تأثير تدريب العضلات الشهيقية (IMT) على التهوية الطوعية القصوى(MVV)

Effect of Inspiratory Muscle Training (IMT) on Maximum Voluntary Ventilation (MVV)

chyavan mohammed almufti	*College of Physical Education & Sports Sciences / University of Duhok* *cheaabdulrahman@gmail.com*
Ahmed Abdulghani Taha	*College of Physical Education & Sports Sciences / University of Mosul* *aat@uomosul.edu.iq*

ABSTRACT

Background: Inspiratory muscle training (IMT) is a technique that applies resistance to the diaphragm and other muscles involved in inhalation and provides numerous physiological benefits, to enhance their power and function capacity. Purpose: To determine the influence of an 8-week IMT on Maximum Voluntary Ventilation (MVV). Methods: The research design incorporated both pre- and post-tests over 8 weeks. The sample of the study included twenty healthy participants who experience moderate daily physical activities. The sample was allocated at random to either the experimental group, which underwent an IMT training program, or the control group, which continued with their daily routine. The experimental group utilized a "big breath" threshold device to enhance their respiratory muscles. ANCOVA test was used to process the pre-tests of two groups. Results: Following 8 weeks of IMT, the findings indicate a considerable improvement in MVV. Conclusion: An eight-week IMT has the potential to improve MVV.

Keywords : strength of respiratory muscles, breathing threshold, respiratory function.

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جيافان محمد المفتي	كلية التربية البدنية وعلوم الرياضة / جامعة دهوك *cheaabdulrahman@gmail.com*
احمد عبد الغني طه الدباغ	كلية التربية البدنية وعلوم الرياضة / جامعة الموصل *aat@uomosul.edu.iq*

الملخص

يعد تدريب العضلات الشهيقية (IMT) من التقنيات التي تفرض مقاومة على عضلة الحجاب الحاجز والعضلات الأخرى المشاركة في الاستنشاق، وتوفر لعديد من الفوائد الفسيولوجية لتعزيز قوتها وقدرتها على الوظيفة. يهدف البحث الى تحديد تأثير تدريب العضلات الشهيقية لمدة ٨ أسابيع على التهوية الطوعية القصوى (MVV. تضمنت اجراءات البحث التصميم ذو الاختبارات القبلية والبعدية على مدى ٨ أسابيع. شملت عينة البحث عشرين مشاركا من ذوي الصحة الجيدة والممارسون للنشاط البدني بشكل متوسط. وتم

توزيع عينة البحث بشكل عشوائي إما على المجموعة التجريبية، التي خضعت لبرنامج تدريب العضلات الشهيقية، أو المجموعة الضابطة ، التي استمرت في روتينها اليومي المعتاد. استخدمت المجموعة التجريبية جهاز عتبة التنفس من نوع "bigbreath™" لتعزيز قوة عضلات الجهاز التنفسي. تم استخدام اختبار تحليل التغاير ANCOVA لمعالجة الاختبارات البعدية للمجموعتين. اسفرت النتائج بعد ٨ أسابيع من تدريب العضلات الشهيقية، تشير النتائج إلى تحسن كبير في تدريب العضلات الشهيقية. وخلص البحث الى إن تدريب العضلات الشهيقية لمدة ثمانية أسابيع لديه القدرة على تحسين التهوية الطوعية القصوى

الكلمات المفتاحية : قوة عضلات الجهاز التنفسي، عتبة التنفس، الوظيفة التنفسية.

Introduction:

Inspiratory muscle training (IMT) is an approach that involves imposing an extra load on the diaphragm along with other muscles involved in inspiration, to improve their strength and ability to sustain effort. Thus, IMT is a vital component of sports training. It enhances an athlete's physical and improves pulmonary function. The inspiratory muscles exhibit similar responses to training as other skeletal muscles, according to the principles of overload, specificity, and reversibility. Research indicates that IMT can increase the efficiency and effectiveness of the inspiratory muscles in those who are healthy as well as those with chronic obstructive pulmonary disease. (Aznar-Lain et al., 2007; Irene Carlos de Medeiros et al., 2017; Mackała et al., 2020).

Maximal Voluntary Ventilation (MVV) is a spirometry test that measures an individual's capacity to inhale and exhale as quickly as possible for 12-15 seconds while exerting the maximum amount of voluntary effort. The results of this test are expressed in liters per minute at Body temperature, pressure, and water vapor saturated (BTPS). Assessing maximal ventilation capacity and respiratory muscle endurance, the MVV test offers information about the functioning of the inspiratory pump and the chest wall. It also represents the strength of the respiratory muscles and the compliance of the chest wall. For healthy individuals of college age, a normal MVV varies from 140 to 180 liters per minute. Considerations such as respiratory muscle strength, lung-thorax system compliance, and airway resistance are considered in this all-encompassing measurement (Romer et al., 2002; Otto-Yáñez et al., 2020; Colwell & Bhatia, 2017b; Neder et al., 1999; Vašíčková et al., 2017).

This research on the effects of IMT on MVV is significant for athletes trying to progress in physical performance, pulmonary function, and aerobic capacity. Understanding how IMT impacts MVV, can demonstrate the potential benefits of this training technique for respiratory health and performance levels, making it an intriguing research field.

Research problem:

The influence of IMT on MVV value in athletes has become an essential issue in the fields of physical education and sports science. MVV has become an essential indicator of respiratory endurance for sports. It is a vital variable that determines the higher quantity of air that individuals can breathe in and out of their lungs during strong maximal breathing efforts, making it one of the key predictors of respiratory performance. This study attempts to explore the extent to which IMT influences MVV in men participating in average physical activities, to understand its potential benefits in improving respiratory health and aerobic capacity. By examining this research problem, the study endeavors to provide valuable insights into the possibility of IMT to improve the functions of the respiratory system, endurance, and overall athletic performance. This current research problem provides the complex connection between respiratory health and sports performance. Moreover, it highlights the possible advantages that may be obtained from utilizing these respiratory training techniques to optimize respiratory muscle function. The findings of this study offer the potential to formulate respiratory training methodologies that can benefit athletes across multiple sports disciplines, thereby making a positive contribution to the success and welfare of the athletes.

Purpose:

This study aims to determine the impact of IMT on the performance of MVV in students enrolled in the College of Physical Education and Sports Science at the University of Duhok.

Hypothesis:

This study hypothesizes that the IMT-trained males will have better MVV values than untrained males.

Methods:

The study utilized an experimental research design with two groups: the control group and the experimental group. Both groups underwent pre- and post-tests. A total of twenty male students from the second academic year at the University of Duhok, College of Physical Education and Sports Sciences, were assigned at random to either the experimental group or the control group. The inclusion requirements were that participants be in good health, between the ages of 18 and 22, actively involved in sports, and not smoke. The experimental group, which included ten individuals, went through an eight-week training program in which they used the threshold (big breath™) gadget to help their inspiratory muscles strengthen. In contrast, the control group of ten volunteers

received no specialized training. Exclusion criteria included the absence of cardiovascular or respiratory problems, habitual drug use, recent surgical operations, respiratory infections, and other characteristics that could interfere with respiratory muscle training. The ethical concerns were addressed by gaining permission from the university's Institutional Ethics Committee, and participants were required to provide written consent after being fully informed.

Data were collected utilizing up-to-date technology, including a spirometer (MIR Spiro Lab III™) to evaluate MVV as a function of respiratory muscle strength. The experimental group performed IMT with a commercially available respiratory muscle trainer, BIG Breath™ Threshold IMT, with participants told not to engage in any other physical activities during the trial. The tests were given to both groups at the same time.

Exploratory experiments were carried out to detect potential issues and ensure proper equipment utilization, accuracy, and safety. In addition, the study had trials that included familiarization, dietary instructions, and timing to minimize diurnal effects. The pre- and post-training tests were conducted at the college's physiology lab and fitness hall before and after an eight-week program. Before the IMT training, instructional sessions were undertaken to guarantee the proper use of the hand-held threshold IMT equipment (BIG Breath™). A training program was implemented to improve the development of respiratory muscles.

The training session took place in the morning. The participants chose a suitable level of training intensity and then wore a nasal clip while securely gripping the mouthpiece with their lips. Subsequently, the people engaged in rapid, vigorous inhalations and deliberate, controlled exhalations.

A pressure threshold loads equal to 100% of the MIP was utilized as a criterion to calculate submaximal loads and as a full load in certain sessions of IMT. During the initial week, each session consisted of two sets of 10 repetitions, with a 60-second interval between sets. Each repetition had a duration of 2 seconds, with a 6-second interval recovery between them, and a 15-second recovery following the completion of each set. During the first week, participants in the IMT group established a training load equivalent to 25% of their MIP. During the eight-week length, they systematically raised the intensity from 30% of MIP in week 4 to 100% of MIP in week 8, while also prolonging the duration of the respiratory muscle workout. The cumulative exercise duration throughout the initial week amounted to 1826 seconds (≈ 32 minutes). At the end of the eighth week, the length of respiratory muscle exercise amounted to a total of 3646 seconds (≈ 61 minutes).

Post-tests were administered at the end of the 8-week program, consisting of repeating the same beginning measurements.

The MVV was assessed using MIR Spiro Lab III™ spirometry. The participant assumed an upright sitting position and affixed a nasal clip before securely closing the mouthpiece. Following regular breathing, the person was instructed to engage in rapid shallow breathing for 12 seconds. Inhaling and exhaling quickly and thoroughly was necessary. The test concludes automatically after 12 seconds of rapid respiration. After this interval, the tester ceases voluntary respiration, and the program predicts the remaining 60 seconds. The computer software application used to measure pulmonary ventilation variables is directly connected to the spirometer, enabling the acquisition of all these measurements. The presented data provided the percentage of the anticipated value for age, height, and sex, measured in liters per minute.

Statistical methods:

The arithmetic mean, standard deviation, and Analysis of Covariance (ANCOVA) were used to process data statistically. Statistical package SPSS version 25 was used. ANCOVA was utilized to compare statistical differences between means of post-tests of experimental and control groups after adjusting them according to their corresponding post-tests as covariates. The statistical comparisons were conducted with a predetermined level of significance at $p < 0.01$.

Result:

Table (1) shows Descriptive Statistics of MVV values collection of Post-tests in rest for participants of two groups.

GROUP	Mean	Std. Deviation	N
Control	142.43	57.62	10
Experiment	206.06	21.16	10
Total	175.92	52.58	19

MVV = maximal voluntary ventilation, measured in liters per minute

Table 1 displays Descriptive Statistics of the actual MVV values collection of Post-tests in rest for participants of two groups. The control group had a mean of (142.43) and standard deviation of (57.62). The Experiment group had a mean of (206.06) and a standard deviation of (21.16).

Table (2) shows Estimates of MVV values collection of Post-tests in rest for participants of two groups.

GROUP	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Control	146.55[a]	13.38	118.20	174.91
Experiment	202.34[a]	12.67	175.48	229.21
a. Covariates appearing in the model are evaluated at the following values of the Pre MVV test in Rest = 177.12.				

Table 2 displays Estimates of MVV values collection of Post-tests in rest for participants of two groups. The adjusted means of post-tests were according to the value of the pre-test (177.12). The control group had an adjusted mean of (146.55). The Experiment group had an adjusted mean of (202.34).

Table 3 displays Univariate Tests (ANCOVA) of MVV values collection of Post-tests in rest for participants of two groups.

	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Contrast	14002.02	1	14002.02	8.94	0.009	0.36
Error	25064.31	16	1566.52			

Table 3 displays Univariate Tests (ANCOVA) of MVV values collection of Post-tests in rest for participants categorized by both groups before and after training. The Fisher F value was (8.94) at probability of (0.009). this finding suggests a considerable deference is statistically significant.

Discussion:
IMT is a sort of exercise that concentrates on the muscles of breathing such as the diaphragm and intercostal. It has been shown that it enhances endurance, MVV, and respiratory muscle strength in both healthy people and those with respiratory diseases like asthma and obstructive pulmonary disease.(Otto-Yáñez et al., 2020; Neder et al., 1999; Neufeld et al., 2018)

Several studies have demonstrated that respiratory muscle training positively impacts the evaluation of MVV and lung function. The investigations have shown the positive influences of IMT training on these participants. (Lumb, 2016; Ouattara et al., 2020; Otto-Yáñez et al., 2020).

The mechanism that is behind this improvement is probably a consequence of the increasing strength and endurance of the respiratory muscles, which allows for increasing ventilation and oxygen delivery to the body. Furthermore, respiratory muscle training has been shown to improve the contractile properties of the diaphragm and increase neuromuscular activation of the respiratory muscles. (Ouattara et al., 2020; Neufeld et al., 2018)

IMT helps athletes improve respiratory muscle endurance, which allows them to maintain maximal ventilator efforts for extended durations. Moreover, IMT assists in enhancing a breathing pattern that is more efficient and coordinated, and this leads to decreased breathing effort and facilitates better ventilation rates during MVV tests, delaying fatigue during intense physical exertion. Additionally, RMT may lead to adaptations in the respiratory system, such as increased lung volumes and improved gas exchange efficiency, which can also contribute to the increase in MVV at rest. (Mackała et al., 2020; Markov et al., 2001; Colwell & Bhatia, 2017; Bender & Martin, 1985)

Conclusion:

This study explores the relationship between IMT and MVV, shedding light on how IMT can affect MVV. the evidence suggests that IMT can improve respiratory muscle function in healthy individuals, leading to increased lung function and exercise capacity. These improvements are thought to be related to the increased strength and endurance of the respiratory muscles, which allows for greater air movement in and out of the lungs. Thus, it offers a comprehensive understanding of the advantages of this training method for athletes and other individuals who are looking to improve their respiratory health.

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