National Institute of Longevity Elderly Sciences
NILES Journal for Geriatric and Gerontology
Abu ElFtouh KAM, HVLAM on Smoking Quitters
Volume 8, Issue 1
Original Article

Effect of High-velocity Low-amplitude Manipulation on Ventilatory Functions among Male Smoking Quitters

Kareem Adel Mohamed Abu ElFtouh[1*], Hany Ezzat Obaya[2], Mona Ahmed Mohamed Abdelwahab[3], Alaa Mohamed El-Moatasem Mohamed[3]

[1]Physical Therapy Department, October Administration, Egypt

[2]Physical Therapy for Cardiovascular/Respiratory Disorders and Geriatrics Department, Faculty of Physical Therapy, Cairo University, Cairo, Egypt

[3]Physical Therapy for Cardiopulmonary Disorders and Geriatrics Department, Faculty of Physical Therapy, Cairo University, Cairo, Egypt

Email: Adelkareem302@gmail.com, **Mobile:** +201068908618

Abstract

Background: Recent smoking quitters are still affected by their previous smoking years in the form of breathing limitations and alterations. Thoracic spinal manipulation is capable of resolving ventilation inefficiency. ***Aim:*** Our aim is to ascertain the impact of thoracic spine high-velocity, low-amplitude manipulation (HVLAM) on ventilatory functions among male smoking quitters. ***Design:*** This is a randomized, two-group pre–post-test, controlled study. ***Setting:*** Health Units in the 6th of October City, Egypt. ***Subjects:*** This study enrolled 54 males aged 35–50 years who were smoking quitters of less than one year and were equally allocated at random into groups A and B. Group A received HVLAM intervention for the thoracic spine along with a conventional physical therapy (CPT) program for the chest in the form of diaphragmatic and pursed-lip breathing exercises, mobility exercises for thoracic spine in the form of foam roll hyper-extension exercise, chest expansion exercise (Open book) and thoracic hyper-extension from kneeling. Group B only received the CPT program. Both groups received sessions twice weekly for 8 weeks. ***Tools:*** Participants were evaluated by a computed spirometer to assess ventilatory functions and a 12-item Short Form Health Survey (SF-12) to assess quality of life. Outcome measures were forced vital capacity (FVC), maximum voluntary ventilation (MVV), forced expiratory volume in 1 s (FEV1), physical component summary (PCS), and mental component summary (MCS). ***Results:*** Ventilatory functions and the SF-12 survey both improved significantly within both groups. Moreover, groups A and B had significantly increased ($P<0.05$) FVC, MVV, FEV1, PCS, and MCS post-treatment compared to pre-treatment, with nonsignificant differences between both groups. Moreover, group A showed more improvement in FVC (68.63% vs. 62.69%), MVV (9.46% vs. 8.91%), FEV1 (46.10% vs. 36.21%), PCS (30.39% vs. 29.79%), and MCS (13.67% vs. 12.26%) than Group B. This indicates that both groups showed improvement in ventilatory functions and the SF-12 survey, with group A displaying more percentage of improvement. ***Conclusion:*** Thoracic HVLAM did not significantly impact ventilatory functions in male smokers, but it resulted in a higher percentage of improvement. ***Recommendations:*** Male smoking quitters should consider incorporating thoracic spine HVLAM with the CPT into their rehabilitation program to improve their ventilatory functions effectively.

Keywords: High-velocity-low-amplitude thrust; Smoking quitters; Mobility exercises; Manipulation; Ventilatory functions

Receive Date: 20/7/2024	Accept Date: 1/8/2024	Publish Date: 1/1/2025

Print ISSN 2636-3224
Online ISSN 2636-3232

Introduction

Smoking exerts numerous detrimental impacts on the various systems inside the human body, specifically the respiratory system [1]. Smoking addiction is a significant risk factor leading to bronchial hypersensitivity, airway congestion or constriction, as well as asthma and lung cancer [2]. Smoking-induced lung diseases propagate from small to larger air passages [3]. Former smokers continue to have respiratory limitations and changes as a result of their prior years of smoking. Smoking additionally diminishes pulmonary functioning by reducing forced expiratory volume in 1 second (FEV1) and forced vital capacity (FVC) [4]. Exposure to cigarette smoke results in a rapid decrease in FEV1, ultimately causing a blockage in the airways (FEV1/FVC < 0.7). The presence of emphysema, either alone or in combination with various inflammatory cells and mucus, is responsible for the structural anomaly that leads to airflow obstruction and decreased flow rates [5]. This abnormality specifically causes the narrowing of the small airways. Smoking cessation does not completely reverse the accelerated rate of decline, suggesting that individuals with limited smoking histories are nonetheless susceptible to developing lung diseases with symptoms in years to come [6].

Exercise and physical activity have a direct impact on the respiratory system. Thoracic spinal manipulation (TSM) can enhance the mobility of the chest wall, intervertebral, and costovertebral joints [7]. Performing joint mobility exercises for the spinal segments enhances muscle efficiency by preventing excessively utilizing besides strengthening the erector spinae muscle [8]. Furthermore, these exercises promote performance by enabling proper muscle usage. In addition, enhancing the movement of the muscles surrounding the joint helps optimize joint motion [9]. Thoracic and spinal joint mobilization exercises can effectively address breathing inefficiencies resulting from chest pump malfunction [10]. Prior to the occurrence of irreversible injury to the pulmonary blood vessels, it is necessary to execute corrective procedures for chest cage deformations and engage in exercises aimed at enhancing chest wall flexibility in order to alleviate pressure on the lung parenchyma [11].

Therefore, we aim to evaluate the impact of thoracic spine high-velocity, low-amplitude manipulation (HVLAM) on ventilatory functions among male smoking quitters. This study intends to gain insights into the possible benefits of HVLAM in managing deficits in ventilatory function by analyzing changes in functions using computed spirometers like Spiro-Spectrum.

Materials and methods

Participants

This randomized, two-group pre–post-test, controlled study enrolled 54 males aged 35–50 years who were smoking quitters of less than one year from Health

Print ISSN 2636-3224
Online ISSN 2636-3232

Units in the 6th of October City, Egypt, and were allocated randomly into groups A and B.

Group A received HVLAM intervention for the thoracic spine along with a conventional physical therapy (CPT) program for the chest in the form of diaphragmatic and pursed-lip breathing exercises, mobility exercises for the thoracic spine in the form of foam roll hyper-extension exercise, chest expansion exercise (Open book) and thoracic hyper-extension from kneeling. Group B only received the CPT program. Both groups received sessions twice weekly for 8 weeks.

The study included patients who were smokers for 10 years or less, had a body mass index (BMI) of 18.5–24.9 kg/m^2, had less than 1 year of cessation, and did not perform routine exercises. Patients were excluded if they could not understand and follow verbal instructions, were athletes, had any cardiovascular, abnormal chest wall, spinal deformities, previous chest surgery or respiratory disorders, had a history of aneurysm, uncontrolled blood pressure, any metabolic disorders (diabetes) or were medically unstable **(Figure 1)**.

Randomization was conducted for the 54 participants utilizing 54 closed envelopes prepared by the researcher, and each envelope had a card labeled as either Group A or B. Each patient was requested to choose a closed envelope through 1:1 simple randomization to be allocated at random to either group A or B (n = 27/group).

The Scientific Research Ethics Committee of Faculty of Physical Therapy, Cairo University, authorized the study (P.T.REC/012/005046). Participants were aware of the trial's nature and effects and signed informed consent

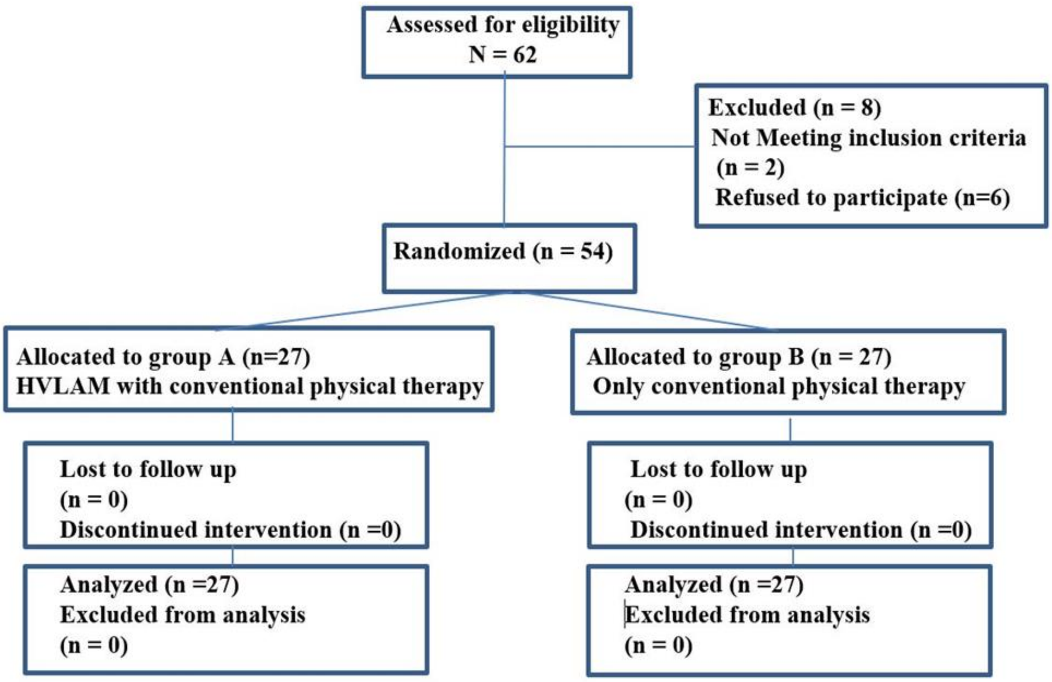

Figure 1. Study flow chart.

Print ISSN 2636-3224
Online ISSN 2636-3232

Procedures

Evaluation Procedures

Spirometric measurements, including FVC, FEV1, and maximum voluntary ventilation (MVV), were documented for each participant using a spirometer pre- and post-intervention. Spirometry (Russia, 2017) is a simple test diagnosing and monitoring lung conditions by measuring the exhaled air in one forced breath. Body mass and height were measured to estimate the value of BMI for each participant. Each participant in both groups fulfilled a 12-item Short Form Health Survey (SF-12) that evaluates eight health domains to evaluate physical and mental health.

Treatment Procedure

Group A received an eight-week CPT with two HVLAM sessions weekly, while Group B (Control) received only the CPT program for eight weeks, two sessions weekly.

HVLAM program

The therapist positions themselves on the opposite side of the thoracic rotation. From the therapist's viewpoint, when the participant crosses their arms, the arm on the opposite side of where they are standing should be positioned on top. From the participant's viewpoint, the arm on the side of the thoracic rotation should be placed on top. The therapist extends their arm across the patient and positions their thenar eminence behind the posterior transverse process. The therapist applies pressure to the participant's crossed elbows using their epigastric area. The therapist's other hand elevates the participant's head and trunk, causing the hand on the posterior transverse process to experience pressure from leaning on the elbows. The participant is instructed to inhale deeply as the therapist applies pressure to the elbows during exhale. During maximum exhalation, the therapist forcefully delivers a sudden and brief movement from the trunk onto the participant's elbows in order to mobilize the joint. Subsequently, the participant should have a reassessment following the manipulation. The participant is thereafter reevaluated [12].

The CPT program for the chest and mobility exercises for the thoracic spine were in the forms of :

1- The foam roll hyper-extension exercise involves lying face up with the glutes and shoulders on the ground (crook lying). The foam roller was placed behind the upper thorax and used as a pivot to arch the spine backward. This exercise flexes and extends the spine, using the foam roller as a pivot point along the mid to upper back [13].

2- Chest expansion exercise (Open book): The participant got into a half-kneeling position; his elbows were extended, and his arms were in 90-degree flexion abduction. The participant then rotated his body towards the flexed hip

Print ISSN 2636-3224
Online ISSN 2636-3232

side, taking a breath in while rotating, breathing out while returning, and repeating [14].

3- Thoracic hyper-extension from kneeling: The participant got into a kneeling position and then bent forward to put his elbows and forearms on a surface (chair, ball). The participant then dropped his chest downward, increasing the back extension, held for 1-2 min, and repeated five times [15].

4- Diaphragmatic breathing exercise: The participant assumed a comfortable position, inhaling through the nostrils for approximately 4 s, allowing the abdomen to expand. They then held their breath for 2 s before exhaling slowly and steadily through the mouth for roughly 6 s, ensuring that the mouth remains relaxed and the abdomen contracts. This cycle was repeated for 5 min [16].

5- Pursed-lip breathing exercise: The participant inhaled through the nose for 2 s and pursed their lips as if preparing to extinguish the candles on a cake. Then, they exhaled gradually and steadily via pursed lips for 4–6 s and repeated if necessary [17].

Sample size calculation

The sample size was determined through the G*power software 3.1.9 (G power program version 3.1, Heinrich-Heine-University, Düsseldorf, Germany). The effect size used in the sample size calculation was selected following the findings of prior studies [18, 19]. Sample size calculation was performed using F tests (MANOVA: Special effects and interactions) with the following parameters: Type I error (α) = 0.05, power (1-β error probability) = 0.80, effect size f2 (V) = 0.2309871, and Pillai V = 0.3752876. The total sample size required for comparing two independent groups on five major variable outcomes was determined to be 40 participants. Given a dropout rate of 15%, the study requires a minimum sample size of 46 patients (with a minimum of 23 patients in each group) **(Figure 2)**.

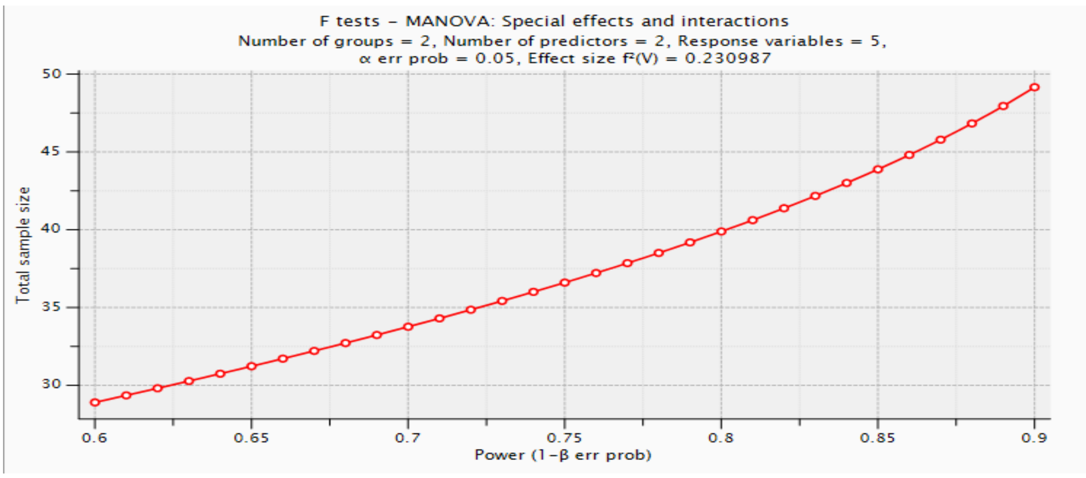

Figure 2. Sample size calculation.

Print ISSN 2636-3224
Online ISSN 2636-3232

Statistical analysis

The statistical analysis was performed employing the SPSS version 25 for Windows (SPSS, Inc., Chicago, IL). The subsequent statistical analyses were carried out: The quantitative descriptive statistics data included the mean and standard deviation for various general characteristics of male smoking quitters (age, BMI, smoking years, cessation time, and cigarette number/day) as well as data for variables such as FVC, MVV, FEV1, physical component summary (PCS), and mental component summary (MCS). An independent t-test was conducted to compare the general characteristics and factors of the participants between both groups. The study employed multivariate analysis of variance (MANOVA) to compare the primary dependent variables (FVC, MVV, FEV1, PCS, and MCS) across different groups and periods. A mixed design 2 x 2 MANOVA test was conducted, with the first independent variable being the tested groups, which had two levels (Group A vs. B). The second independent variable, which was a within-subject component, involved measuring periods with two levels: pre- and post-treatment.

Results

Baseline Characteristics

The baseline characteristics, including age, smoking duration, and BMI, were comparable between both groups (**Table 1).**

Table 1. Participants' general characteristics.

Items	Participant general characteristics				
	Age (Year)	BMI (kg/m^2)	Years of smoking	Time of Cessation	Number of cigarettes/day
Group A (n=27)	40.96 ±3.53	23.40 ±1.26	3.27 ±1.35	5.44 ±1.71	11.89 ±3.93
Group B (n=27)	42.48 ±4.83	23.26 ±1.44	2.88 ±0.89	4.30 ±1.33	10.70 ±2.10
t-value	1.861	0.370	1.246	1.360	1.443
P-value	0.096	0.713	0.218	0.180	0.162
Significance	NS	NS	NS	NS	NS

Data represent mean ±standard deviation (SD); P-value: probability value; NS: non-significant

FVC Comparison

Within groups A and B, FVC (P=0.001) significantly increased post-treatment compared to pre-treatment ($P < 0.05$), with mean differences (change) of 1.75% and 68.63% as well as 1.63% and 62.69%, respectively **(Figure 3A)**. Between both groups, FVC did not significantly differ post-treatment compared to pre-treatment **(Figure 3B)**. However, group A displayed an increase in FVC percentage of improvement post-treatment (68.63%) than group B (62.69%).

Print ISSN 2636-3224
Online ISSN 2636-3232

A B

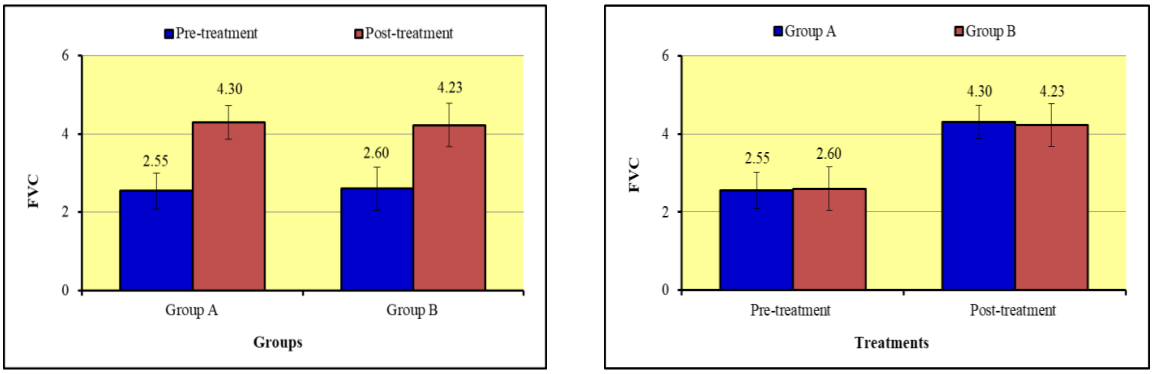

Figure 3. Mean values of FVC pre- and post-treatment within (A) and between (B) groups.

MVV Comparison

Within groups A and B, MVV (P=0.001) significantly increased post-treatment compared to pre-treatment ($P < 0.05$), with mean differences (change) of 9.30% and 9.46%, as well as 8.78% and 8.91%, respectively **(Figure 4A)**. Between groups A and B, MVV did not significantly differ post-treatment compared to pre-treatment. Nevertheless, group A had a higher MVV percentage of improvement post-treatment (9.46%) than group B (8.91%) **(Figure 4B)**.

A B

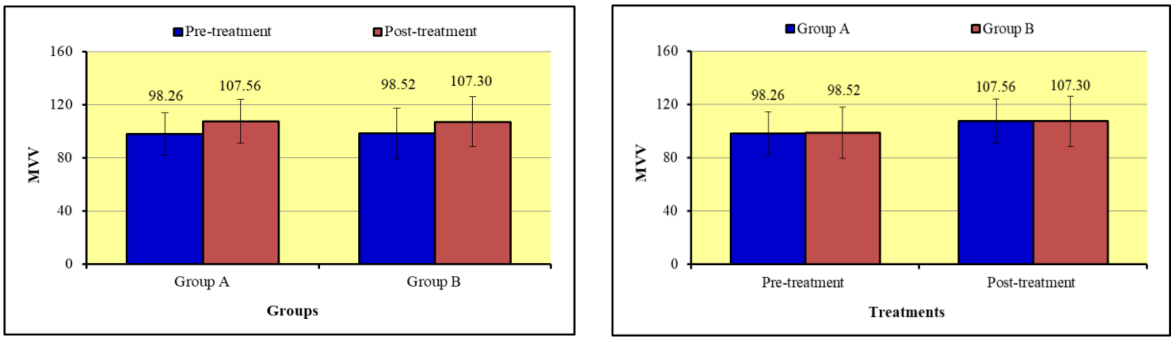

Figure 4. Mean values of MVV pre- and post-treatment within (A) and between (B) groups.

FEV1 Comparison

Within groups A and B, FEV1 (P=0.001) was significantly increased post-treatment compared to pre-treatment ($P<0.05$), with mean differences (change) of 1.36% and 46.10%, as well as 1.09% and 36.21%, respectively **(Figure 5A)**. Between groups A and B, FEV1 had no statistically significant differences post-treatment compared to pre-treatment. Nonetheless, group A exhibited a higher FEV1 percentage of improvement post-treatment (46.10%) than group B (46.10%) **(Figure 5B).**

Print ISSN 2636-3224
Online ISSN 2636-3232

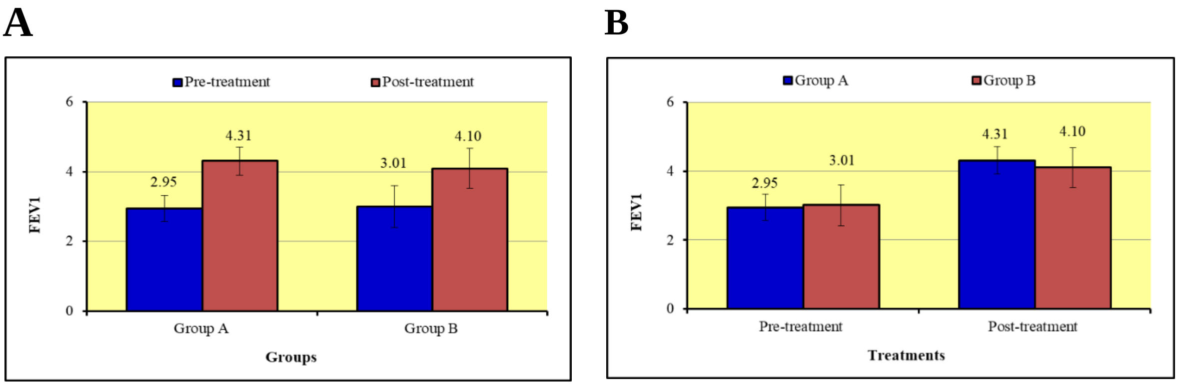

Figure 5. Mean values of FEV1 pre- and post-treatment within (A) and between (B) groups.

PCS Comparison

Within groups A and B, PCS (P=0.001) was significantly increased post-treatment compared to pre-treatment (P<0.05), with mean differences (change) of 10.51% and 30.39%, as well as 10.28% and 29.79%, respectively **(Figure 6A)**. Between groups A and B, PCS did not significantly differ post-treatment compared to pre-treatment. Meanwhile, group A had an increased PCS percentage of improvement post-treatment (30.39%) compared with group B (29.79%) **(Figure 6B)**.

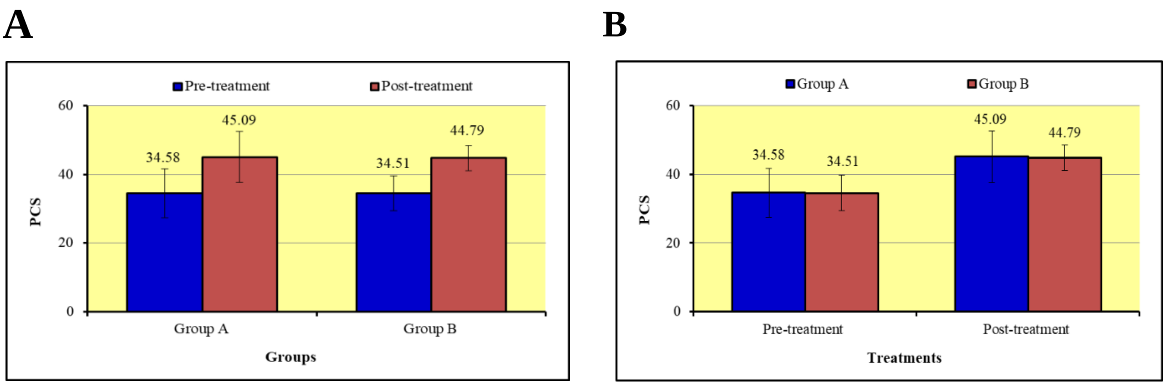

Figure 6. Mean values of PCS pre- and post-treatment within (A) and between (B) groups.

MCS Comparison

Within groups A and B, MCS (P=0.001) significantly increased post-treatment compared to pre-treatment (P<0.05), with mean differences (change) of 5.57% and 13.67%, as well as 5.18% and 12.26%, respectively **(Figure 7A)**. Between groups A and B, MCS did not significantly differ post-treatment compared to pre-treatment. However, group A had an increased MCS percentage of improvement post-treatment (13.67%) compared with group B (12.26%) **(Figure 7B)**.

Print ISSN 2636-3224
Online ISSN 2636-3232

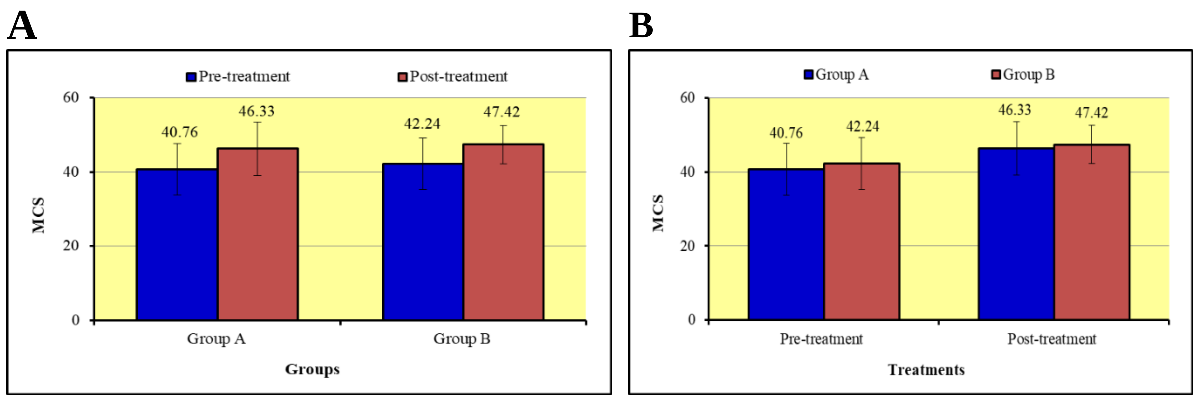

Figure 7. Mean values of MCS pre- and post-treatment within (A) and between (B) groups.

Discussion

Our aim was to detect the effect of thoracic spine HVLAM on ventilatory functions such as FEV1, FVC, and MVV among smoking quitters men aged 35–50 years old who were recruited from multiple Health Centers in the 6th of October City, Egypt. Participants were randomly assigned into two groups and received two sessions weekly for 8 weeks. Group A received HVLAM for the thoracic spine with chest CPT program and thoracic mobility exercises in the form of diaphragmatic breathing exercise, pursed-lip breathing exercise, foam roll hyper-extension exercise, chest expansion exercise (Open book) and thoracic hyper-extension from kneeling. Meanwhile, group B only received the CPT program chest and mobility exercises for the thoracic spine. According to our knowledge, few researchers have studied the effect of HVLAM on ventilatory functions in this specific gender and range of age, especially recording a long-term effect after multiple sessions along with conventional chest exercises and thoracic mobility exercises. Therefore, we depended on the explanation of our results on different research characteristics.

The current study found a slight increase in FEV1 in group A compared to group B, but it was not statistically significant. This aligns with a study by Williams et al.[20], who examined the lasting effects of thoracic manipulation and rib raising on spirometric measurements in 38 asymptomatic participants and revealed no significant difference in mean FEV1 between group values at 1 week. Consistently, thoracic HVLAM and types of conventional chest exercises should have an equivalent impact on enhancing pulmonary function. The study by Kleyn et al.[21] contradicts the findings of this study, in which they found an improvement in FEV1 pulmonary function due to the thoracic spine and posterior rib manipulation in the intervention group and a significant difference between the groups. Same as Shin et al.[19] demonstrated that after an intervention with TSM, the experimental group showed significantly increased FVC and FEV1 levels. In contrast, the control group that received a placebo TSM showed no

Print ISSN 2636-3224
Online ISSN 2636-3232

difference. The differences in results pre- and post-intervention may be due to the frequency of the intervention, the type of intervention in the control group, and the participants' characteristics. Meanwhile, the intervention approach in this study, where group A had HVLAM intervention and CPT program and group B only received the CPT program, minimized the difference in outcome measures. Kleyn et al.[21] and Shin et al.[19] conducted studies involving a single intervention applied to a single group, while a control group received no intervention.

Our outcomes showed a slight increase of FVC in group A, more than in group B, with a change of 5.94%, but that change was not statistically significant. These results agreed with Kleyn et al.[21] . Although their study did not come in agreement with our study in FEV1 values post-intervention, however, our results came in agreement with their results in the insignificant changes in FVC in both groups ($P > 0.05$). However, studies examining the immediate effect of HVLAM on pulmonary function, such as those by Joo et al.[18] and Shin et al. [19], who found significant differences in FVC and other ventilatory functions in the TSM group ($P < 0.05$), while no significant changes were observed in the sham group, which did not align with our study results. As an explanation, these differences between results may be attributed to whether the re-evaluation was performed immediately after the intervention or after some time. In our study, we depended on a single evaluation before starting the course of sessions and a single re-evaluation after the end of the course. Accordingly, immediate re-evaluation can significantly affect results than re-evaluation after sessions over time.

Herein, a slight increase of MVV was observed in group A more than in group B with a change of 0.55% but that change was not statically significant. These results agreed with Cordeiro et al.[17], who revealed no significant differences in MVV evaluated at five evaluation moments: baseline, 1, 10, 20, and 30 min after the TSM procedures. Nevertheless, our findings contradicted the conclusions of Jonely et al.[22], whose study reported a significant disparity in MVV among the manipulation group, as measured within one week after the third intervention session. As an explanation for the difference in outcomes, in this study, participants were smoking quitters, so there was a factor that impacted the lungs' response to an outer intervention. However, Jonely et al.'s study[22] included healthy subjects I who may have had more lung flexibility to respond to intervention and conducted an immediate reassessment post-HVLAM. Therefore, as previously stated, immediate reassessment would have had significant effects on the outcomes.

Conclusion

HVLAM application has no statistically significant difference in the ventilatory functions among male smoking quitters. However, participants who received HVLAM showed a higher percentage of improvement.

Print ISSN 2636-3224
Online ISSN 2636-3232

Limitations

This study was constrained by the relatively small sample size, which may limit generalizing the findings to a broader population. In addition, personal and individual differences between participants might affect outcome measures. Participants faced challenges in receiving several sessions, particularly in group A, as it necessitated visiting the clinic to attend the sessions. Future studies should focus on resolving the limitations mentioned in our current study. A larger sample size is required to confirm our results. Studies should evaluate the effect of HVLAM between immediate and long-term effects. Our methods should be applied to participants with moderate and severe loss in ventilatory functions. Additional research should be carried out on female participants to compare the effects for both genders and different ages with more respiratory dysfunctions.

Acknowledgment

All the participants have our deepest gratitude and appreciation. We express our genuine gratitude to EdigenomiX Scientific Co., Ltd. for their proficient editing and proofreading services, which significantly enhanced the lucidity and excellence of our article. We greatly applaud their fastidious attention to detail and assistance in revising the paper for publication.

Authors' contributions

Hany Ezzat Obaya, Mona Ahmed Mohamed Abdelwahab, and Alaa Mohamed El-Moatasem Mohamed designed the study; Kareem Adel Mohamed Abu ElFtouh, Hany Ezzat Obaya, and Mona Ahmed Mohamed Abdelwahab collected the samples and clinicopathological data; Mona Ahmed Mohamed Abdelwahab , Kareem Adel Mohamed Abu ElFtouh and Alaa Mohamed El-Moatasem Mohamed conducted experiments and the data analysis; Kareem Adel Mohamed Abu ElFtouh and Mona Ahmed Mohamed Abdelwahab wrote the manuscript; and all authors approved the final version.

Funding

No finding.

Availability of data and material

The data are available upon request.

Consent for publication

Not applicable.

Conflict of interest

No conflicts of interest.

Print ISSN 2636-3224
Online ISSN 2636-3232

References

1. Cha S-R, Jang J, Park S-M, Ryu SM, Cho S-J, Yang S-R. Cigarette Smoke-Induced Respiratory Response: Insights into Cellular Processes and Biomarkers. Antioxidants. 2023; 12: 1210.

2. Lin H, Li H. How does cigarette smoking affect airway remodeling in asthmatics? Tob Induc Dis. 2023; 21: 13.

3. Bilici MF, Genç A. The effects of smoking addiction and physical activity on some respiratory functions in female university students. Pedagogy of Physical Culture and Sports. 2020; 24: 54-8.

4. Nikniaz L, Ghojazadeh M, Nateghian H, Nikniaz Z, Farhangi MA, Pourmanaf H. The interaction effect of aerobic exercise and vitamin D supplementation on inflammatory factors, anti-inflammatory proteins, and lung function in male smokers: a randomized controlled trial. BMC Sports Sci Med Rehabil. 2021; 13: 102.

5. Hogg JC, Paré PD, Hackett T-L. The Contribution of Small Airway Obstruction to the Pathogenesis of Chronic Obstructive Pulmonary Disease. Physiol Rev. 2017; 97: 529-52.

6. Oelsner EC, Balte PP, Bhatt SP, Cassano PA, Couper D, Folsom AR, et al. Lung function decline in former smokers and low-intensity current smokers: a secondary data analysis of the NHLBI Pooled Cohorts Study. Lancet Respir Med. 2020; 8: 34-44.

7. Engel RM, Vemulpad S. The effect of combining manual therapy with exercise on the respiratory function of normal individuals: a randomized control trial. J Manipulative Physiol Ther. 2007; 30: 509-13.

8. Hooker DN, Prentice WE. Rehabilitation of injuries to the spine. Rehabilitation Techniques for Sports Medicine and Athletic Training. Routledge; 2024. p. 785-840.

9. Nelson AG, Kokkonen J. Stretching anatomy. Human Kinetics Publishers; 2020.

10. Vanti C, Golfari M, Pellegrini G, Panizzolo A, Turone L, Giagio S, et al. The Effectiveness of Pump Techniques and Pompages: A Systematic Review. Applied Sciences. 2021; 11: 4150.

11. Kim KH, Kim DH. Effects of Maitland Thoracic Joint Mobilization and Lumbar Stabilization Exercise on Diaphragm Thickness and Respiratory Function in Patients with a History of COVID-19. Int J Environ Res Public Health. 2022; 19.

12. Nim CG, Downie A, O'Neill S, Kawchuk GN, Perle SM, Leboeuf-Yde C. The importance of selecting the correct site to apply spinal manipulation when treating spinal pain: Myth or reality? A systematic review. Sci Rep. 2021; 11: 23415.

13. Sağiroğlu İ. Acute Effects of Applied Local Vibration During Foam Roller Exercises on Lower Extremity Explosive Strength and Flexibility Performance. European Journal of Physical Education and Sport Science 2017; 3.

14. Ito M, Kakizaki F, Tsuzura Y, Yamada M. Immediate effect of respiratory muscle stretch gymnastics and diaphragmatic breathing on respiratory pattern. Respiratory Muscle Conditioning Group. Intern Med. 1999; 38: 126-32.

15. Sewall H, Pollard ME. On the Relations of Diaphragmatic and Costal Respiration, with particular reference to Phonation. J Physiol. 1890; 11: 159-264.1.

Print ISSN 2636-3224
Online ISSN 2636-3232

16. Nerini M, Gigliotti F, Lanini I, Grazzini M, Stendardi C, Castellani R. Changes in global and compartmental lung volumes during pursed lip breathing (PBL) in COPD patients. Eur Respir J. 2001; 18: 489.

17. Cordeiro A, Teixeira M, Faria M, Sousa M, Serrasqueiro P, Ruivo RM. The effect of thoracic manipulation on pulmonary function in swimmers. Revista Andaluza de Medicina del Deporte. 2020; 14: 65-9.

18. Joo S, Lee Y, Song CH. Immediate Effects of Thoracic Spinal Manipulation on Pulmonary Function in Stroke Patients: A Preliminary Study. J Manipulative Physiol Ther. 2018; 41: 602-8.

19. Shin DC, Lee YW. The immediate effects of spinal thoracic manipulation on respiratory functions. J Phys Ther Sci. 2016; 28: 2547-9.

20. Williams K. An investigation of the lasting effects of thoracic manipulation and rib raising on spirometric measurements of asymptomatic participants. Victoria University; 2003.

21. Kleyn M. The effect of thoracic spine and posterior rib manipulation on pulmonary function in first year emergency medical care students. In: Yelverton C, Nugteren B, editors.: MTech, University of Johannesburg; 2019.

22. Jonely H, Jayaseelan D, Costello E, Signorino J, Wooten L, Murray D, et al. Changes in pulmonary function following thoracic spine manipulation in a healthy inactive older adult population-a pilot study. J Phys Ther Sci. 2023; 35: 492-6.

Print ISSN 2636-3224
Online ISSN 2636-3232