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Original Article

Changes in pulmonary function following thoracic spine manipulation in a healthy inactive older adult population—a pilot study

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Abstract. [Purpose] Pulmonary function pathology is primarily treated pharmacologically, with a range of medication side effects. Few studies have systematically examined non-pharmacologic approaches such as joint manipulation effects on pulmonary function. This study examined the immediate and short-term effects of thoracic manipulation on pulmonary function. [Participants and Methods] Twenty-one physically inactive otherwise healthy participants aged 50 years or older were randomly assigned to either receive three sessions of thoracic manipulation (n=10) or three sessions of “sham intercostal training” (n=11). Outcome measures included forced vital capacity, maximal voluntary ventilation and thoracic excursion during maximal inhalation and exhalation. [Results] There was a statistically significant difference in maximal voluntary ventilation in the manipulation group, when measured within a week of the third intervention session and immediate effects in thoracic excursion during exhalation in the sham group following a single intervention session. There were no significant changes in other measures. [Conclusion] Spinal manipulation had no immediate effect on pulmonary function, however, affected an improvement in maximal voluntary ventilation within 7 days following a third session. The sham intervention showed a change in thoracic excursion during exhalation after the first session. Future research is necessary to further explore the relationship between thoracic manipulation and pulmonary function.
Key words: Spinal-manipulation, Pulmonary function, Physical therapy

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INTRODUCTION

Optimal pulmonary function (PF) plays a critical role in providing oxygen to adequately meet the bioenergetic demands of the metabolic tissues that support physical activity. Declines in PF are observed with age and can have a negative impact on physical activity[1)]. Several lung diseases such as chronic obstructive pulmonary disease impair PF and result in substantial physical disability. People with impaired PF are often treated by pharmacologic agents to change airway diameter through bronchodilatory mechanisms and/or by increasing force production of the muscles of inspiration to remediate losses in function. However, these agents have many deleterious side effects.

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One understudied intervention with potential to improve PF is thoracic joint manipulation. Movement of costovertebral (CV), costotransverse (CT) and sternocostal joints contribute to thoracic excursion (TE) and subsequent PF, however, these joints are subject to developing hypomobility impairments. Increase in thoracic spine kyphosis, spinal stiffness, impaired chest wall mobility, and decreased chest wall compliance are observed with increased age and have been shown to impair PF[2–6]. A decrease in thoracic spine mobility has also been associated with prolonged sitting time in younger adults[7] and has been implicated in causing a decrease in lung volumes[8]. Additionally, physical inactivity is also associated with a reduced ability to move air out of the lungs, decreased respiratory muscle strength, and poor physical performance in older adults[9, 10].

Manual therapy has been shown to effectively remediate hypomobility impairments in other joints by improving joint motion, decreasing pain, decreasing resting muscle tone, and improving muscle activity[11–15]. Given the available evidence, the authors hypothesized that reduced spinal and thoracic mobility secondary to aging and physical inactivity may positively respond to manual physical therapy interventions and subsequently improve PF and TE.

Although there are a few studies that investigated the effects of manual therapy interventions on respiratory function in individuals with lung disease and post stroke, they are multimodal in nature, lack randomization and controls, therefore, limiting their generalizability[16–18]. To date, few studies have systematically examined the effect of manual therapy interventions, including high-velocity, low-amplitude manipulation, on joints of the thoracic spine and ribs in healthy inactive older adult populations. The purpose of this research was to examine the effects of thoracic extension spinal manipulation when compared to sham intervention on PF and TE in inactive participants older than 50 years of age both immediately following a single session and when assessed within seven days following a third intervention session.

PARTICIPANTS AND METHODS

This study was a randomized controlled trial with a pre-test, post-test design. The study received approval from the institutional review board at The George Washington University (#180582). Inclusion and exclusion criteria are listed in Table 1.

After obtaining written informed consent, all individuals who met inclusion criteria and who did not meet exclusion criteria were screened for hypermobility using the Beighton[19] score. Individuals who did not present with evidence of hypermobility were enrolled in the study. An investigator not involved in either the performance of an intervention or the collection of outcome measures randomly assigned participants to either a spinal manipulation group or a group receiving "sham" intercostal training. Investigators who performed the intervention did not collect outcome measures. Investigators who collected outcome measures were blinded to participant group assignment and did not assist in the performance of the study interventions.

Spinal manipulation included a high-velocity, low-amplitude joint manipulation extension glide targeted at the area of the upper (T3–4), middle (T6–7) and lower (T9–10) thoracic spine[20]. This type of manipulation was selected to affect multiple spinal levels as well as indirectly impact the corresponding CT and CV joints at the selected segments without the need to perform multiple manipulations at each corresponding level. The participant sat with their body perpendicular to the length of the plinth with their arms crossed over their chest. After palpating the relevant spinous process, the investigator stood behind the participant and placed a small, rolled towel between the midpoint of their sternum with the participant's desired thoracic spinal level. The investigator then reached around the participant and placed their hands over the corresponding contralateral elbow and pulled the elbows toward the participant's chest as if hugging them from behind. The participant was instructed to exhale, during which time the investigator took up additional tissue slack by pulling the participant towards them. At the end of the exhalation the investigator performed a high velocity low amplitude thrust in a posterior-anterior direction through the

Table 1. Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
● 50 years of age or older	● Diagnosis of ankylosing spondylitis
● Inactive (not participating in structured exercise program more than twice a week)	● Diagnosis of osteopenia or osteoporosis
	● History of scoliosis
	● Active respiratory infection
	● Vertebral tumor
	● Vertebral or rib fracture
	● Congenital dysplasia
	● Corticosteroid use greater than 3 months
	● Severe hemophilia
	● History of thoracic cord or thoracic nerve root compression
	● Current diagnosis of thoracic spondylolysis or spondylolisthesis
	● Diagnosis of a connective tissue disorder
	● Thoracic spine hypermobility/instability screened via the Beighton Score

towel. The intervention included a minimum of one manipulation at each region (upper, middle, lower) of the thoracic spine. Up to two attempts per region could be performed based on the investigator's discretion regarding quality of the technique.

"Sham" intercostal training included positioning the participants in a neutral seated posture with arms crossed. Participants flexed the spine while inhaling and extended the spine while exhaling. They performed a self-selected number of slow repetitions within a 30-second timeframe (one set), repeated for a total of four sets. The number of repetitions and sets were selected to correspond with the total time spent performing the intervention in both groups including set up and instruction; less than five minutes. Investigators placed their hands on the participants' backs and shoulders during the motion to ensure both intervention groups received similar interactions with investigators as physical touch can influence outcomes in manual therapy interventions[21–23]. The investigators who provided the interventions were physical therapists with advanced training in manual and manipulative therapy as fellows of the American Academy of Orthopaedic Manual Physical Therapists.

Each group received three intervention sessions over the course of two weeks: one session within the first week and two sessions within the second week. The second and third sessions took place during the second week and were separated by at least one day. Participants were blinded to the nature of the interventions being led to believe that both interventions were likely to influence PF. Outcome measures were collected twice on the first day just before and immediately after the first intervention session. To examine short-term effects a third and final set of outcome measures were obtained within seven days ($\bar{X}$=5.8) after receiving the third intervention session. The investigators who collected the outcome data had advanced training in exercise physiology and were blinded to all participant group assignments.

Outcome measures assessing PF included vital capacity (VC), maximal voluntary ventilation (MVV) and thoracic excursion (TE). Both VC and MVV were obtained using the Ultima PFX system (MGC Diagnostics, St. Paul, MN, USA) and were obtained in accordance with guidelines published by the American Thoracic Society. TE was obtained from circumferential measurements made of the thorax during maximal inhalation and exhalation in accordance with the method described by Bockenhauer et al[24]. Descriptive data (age, height, weight) and scores from the Human Activity Profile (HAP)[25] were collected to estimate the activity level of each participant.

Data were analyzed using IBM SPSS Statistics for Windows, version 26.0[26]. Descriptive statistics were reported using means and SDs. A Mixed-Design ANOVA was utilized to examine the between-subjects effects of treatment (manipulation/sham) and the within-group effects of time and any associated interactions. An alpha level of $p<0.05$ was used for all inferential statistics. The effect size was identified as small (d=0.2), medium (d=0.5) or large (d≥0.8) as determined by Cohen's d[27].

RESULTS

Twenty-one physically inactive but otherwise healthy participants (12 females, 9 males) participated in the study. Demographic data were not significantly different between the two groups at baseline (Table 2). There were no significant between group differences on any outcome measures. There were no significant interaction effects. There was a significant difference in TE measured during exhalation in the sham group after session one ($p<0.05$, d=0.57); MVV was significantly increased in the manipulation group when comparing session one and session three outcomes ($p<0.05$, d=0.71) (Table 3).

DISCUSSION

This study investigated the effects of thoracic manipulation on pulmonary function (VC, MVV and TE). The main finding from this study is that a single session of thoracic manipulation does not change PF, however, changes in MVV were observed within seven days following a third treatment session. Previous research supports the authors' findings following a single session[10, 28, 29]. Only one study noted a change in peak expiratory flow in young healthy females following a single thoracic manipulation[30].

MVV was selected as an outcome measure to assess PF to potentially identify small changes in ventilatory function that otherwise might go undetected in other ventilatory assessments. Changes in a single measure of VC may be too small to detect in a small sample size, therefore the MVV assessment was selected to potentially capture the aggregation of a small change in VC summated over multiple ventilatory cycles, making such a small VC change easier to detect. Furthermore,

Table 2. Participant demographics

Data	Manipulation group (n=10)	Sham group (n=11)
Age (years)	63.7 ± −9.1	61.6 ± −8.9
Height (cm)	165.1 ± −9.7	170.2 ± 7.6
Weight (kg)	80.1 ± 13.6	83.2 ± 22.8
HAP scores	72.2 ± 11.6	75.7 ± 7.0

Values are expressed as Mean ± standard deviation.
No statistically significant differences were observed between the two groups.
HAP: Human activity profile.

Table 3. Comparison of pulmonary function within groups and between groups

Measure	Time of collection	Manipulation group	Sham group
FVC (L)	Pre-treatment 1	3.2 ± 1.3	3.6 ± 1.1
	Post treatment 1	3.2 ± 1.3	3.5 ± 1.1
	Post treatment 3	3.2 ± 1.3	3.6 ± 1.2
MVV ($L.min^{-1}$)	Pre-treatment 1	98.1 ± 52.2	106.1 ± 33.9
	Post treatment 1	96.7 ± 47.1	107.0 ± 30.7
	Post treatment 3	107.7 ± 50.1*	114.9 ± 31.7
TE inhalation (cm)	Pre-treatment 1	99.9 ± 7.6	104.4 ± 16.6
	Post treatment 1	99.9 ± 7.6	103.8 ± 16.2
	Post treatment 3	99.8 ± 7.3	103.6 ± 16.2
TE exhalation (cm)	Pre-treatment 1	96.6 ± 8.3	101.1 ± 17.0
	Post treatment 1	96.4 ± 8.0	99.9 ± 16.9*
	Post treatment 3	95.7 ± 8.1	100.6 ± 16.9

Values are expressed as Mean ± standard deviation.
*Significant change between pretest and posttest.
FVC: forced vital capacity; MVV: maximum voluntary ventilation; TE: thoracic excursion.

MVV has been shown to be prognostically significant for people with common lung diseases. Recently, Andrello et al.[28] observed that MVV was a better predictor of exercise capacity and respiratory muscle strength in clinical lung disease populations when compared to other measures.

Manual therapy is typically used to manage pain and/or mobility deficits and previous studies have demonstrated plausibility for improving lung function in pathologic populations (e.g., COPD, low back pain, stroke)[10, 16, 31–33]. However, these studies frequently incorporate multimodal interventions leaving it unclear to the clinician which specific intervention component is most likely to effect a desired clinical change. This present study is unique in that it examined the impact of a single manipulation intervention on older inactive adults and provides preliminary evidence that manipulation alone may effect important changes in PF.

One major limitation of this study is the number of individuals recruited in this pilot study which influences statistical power and the generalizability of the findings. Another limitation is the sham treatment used in this study. The authors' intent was to create a sham treatment of sufficient fidelity to common physical therapy interventions known to the general populace to create plausibility in the minds of the study participants that they indeed might be receiving an intervention that could improve PF. It is possible that the sham treatment inadvertently had some beneficial effects on PF that are unknown to the authors resulting in the change in TE during exhalation immediately following the first intervention session. Despite the noted limitations, findings from this pilot study can guide future research. Thirdly, the exact mechanism by which manipulation has improved MVV is unclear. Future research should examine mechanisms of spinal manipulation with regards to ventilation as well as explore whether the proposed number of treatment sessions and selected intervention are sufficient to identify change.

Thoracic manipulation did not contribute to an immediate change in PF, as reflected in TE, VC or MVV, but did exhibit a statistically significant change in MVV over repeated sessions in healthy older inactive adults. Given the small sample size used in this pilot study, the authors suggest further research be carried out to verify the relationship between thoracic manipulation and pulmonary function.

Conference presentation

The authors shared these findings at the American Academy of Orthopaedic Manual Physical Therapists annual conference October 28, 2022, San Diego, California.

Funding and Conflict of interest

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