioritized with the other components such as strengthening and balance exercises. It is also to investigate any differences that could result from IMT on long-distance and middle-distance runners.

Methodology

This was a quantitative approach to research, whereby a quasi-experimental design was used with the pre-test and post-test design (White, H. and Sabarwal, S., 2014). The University Ethical Review scrutinized all the procedures in this research. The participants in this study were obtained through simple random sampling (Acharya, A.S., et al., 2013). The sample size of this study was calculated with regard to the prevalence rate of physically active people among Malaysians in 2019. It was noted that 75% of adults in Malaysia perform physical exercises that include running (Khoo, S., et al., 2020). A sample size of 24 was attained in this study from 26 young adults that were screened depending criteria of this study. However, only 20 of the participants met the inclusion criteria and were part of this study. The remaining 4 participants were unable to meet the inclusion criteria. Subjects who failed to keep up with the training for at least two weeks were dropped out. The inclusion criteria of this study include subjects who were physically active for the past 12 months, young adults of age 18-26, and males and females. Males and females are subjected to different anatomical built as men depict bigger bodies built with bigger ribcages, lungs and diaphragms but this regulation does not affect the LF (LoMauro and Aliverti, 2018).

The exclusion criteria for this study are an active smoker (Tantisuwat and Thaveeratitham, 2014), subjects with cardiorespiratory symptoms and absence of underlying diseases such as diabetes, pneumothorax and hypertension (Ostrowski and Barud, 2006).

The subjects were split into two groups. Group 1 is the long-distance running group had to undergo a 5km run while Group 2 is the middle-distance running group had to undergo a 1.5km run. After every session, a threshold IMT device will be provided to the subjects and they have to do 30 breaths of 1 set. The threshold IMT was obtained by PHILIPS RESPIRONICS company with a MIP of 41 cm $H2O$. Both the groups are required to perform 60% of MIP which is 24.6 cm $H2O$, in the first two weeks and later 70% of MIP equivalent to 28.7 cm $H2O$, in the last two weeks. The instructions were to inhale deeply into the threshold IMT and exhale away from the device. The cycle was repeated for 30 repetitions. Subjects were also required to run three times per week for four weeks. Subjects were required to exhale through the ES to obtain the FVC and FEV1 readings in the pre-test and the post-test phase. Data were then collected and put into a table for analysis.

Results

Table 3.1: Demographic Data of The Subjects

	N	Mean	Median	Mode	SD	Minimum	Maximum
Gender	20	1.50	1.50	1[a]	0.513	1	2
Age	20	24.00	24.00	23	1.376	21	26
Height	20	164.50	164.50	170a	8.010	150	175
Weight	20	62.71	64.00	53	11.979	45	81

Multiple modes exist. The smallest value is shown

N: Number of subjects

SD: Standard Deviation

Table 3.2: Mean Comparison of Group 1 and Group 2 after 4 Weeks of Intervention

	Group	N	Mean	SD	Std. Error Mean
FVC Before	Group 1	10	3.3150	0.54339	0.17183
Training	Group 2	10	3.0340	0.60531	0.19142
FVC After	Group 1	10	3.5820	0.53431	0.16896
Training	Group 2	10	2.9870	0.60566	0.19153
FEV1 Before	Group 1	10	3.2870	0.53901	0.17045
Training	Group 2	10	3.3230	0.61485	0.19443
FEV1 After	Group 1	10	3.5670	0.53271	0.16846
Training	Group 2	10	3.2940	0.60947	0.19273

N: Number of subjects

SD: Standard deviation

Table 3.2 shows the means and standard deviation values of FVC and FEV1 for Group 1 and Group 2. Group 1 has a mean value for FVC of (3.3150±0.54339) before training and (3.5820±0.53431) after training. Group 2 however showed (3.0340±0.60531) before training and (2.9870±0.60566) after training. For FEV1 values, Group 1 has a mean value of (3.2870±0.53901) before training and (3.5670±0.53271) after training. On the other hand, Group 2 has (3.3230±0.61485) before training and (3.2940±0.60947) after training.

Table 3.3: Independent T-test Between Groups after 4 Weeks

		p-value	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
					Lower	Upper
FVC After Training	Equal variances assumed	1.142	0.595	0.255	0.058	1.132
FEV1 After Training	Equal variances assumed	1.230	0.273	0.256	-0.265	0.811

Table 3.3 depicts the *p*-value for comparison of Group 1 and Group 2 after 4-weeks of interventions. The FVC values have a mean difference of 0.595±0.255, while the FEV1 values have a mean difference of 0.273±0.256. Based on the data above, there is no significant difference between Group 1 and Group 2 whereby the *p*-value for FVC after 4 weeks of intervention is 1.142 ($p>0.05$), and 1.230 ($p>0.05$) for FEV1.

Discussion

Eastwood, Hillman, and Finucane (2001) conducted a study in observing the inspiratory muscle performance in marathon runners and sedentary runners. The results showed that there was no significant difference in comparing the two groups when IMT was introduced. By keeping the perceived effort or Borg's Scale maximal in both groups, it showed that the efficiency of the respiratory muscles in adapting to respiratory pressure was the same. Meanwhile, a recent study was conducted by Oliveira et al. (2018), whereby the effectiveness of IMT was evaluated in subjects who exercise regularly compared to sedentary lifestyle subjects. The outcome was both groups showed improvements in the LF but when compared between the two groups, the results did not show any significance. It was understood that it was more sensory conditioning rather than respiratory muscle conditioning which allowed both groups to excel in terms of LF after the intervention. According to Faghy, et al. (2021), IMT or any respiratory resistive device can greatly impact the inspiratory volume and overall LF. As this study looks into the effectiveness of IMT in subjects who run 5km and perform High-Intensity Interval Training (HIIT), the results portray similar values. The performance and running endurance significantly improve allowing for higher maximum oxygen volume (VO2max) and better physiology. Nonetheless, different exercise physiology is distinguished and the time frame of this experimental study was longer with a higher intensity as the intervention led to respiratory muscle fatigue so greater muscle adaptation is achieved.

Contradictory to recent studies, one study claimed that by constantly adding resistive load to the respiratory muscles, the activation of metaboreflex may disrupt the exercise performance. This is because breathing with resistance to task failure results in the sympathetic system being activated and also induces peripheral vasoconstriction **(**Callegaro, C.C., et al., 2011). Albeit, demonstrating an increase in heart rate and better endurance of the whole body for sedentary lifestyles and trained individuals, inducing 60% of MIP prompts a declination of the respiratory muscle metaboreflex, especially in trained individuals. The study also suggested that implementing 40% of MIP in IMT will not allow any effects on the respiratory LF even with aerobic exercises conducted.

On the other hand, the MIP of this study was kept at a minimal rate whereby it would allow improvements to the LF when incorporated with running. The increase of MIP in IMT for the last two weeks of the intervention period was induced due to the adaptation of the respiratory muscles to be stronger. Consequently, the stroke volume and oxygen-carrying capacity is enhanced (McKenzie, 2012). Distance is not a prime variable that could alter the results. In relative to this matter, the intensity, frequency and duration of IMT to improve the LF does not have a fixed program as long as the is moderate exertion on the respiratory muscles (Seixas, et al., 2020). Notwithstanding the evidence provided, at least 4 weeks of intervention are required to allow the respiratory muscles to adapt to the change in improving the LF.

Hence, it is undeniable that IMT has the necessary benefits to our CR system and endurance. The usage of IMT as an ergogenic tool plays a role in enhancing the respiratory muscles' strength and endurance which leads to better performance in exercise capacity. IMT was also understood to contribute to better endurance in daily functional activities which includes walking and stair climbing (Ferraro et al., 2019).

Conclusion

In the denouement, the purpose of this study was to investigate the effectiveness of inspiratory muscle training on lung functions in long and middle distanced runners. The results suggest that there was no significant difference in post-test of the lung functions between both groups. Despite having a significant difference from the four weeks intervention within the two groups, the value of the results was not substantial enough to show distinguish the effectiveness of IMT on the lung functions of the subjects.

The limitation of this study is the Movement Control Order (MCO) that has been implemented for a few months in Malaysia due to the Covid-19 virus that has caused a pandemic. The restrictions imposed by the government to reduce outdoor activities have affected the process of this research in finding samples and conducting the research. This has also affected the recruitment of subjects to the study. Having a small sample could thus affect the statistics of the results.

For future studies, it is recommended that a control group is included in the study to allow the significant difference in the results between the groups and would allow the experimental study to be more valid. Also, a bigger sample with a wider variety of age groups can be executed to give rise to a more fairly distributed result. The significance of the results would be more valid and reliable.

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