Al-Rafidain Journal for Sports Sciences

https://rsprs.uomosul.edu.iq

The Effect of Inspiratory Muscle Training (IMT) on the Strength of Respiratory Muscles

Chyavan Mohammed Almufti
cheaabdurahman@gmail.com
College of Physical Education & Sport Sciences/ University of Duhok

Ahmed Taha Abdulghani
aat@uomosul.edu.iq
College of Physical Education & Sport Sciences/ University of Mosul

Article information

Article history:
Received:20/01/2024
Accepted:11/02/2024
Published online:15/04/2025

Keywords:
Respiratory Muscle training,
Inspiratory,
Diaphragm muscle

Correspondence:
chyavan mohammed almufti
cheaabdulrahman@gmail.com

Abstract

Inspiratory muscle training (IMT) puts an extra load on the diaphragm, an accessory to the inspiratory muscles, to improve their strength. Objective: This study aimed to determine the effect of an eight-week inspiratory training program (IMT) on respiratory muscle strength in second-year male students from the College of Physical Education and Sports Sciences. Methods: The experimental study design consists of pre- and post-tests for eight weeks. Twenty participants were randomly selected and divided into either the experimental group which received an IMT training program for inspiratory muscles, or the control group, which maintained their daily routine. ANCOVA tests were utilized to process the interference of post-tests statistically and to decrease the effect of pre-tests as covariates. Results: The results showed that inspiratory muscle training had a significant impact on respiratory muscle strength. Conclusion: An eight-week IMT has a positive effect on improving respiratory muscle strength.

DOI: (10.33899/rjss.2025.187262),

تأثير تدريب العضلات الشهيقية IMT على قوة عضلات الجهاز التنفسي

جيافان محمد المفتي كلية التربية البدنية وعلوم الرياضة / جامعة دهوك
cheaabdulrahman@gmail.com

احمد عبدالغني طه الدباغ كلية التربية البدنية وعلوم الرياضة / جامعة الموصل
aat@uomosul.edu.iq

تاريخ تسليم البحث (٢٠٢٤/١/٢٠) تاريخ قبول النشر (٢٠٢٤/٢/١١) تاريخ النشر (٢٠٢٥/٤/١٥)

DOI: (10.33899/rjss.2025.187262)

الملخص

يفرض تدريب العضلات الشهيقية (IMT) عبئا إضافيا على الحجاب الحاجز ، كونها عضلة مساعدة للعضلات الشهيقية لتحسين قوتها شأنها شأن العضلات الهيكلية الاخرى. هدفت هذه الدراسة إلى تحديد تأثير برنامج تدريبي شهيقي استغرق مدة ثمانية أسابيع على قوة عضلات الجهاز التنفسي لدى عينة من طلاب السنة الثانية من كلية التربية البدنية وعلوم الرياضة. تضمنت اجراءات البحث تصميم البحث التجريبي من اختبارات قبلية وبعدية على مدى ثمانية أسابيع. تم اختيار عشرين مشاركا بطريقة عشوائية وتم تقسيمهم لاحقا إما إلى المجموعة التجريبية التي تلقت برنامج تدريب العضلات الشهيقية(IMT) ، أو المجموعة الضابطة، التي حافظت على روتينهم اليومي المعتاد. تم استخدام اختبارات التغاير المشترك ANCOVA لمعالجة تداخل الاختبارات البعدية إحصائيا ولتقليل تأثير الاختبار القبلي كمتغير دخيل . أظهرت النتائج أن تدريب عضلات الشهيق كان له تأثير كبير على قوة عضلات الجهاز التنفسي. وخلصت الدراسة الى ان مدة ثمانية أسابيع من تدريب العضلات الشهيقية (IMT)كان لها تأثير إيجابي على تحسين قوة عضلات الجهاز التنفسي

الكلمات المفتاحية: تدريب العضلات التنفسية، العضلات الشهيقية، عضلة الحجاب الحاجز

Introduction

Respiratory muscle strength is a vital variable for assessing the respiratory health of athletic. It functions as an essential component in maintaining the body's supply of oxygen and remove carbon dioxide. Respiratory muscle strength is frequently overlooked as an aspect of the performance of an athlete. During workout, respiratory muscles are vulnerable to fatigue which limits their capability to work adequately, leading into insufficient oxygen supply to the working muscles. (Mackała et al., 2020; Alison McConnelí et al., 2004).

In spite of athletics is often linked with traits such as speed, strength, and endurance, the efficacy of an athlete in their sport is greatly impacted by the strength and efficiency of the muscles associated with breathing, specifically the muscles of the diaphragm and intercostal. The strength of these muscles is essential for both automatic, regular respiration and intentional, forceful breathing, making it an important component of our pulmonary health. Strong respiratory muscles are necessary for many types of activities, including everyday activities such as speaking and walking to more demanding physical activities such sports exercise.

Respiratory muscles are responsible for generating the necessary force to expand the lungs, draw air in, and expel carbon dioxide, ensuring an adequate supply of oxygen to the body's tissues. Without strong respiratory muscles, individuals may experience shortness of breath, fatigue, and reduced endurance during physical activities, and it can even affect their quality of life (Alison McConnelí et al., 2004 ;Pereira et al., 2016 ;Sapienza et al., 2011)

The impact of inspiratory muscle training (IMT) on respiratory muscle strength is garnering increasing attention in sports science, exercise physiology, and respiratory health. IMT, a targeted technique concentrating on fortifying inhalation muscles, particularly the diaphragm and intercostal muscles, holds the potential to substantially enhance the strength of these critical respiratory muscles. During physical exertion, respiratory muscles encounter fatigue, curtailing their optimal functionality and resulting in an insufficient oxygen supply to working muscles. In sports, where every molecule of energy and each millisecond of performance is pivotal. The robustness of respiratory muscles, particularly the diaphragm and intercostal muscles, can be the determining factor between success and failure (Lorca-Santiago et al., 2020;Aznar-Lain et al., 2007; Romer et al., 2002).

One method that has the possibility to improve the respiratory muscle's function is respiratory muscle training. This training approach consists of

repetitive breathing training against an external load, which can be controlled by several aspects, such as intensity, duration of training, and frequency of the exercise (Fernández-Lázaro et al., 2023, Enright & Unnithan, 2011).

So, what is the proper and adequate training load of duration or frequency or both will be produce a maximal effect on respiratory muscle strength. A lot of studies suggested that threshold training in normal average subjects has increased respiratory muscle strength (Pereira et al., 2016 ;Ray et al., 2018).

So, the work of Respiratory Muscles is so obvious in sports training. This work adds an Extra Loud on Diaphragm to improve its power and endurance (Mackała et al., 2020). Knowing effects of IMT upon Respiratory muscle strength offers further opportunities to enhance Respiratory and Sports performance. Understanding relations and complexities of training Respiratory muscles by such as Research offers a very featured source for those who looking to improve their Respiratory ability.

Purpose

This study aims at being acquainted the effects of IMT program upon respiratory muscle strength at the level of students in College of Physical Education and Sports Science at the University of Duhok.

Hypothesis

It is hypothesized in this study that students with IMT will have better strength of respiratory muscle compared to corresponding with those who do not undergo IMT.

Research problem

This study is interested with the effects of IMT upon strength of respiratory muscles which is an important concert in sports and physical fitness. Strength of respiratory muscles is critical for improving pattern of breathing, oxygen supply and sports performance. Further research is required to know how IMT

effect upon strength of respiratory muscles to improve both the health and sports performance. Understanding IMT effects is vital to building more effective sports performance. So, this study examines how IMT affect upon strength of respiratory muscle in average subjects participating in normal physical activities, to have deep insights and recommendation for training programs.

Material and Methods

The experimental design of two-groups, experimental and control featured by pre-posttests was utilized in this study.

Twenty males from the students of the second academic year in College of Physical Education and Sports Science at University of Duhok were chosen at random as samples for experimental and control groups. The inclusion criteria guaranteed that the participants were in good health, between the ages of 18 and 22, actively involved in sports, and non-smokers. The experimental group, consisting of 10 participants, completed an 8-week training program, utilizing the "big breath" device to enhance the development of their inspiratory muscles. In contrast, the control group, also including 10 participants, did not undergo any specific training. Exclusion criteria involved the absence of cardiovascular or respiratory diseases, consistent drug usage, recent surgeries, respiratory infections, and other conditions potentially conflicting with respiratory muscle training. The ethical considerations were addressed through approval from the University's Institutional Ethics Committee, and participants provided with written, informed consent. Data were collected through modern technological devices, testing, and measurement, utilizing a manometer (GM522™) for respiratory muscle strength measurement and the "BIG Breath™" Threshold IMT and PEP device for respiratory muscle training.

The study employed an experimental design with both experimental and control groups, conducting pre and post-tests. The experimental group underwent IMT using a commercially available respiratory muscle trainer (BIG

Breath™), with participants instructed to abstain from additional physical activities during the study. Respiratory muscle strength was assessed using a manometer (GM522™). The tests were performed at similar times for both groups. Exploratory experiments were conducted to identify potential challenges and ensure proper equipment use, validity, and safety. Pre- and post-training tests, conducted before and after an eight-week program, took place in the physiology lab and fitness hall at the college. The pre - test (Initial) trials involved familiarization, dietary guidelines, and scheduling to minimize diurnal effects.

A training program was conducted to enhance the development of respiratory muscles. Prior to the IMT training, instructional sessions were conducted to ensure the correct usage of the hand-held threshold IMT equipment (BIG Breath).

The training session took place in the morning at the college of physical education and sports sciences. Training was overseen to ensure the proper technique and suitable workload. The players established a suitably chosen training intensity, then donning a nasal clip and firmly grasping the mouthpiece with their lips. Subsequently, the individuals executed rapid, vigorous inhalations and deliberate, subdued exhalations.

During the IMT sessions, a pressure threshold load equivalent to 100% of the Maximum Inspiratory Pressure (MIP) was applied. In the first week, each session comprised two sets of ten repetitions, with a 60-second rest interval between sets. Each repetition lasted 2 seconds, separated by a 6-second rest interval, and a rest of 15-second pause followed the completion of each set. In the initial week, in the IMT group, the training load at 25% was set of MIP. Over the eight-week period, the load progressively increased from 30% of MIP in week 2 to 100% of MIP in week 8, concurrently extending the duration of respiratory muscle exercise. The total exercise time in the first week was 1826 seconds (≈30 minutes). By the eighth week, the respiratory

muscle exercise duration reached a total of 3646 seconds (≈60 minutes). Post-tests occurred after the 8-week program, repeating the initial measurements.

Statistical analysis

The arithmetic mean and standard deviation of the variables were determined using SPSS version 2021 for descriptive statistics. Analysis of Covariance (ANCOVA) was used to analyze the effects of interference among post-tests after removing the effect pre-test as covariate. pre- and post-IMT intervention. The level of significance for all statistical comparisons was set at $p < 0.01$.

Result

Table (1) show Descriptive Statistics of mean and standard deviation of post IMP values for participants of two groups.

GROUP	Mean	Std. Deviation	N
Control	86.8600	25.66763	10
Experiment	360.0400	309.16674	10
Total	223.4500	255.39677	20

The mean and standard deviations of the data for IMP variable as a function of post-tests for both groups are shown in Table 1. The mean and standard deviation of post-score for the control group are (86.86) and (± 309.17) respectively, whereas for the Experiment group are (360.04) and (± 25.67) respectively.

Table (2) show Estimates of mean of post IMP values for participants of two groups.

GROUP	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Control	144.36[a]	45.84	47.65	241.07
Experiment	302.54 [a]	45.84	205.83	399.25
a. Covariates appearing in the model are evaluated at the following values of pre- IMP test = 132.25.				

Table 2 display the mean of the data for IMP variable as a function of adjusted post-tests for both groups according to the pre-IMP test (132.25) as a covariate. The adjusted post-tests of Control an Experiment were (144.36) and (302.54) respectively.

Table (3) show Univariate Tests (ANCOVA) of post IMP values for participants of two groups.

	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Contrast	111230.716	1	111230.716	5.624	.030	.249
Error	336199.454	17	19776.438			
The F tests the effect of GROUP. This test is based on the linearly independent pairwise comparisons among the estimated						

Table 3 display the analysis of covariance (ANCOVA) used to analyses the effect of IMT on respiratory muscle strength by comparing post-tests between the experiment and control groups. The ANCOVA test showed significant

differences in respiratory strength tests between both groups at probability of (0.030) after 8 weeks of program training.

Discussion

Using IMT for sports and fitness has been widely investigated. IMT is a treatment that utilizes resistance threshold devices to improve respiratory muscles efficiency by increasing the endurance and strength of breathing muscles by making them more strength and more resistant to fatigue (Deme et al., 2022; Kaneko & Suzuki, 2017; Pozuelo-Carrascosa et al., 2020, Enright & Unnithan, 2011).

In many sports such as soccer, swimming and rowing, the IMT has been assessed (Katz et al., 2020). A study by Mackała et al. (2020) which measured effects of eight weeks of inspiratory muscles training for young soccer player suggested that IMT program had a significant improvement of inspiratory Muscles Strength. Another study by Volianitis et al. (2001) suggested after eleven weeks of IMT have positive effects upon performance of a rowing ergometer (Volianitis et al., 2001). In addition, another study showed an improvement of inspiratory muscles strength for 50 meter sprint swimmers after eight week of RMT (Deme et al., 2022).The finding of all these studies showed a significant improvement on inspiratory muscle strength between the treatment group in comparison to the control group after IMT program. This improvement in respiratory muscles strength was attributed to several mechanisms, including increases in muscle cross-sectional area, thus, improving strength. These enhancement in respiratory functions is probable due to a combination of factors, which include neuromuscular activation, hypertrophy, and coordination of the respiratory muscles. Moreover, these improvements in the respiratory muscle's strength could be linked to improvement in activity and concentration of enzymes involving in aerobic metabolism, consequences increasing energy production and utilization. Thus, such as these adaptation in physiological mechanisms

could improve strength of muscle. In addition, IMT could contribute to enhancing motor units. Also, certain investigations showed that such as this method of RMT could lead to Higher levels of GH and Testosterone which way Contribute furtherly to adaptation of respiratory muscles (F Everstsen et al., 1999;. Cesare Granata, 2018; Pancar, 2020 ;Ratnovsky et al., 2008; Sartorio et al., 2012; Ramsook et al. (2017).

Conclusion

IMT is a useful method to improve the strength of Respiratory muscles, contributes to hypertrophy, neuro−muscular activation and increased activity of enzymes of aerobic, may all support energy production and usage − final, this strengthens muscles controlling breathing.

Reference

1. Alison McConnelí, C. K., McConnell, A. K., & Romer, L. M. (2004): Respiratory Muscle Training in Healthy Humans: Resolving the Controversy, Int J Sports Med, 25. https://doi.org/10.1055/s-2004-815827
2. Aznar-Lain, S., Webster, A. L., Cañete, S., San Juan, A. F., López Mojares, L. M., Pérez, M., Lucia, A., & Chicharro, J. L. (2007): Effects of inspiratory muscle training on exercise capacity and spontaneous physical activity in elderly subjects: A randomized controlled pilot trial, International Journal of Sports Medicine, 28(12), 1025–1029. https://doi.org/10.1055/s-2007-965077
3. Cesare Granata, N. A. J. D. J. B. (2018): Training-Induced Changes in Mitochondrial Content and Respiratory Function in Human Skeletal Muscle, Sports Med Icine, 48.
4. Deme, S., Lamba, D., Alamer, A., Melese, H., Ayhualem, S., Imiru, D., & Abebe, T. (2022): Effectiveness of Respiratory Muscle Training on Respiratory Muscle Strength, Pulmonary Function, and Respiratory Complications in Stroke Survivors: A Systematic Review of Randomized Controlled Trials, Degenerative Neurological and Neuromuscular Disease, Volume 12, 75–84. https://doi.org/10.2147/dnnd.s348736
5. Enright, S. J., & Unnithan, V. B. (2011): Effect of Inspiratory Muscle Training Intensities on Pulmonary Function and Work Capacity in Healthy People: A Randomized Controlled Trial, HTTPs://academic.oup.com/ptj/article/91/6/894/2735033
6. Everstsen, F., Medbo, J. I., Jebens, E., & Gjovaag, T. F. (1999): Effect of training on the activity of five muscle enzymes studied on elite cross-country skiers, Acta Physiological Scandinavica.
7. Fernández-Lázaro, D., Corchete, L. A., García, J. F., Jerves Donoso, D., Lantarón-Caeiro, E., Cobreros Mielgo, R., Mielgo-Ayuso, J., Gallego-Gallego,

D., & Seco-Calvo, J. (2023): Effects on Respiratory Pressures, Spirometry Biomarkers, and Sports Performance after Inspiratory Muscle Training in a Physically Active Population by Powerbreath®: A Systematic Review and Meta-Analysis, Biology, 12(1). MDPI. https://doi.org/10.3390/biology12010056

8. Kaneko, H., & Suzuki, A. (2017): Effect of chest and abdominal wall mobility and respiratory muscle strength on forced vital capacity in older adults, Respiratory Physiology and Neurobiology, 246, 47–52. https://doi.org/10.1016/j.resp.2017.08.004
9. Lorca-Santiago, J., Jiménez, S. L., Pareja-Galeano, H., & Lorenzo, A. (2020): Inspiratory muscle training in intermittent sports modalities: A systematic review, International Journal of Environmental Research and Public Health, 17(12), 1–17. MDPI. https://doi.org/10.3390/ijerph17124448
10. Mackała, K., Kurzaj, M., Okrzymowska, P., Stodółka, J., Coh, M., & Rożek-Piechura, K. (2020): The effect of respiratory muscle training on the pulmonary function, lung ventilation, and endurance performance of young soccer players, International Journal of Environmental Research and Public Health, 17(1). https://doi.org/10.3390/ijerph17010234
11. Pancar, Z. (2020): Effects of Inspiratory Muscle Exercise on Liver Enzymes, Creatine Kinase, and Albumin Levels in Cigarette Addicts, International Journal of Applied Exercise Physiology, 9(8). www.ijaep.com
12. Pereira, R. N., Abreu, M. F. R., Gonçalves, C. B., Corrêa, W. F. S., Mizuhira, D. R., & Moreno, M. A. (2016): Respiratory muscle strength and aerobic performance of wheelchair basketball players, Motriz. Revista de Educacao Fisica, 22(3), 124–132. https://doi.org/10.1590/S1980-6574201600030002
13. Pozuelo-Carrascosa, D. P., Carmona-Torres, J. M., Laredo-Aguilera, J. A., Latorre-Román, P. Á., Párraga-Montilla, J. A., & Cobo-Cuenca, A. I. (2020): Effectiveness of respiratory muscle training for pulmonary function and walking ability in patients with stroke: A systematic review with meta-analysis, International Journal of Environmental Research and Public Health, 17(15), 1–22. MDPI AG. https://doi.org/10.3390/ijerph17155356
14. Ramsook, A. H., Molgat-Seon, Y., Schaeffer, M. R., Wilkie, S. S., Camp, P. G., Reid, W. D., Romer, L. M., & Guenette, J. A. (2017): Effects of inspiratory muscle training on respiratory muscle electromyography and dyspnea during exercise in healthy men, Journal of Applied Physiology, 122(5), 1267–1275. https://doi.org/10.1152/japplphysiol.00046.2017
15. Ratnovsky, A., Elad, D., & Halpern, P. (2008): Mechanics of respiratory muscles, Respiratory Physiology and Neurobiology, 163(1–3), 82–89. https://doi.org/10.1016/j.resp.2008.04.019
16. Romer, L. M., McConnell, A. K., & Jones, D. A. (2002): Effects of Inspiratory Muscle Training Upon Recovery Time During High Intensity, Repetitive Sprint Activity, International Journal of Sports Medicine, 23(5), 353–360. https://doi.org/10.1055/s-2002-33143
17. Sapienza, C., Troche, M., Pitts, T., & Davenport, P. (2011): Respiratory strength training: Concept and intervention outcomes, Seminars in Speech and Language, 32(1), 21–30. https://doi.org/10.1055/s-0031-1271972

18. Sartorio, A., Agosti, F., Patrizi, A., Compri, E., Muller, E. E., Cella, S. G., & Rigamonti, A. E. (2012): Growth hormone response induced by respiratory muscle endurance training in healthy subjects, Hormone and Metabolic Research, 44(4), 319–324. https://doi.org/10.1055/s-0031-1301303
19. Volianitis, A., Mcconnell, A. K., Koutedakis, Y., Mcnaughton, L., Backx, K., & Jones, D. A. (2001): Inspiratory muscle training improves rowing performance, Med. Sci. Sports Exerc, 33(5). http://journals.lww.com/acsm-msse