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Research Article

IMMEDIATE EFFECTS OF THORACIC SPINE THRUST MANIPULATION ON CHEST EXPANSION AND LUNG FUNCTION IN HEALTHY SUBJECTS- A PRE- TEST AND POST- TEST EXPERIMENTAL DESIGN

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ABSTRACT

Background: Mobility of joints of the thoracic spine and rib cage influence chest expansion and lung function both in healthy subjects. To investigate the effects of thoracic spine thrust manipulation on circumference measurements of chest expansion and lung function in healthy subjects. A pre-test and post-test experimental design.

Method: 100 healthy subjects received a single session of thoracic spine thrust manipulation (TSTM). All subjects were evaluated before and after intervention through inch tape of the chest expansion in cm at middle and lower ribcage and spirometry measures of FVC (Force Vital Capacity), FEV1 (Force Expiratory Volume per 1 sec) and FEV1/FVC%.

Result: Thoracic Spine Thrust Manipulation (TSTM) produced significant changes on measures of chest expansion at 4^{th} intercostals space (-1.190 ± 0.720 cm), Xiphoid process (-1.300 ± 1.586 cm) and also on FVC (-0.27880 ± 0.280L), FEV1 (-0.24450 ± 0.330L), FEV1/FVC% (-1.97910 ± 3.196L).

Conclusion: TSTM had significant influence on chest expansion and improved of the spirometric measures of lung function. To be performed in patients with cardiopulmonary disorders on large sample size with long-term follow-up studies and population-based clinical trials.

INTRODUCTION

The Guide to Physical Therapist Practice defines “mobilization/ manipulation” as “skilled passive movements to joints and related soft tissue that are applied at varying speeds and amplitudes including small-amplitude/ high-velocity therapeutic movements” and produced popping or crack sound characterized by cavitations in the thoracic spine with the aim of restoration of joint mobility.[1]

Spinal manipulation therapy to a single vertebral joint complex would increase joint mobility and decrease muscle tone. Applying this intervention at multiple levels would alter the overall contribution the posterior elements make towards chest wall mobility.[2] For the purpose of this paper, thoracic spine manipulation (TSM) is defined as a high-velocity/ low amplitude movement or “thrust” directed of the thoracic spine on circumference measurements of chest expansion and lung function in healthy subjects.

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Given the complex anterior and posterior articulations of the thoracic spine and rib cage, it is reasonable to speculate that alignment changes in one plane will have the potential to affect the shape and motion of the chest wall during breathing. Furthermore, as respiratory muscles also have postural function.[4,5] The physiological mechanism by which articulation elicits to clinical effects both locally and peripherally.[6] Postural changes can occur in healthy population due to habitual lifestyle factors.[7] Postural changes will affect chest wall shape, motion and motion distribution between compartments of the chest wall.[8]

Thoracic mobility and lung function may be altered not only due to growth and the onset of respiratory disease but also due to other factors such as body composition, age, sex, height.[9] The chest wall articulations that are true synovial joints may undergo morphologic changes associated with aging which results in reduced mobility.[10] Variation in spinal curvature is associated with differences in muscle activity and joint orientation[11] both of which are likely to influence relative compliance of the rib cage and change breathing movements.[12] In an earlier study by Caro *et al*[19] showed that restricting chest wall expansion on pulmonary function in normal healthy reduced the total lung capacity.[19] The release of chest restriction the mechanical changes in the lungs were reversed via a hysteresis like pathway. Thus any abnormality that affects the muscle of respiration or rib biomechanics will have an effect on the optimal functioning of the lungs and respiratory system as a whole.[20]

In this study, a simple and inexpensive technique for measurement is to use a tape measure. This maneuver, during maximal inspiration and expiration the circumference around the thorax is measured at specific measurement were evaluated at two sites corresponding to the middle chest wall (4th Intercostals Space) and lower chest wall (Xiphoid Process).The purpose of this study was to determine the immediate effect of thoracic spine thrust manipulation on chest expansion and lung function in healthy subjects.

MATERIAL AND METHOD

A single group pre- test and post- test experimental study design was used to examine thoracic spine thrust manipulation effects on chest expansion and lung function in healthy subjects. Ethical approval was granted By Maharishi Markandeshwar University (MMU), Institutional Review Board. Mullana- Ambala, Haryana, India.

Subjects

The medically healthy 100 participants (both male and female) aged 20 – 40 years meeting the research criteria were accepted into the study from August 2013 to May 2014.

Exclusion criteria were a previous history of rib fractures, dislocations, sprains of costochondral, costosternal and inter chondral joints. Spinal deformity, kyphoscoliosis. spine pain, taking pain medications, any serious spinal pathology, surgery, infections, rheumatic disorders, acute fractures, osteoporosis, ankylosing spondylitis, tumors, history of cancer or metastatic disease of the thoracic spine. Previous history of myocardial infarction, pregnancy, participants who were uncooperative. Smokers were excluded from the study. Subject demographics were described in Table 1.

Before starting the session pre intervention base line assessment reading were taken and recorded it as for pre test data. Pre intervention base line assessment on chest expansion at 4th intercostals space and xiphod process were taken by outcome measure inch tape in centimeter (cm) and lung function measurement in liter (FVC, FEV1 and FEV1/FVC ratio).

Variables		Experimental group
Age ^{a}		24.56 ± 3.685**
BMI ^{a}		21.70 ± 1.736**
Gender	Male %^{b}	45 (45%)
	Female %^{b}	55 (55%)
Life style	Athletes %^{b}	10 (10%)
	Sedentary %^{b}	90 (90%)

**p-value ≤ 0.05 considered as significant
a: Data are Mean ± SD
b: Data are number (%)
SD: Standard deviation

Procedures

All subjects were given information about the study and signed the informed consent prior to participation. After subjects gave their informed consent a screening examination was performed for the inclusion and exclusion criteria to ensure eligibility. Healthy 100 participants (both male and female) meeting the research criteria was accepted into the study. Before starting the session pre intervention base line assessment reading were taken and recorded it as for pre test data. Pre intervention base line assessment on chest expansion at 4th intercostals space and xiphod process were taken by outcome measure inch tape in centimeter (cm) and lung function measurement in liter (FVC, FEV1 and FEV1/FVC ratio).[7] Participants in experimental group (N=100) each subject was received thoracic spine thrust manipulation for single thrust a session as for their chest wall expansion and lung function. After the intervention post intervention assessment reading were taken and recorded it as for post test data. The examiner who performed the pre-treatment and post-treatment measurements was blinded to treatment group assignment.[6]

Interventions

The participant lay supine on the couch with crossed arms so their hands were on opposite shoulders and their elbows met in the middle and positioned as close to edge of couch as possible. The researcher's right hand was placed under the thoracic vertebra of the targeted motion segment ($T_4 – T_8$) and used as a fulcrum and his body applied force through the participant arms to produce a high velocity, low-amplitude thrust toward the thoracic spine at a targeted level by momentarily dropping his body weight.[2] When participants doing exhalation thrust was applied on thoracic vertebra, if there is no popping sound are produced then repeat the manipulation once. (Figure 2)

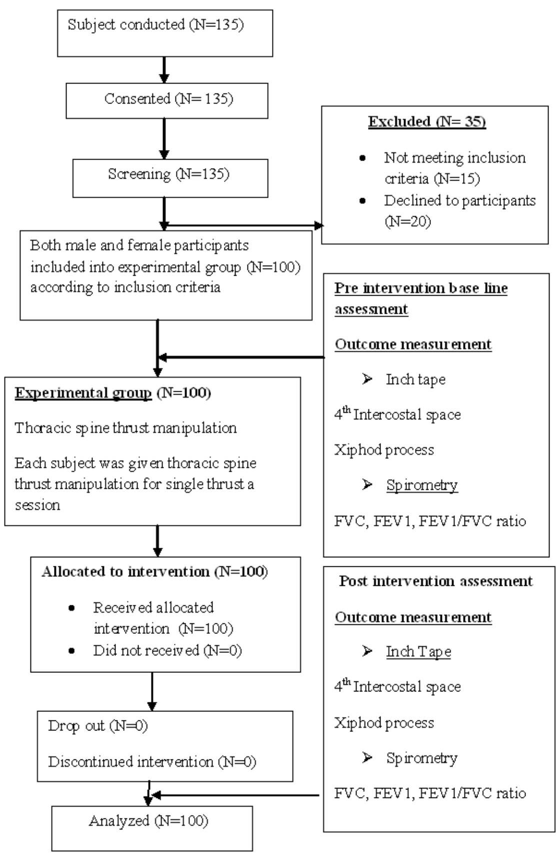

Fig 1 Modified consort flow chart of the participants. 35 participants were excluded for cause did not meet the inclusion criteria and declined to 20 participants of those provided false information to initially qualify for the study.

Figure 2 Thoracic spine thrust manipulation in supine position

Data analysis

The data was analyzed using SPSS for Windows software version 22 perceived effects of treatment at pre-treatment and post-treatment using independent t-tests Statistical significance was set at $P = 0.05$, 95% confidence interval.

RESULTS

100 healthy subjects were considered for inclusion in this study from August 2013 to May 2014. 45 male and 55 female included in this study ranged in age from 20 – 40 years with a mean age of SD 24.56 ± 3.685 years. No significant differences were found between treatment groups for any of the baseline demographics of the subjects (Table 1).

Table 2 represent the mean, standard deviation, standard error mean, 95% confidence interval (lower and upper) of within group pre and post test in chest expansion (4th intercostals and xiphiod process) scores used in the study.

subjects. There is a clinical significance effect with moderate effect size.

Table 3 represent the mean, standard deviation, standard error mean 95% confidence interval (lower and upper) of within group pre and post test lung function (FVC, FEV1 and FEV1/FVC ratio) scores used in the study.

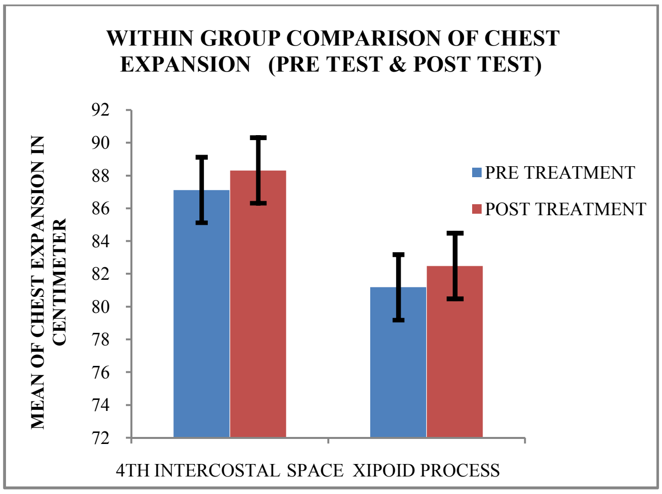

Figure 3 Pre and Post Mean In Within Group Comparison of Chest Expansion at 4th Intercostals Space and Xiphoid Process. Statistically highly significant differences were observed within group pre-post test chest expansion scores in healthy subjects

The data showed that the mean ± SD of FVC pre test scores was 2.961±0.691 (liter) and post test score was 3.240± 0.725 (liter) mean difference: -0.27880 ± 0.28068 and 95% confidence interval: lower = -0.33449; upper = -0.22311; t= -9.933, p<0.000 pre-post test respectively.

Table 2 within group effect of the Chest Expansion before and after thoracic spine Thrust Manipulation

Within group effects					
Chest expansion (cm)	Measure	Mean ± Std. Deviation (95% C.I)	Standard error mean (SEM)	Mean difference ± Std. Deviation difference (Std Error Mean difference)	t value
4th Intercostal space(cm)	Pre Test	87.12 ± 6.076 (-1.333, -1.043)	0.608	-1.190 ± 0.720 (0.072)	-16.517*
	Post Test	88.31 ± 6.091 (-1.333, -1.043)	0.609		
Xiphoid Process(cm)	Pre Test	81.18 ± 6.605 (-1.615, -0.985)	0.660	-1.300 ± 1.586 (0.159)	-8.197*
	Post Test	82.48 ± 6.741 (-1.615, -0.985)	0.674		

*P value <0.0001
* Statistical significance was tested using the student't' test.
SD: Standard deviation
C.I: Confidence interval
SEM: Standard error mean

The data showed that the mean chest expansion scores were increased, i.e. 4th intercostals space pre test score was mean ± SD of 87.12 ± 6.076 (cm) and post test score was 88.31± 6.091(cm) (mean difference: -1.190 ± 0.720, 95% confidence interval: lower = -1.333; upper =- 1.043 and t = - 16.517, p<0.000 pre- post test) respectively. Xiphoid process pre test score was mean ± SD of 81.18±6.605 (cm) and post test score was 82.48 ± 6.741 (cm) (mean difference: -1.300 ± 1.586, 95% confidence interval: lower= -1.615; upper = -0.985 and t = -8.197, p<0.000 pre- post test) respectively.

Statistically highly significant differences were observed within group pre-post test chest expansion scores in healthy

The mean ±SD of FEV1 pre test scores was 2.7427 ± 0.67412 (liter) and post test score was 2.9872 ± 0.67014 (liter) mean difference: 0.24450 ± 0.33064 and 95% confidence interval: lower = -0.31011; upper =-0.17889; t= -7.395, p<0.000 pre-post test respectively. The mean ± SD of FEV1/FVC ratio pre test scores was 90.6528 ± 5.1285 (liter) and post test score was 88.6737± 5.37154 (liter) Mean difference: 1.97910 ± 3.19676 and 95% Confidence interval: Lower =1.34479; Upper = 2.61341; t= 6.191, p<0.000 pre-post test respectively.

Statistically highly significant difference was observed within group pre-post test lung function scores force vital capacity (FVC), force expiratory capacity per second (FEV1) and ratio FEV1/FVC ratio all result was significantly different (p=0.000) in healthy subjects. There is a clinical significance effect with moderate effect size.

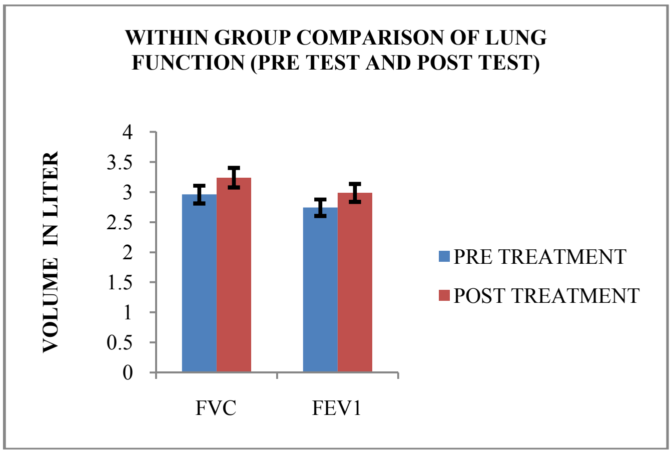

Fig 4 Pre and Post mean in within group comparison of Lung function measurements at FEV1 and FVC. Statistically highly significant differences were observed within group pre-post test chest expansion scores in healthy subjects

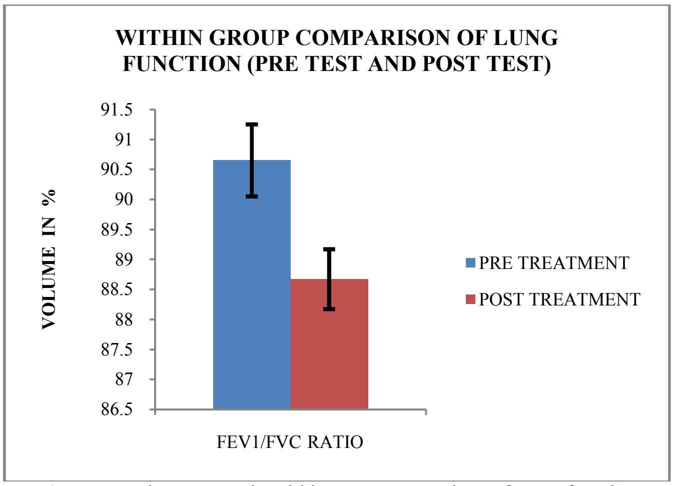

Fig 5 Pre and post mean in within group comparison of Lung function measurements at FEV1/FVC%. Statistically highly significant differences were observed within group pre-post test chest expansion scores in healthy subjects

DISCUSSION

Analysis of the results of present study, revealed a statically significantly improvement of healthy subjects in chest expansion measurements at 4th intercostals space and xiphoid process (p<0.001) along with improvement in lung functions (FVC, FEV1 and FEV1/FVC ratio) (p<0.001) after application of the thoracic spine thrust manipulation. Hence, null hypothesis was rejected and in favor of the research hypothesis for the chest expansion measurements (4th intercostals space and xiphoid process) and lung function (FVC, FEV1 and FEV1/FVC ratio) after thoracic spine thrust manipulation of healthy subjects.

In present study pre – post test mean difference of chest expansion at 4th intercostals space was 1.190 cm with an effect size of (d=0.48) and xiphoid process was 1.300 cm with an effect size of (d=0.50) which meet the MCID value that is (0.9 to 4.7cm). This result was supported by a previous study by Jerome[29] in a single subject pre test post test design study which showed that mean difference of chest expansion at 4th intercostals space was 0.45 cm with an effect size of (d=0.49) and xiphoid process was 0.53 cm with an effect size of (d=0.53).

In present study pre – post test mean difference of lung function at FVC was -0.278 liter with an effect size of (d=0.33), FEV1 was -0.244 liter with an effect size of (d=0.36) and FEV1/ FVC ratio was -1.979% with an effect size of (d=0.37). This result was supported by a previous study by Kriel[20] in comparative clinical trial design a pilot study which showed that mean difference of lung function at FVC was -0.132 liter with an effect size of (d=0.41), FEV1 was -0.174 liter with an effect size of (d=0.39) and FEV1/ FVC ratio -1.400% was with an effect size of (d=0.40).

The thoracic spine thrust manipulation yielded a percentage of mean difference was chest expansion at 4th intercostals space (1.357%) and xiphoid process (1.588%) after the post intervention respectively which supported the previous study at 4th intercostals space (1.52%) and xiphoid process (1.21%) conducted by Custer *et al*[17] a percentage of mean difference was FVC (8.99%), FEV1 (8.55%), FEV1/FVC ratio (2.20%) after the post intervention respectively which supported the previous study FVC (2.40%), FEV1 (3.98%), FEV1/FVC ratio (1.85%) conducted by Kriel.[20] The results of the current study could have positive implications for the incorporation of manual therapy. The finding demonstrated that the effect sizes for chest expansion and lung function were moderate at post treatment. So, the thoracic spine thrust manipulation technique to healthy subjects who were positive on the CPR (clinical prediction rule) was marginal and were evident only at the short-term immediate effects.

According to Steuck[13] the exact mechanism of the thoracic spine thrust manipulation in inducing increased in spirometry value and chest expansion responsible for these positive results due to a combination of the biomechanical muscular reflexogenic effects. The biomechanical effect of the thoracic spine thrust manipulation is that of biomechanical function to the joints of the thoracic spine and rib cage. Inducing the motion to the joints that have decreased motion allows for proper alignment of that joint and decreased resistance to the proper biomechanical function. Muscular reflexgenic effect of the thoracic spine thrust manipulation to affect reflex activation of alpha motor neurons may lead to a resetting of muscle activity and leads to a period of reduced hypertonicity and visceral organs, also evokes paraspinal muscle reflexes and alters motor neuron excitability.[22]

Engel *et al*[2] explored the effect of combining "chiropractic manual therapy" with exercise on respiratory function in normal individuals. The chiropractic manual therapy consisted of soft tissue therapy and nonspecific high-velocity low amplitude (HVLA) manipulation applied to the lower cervical, upper and middle thoracic spines and associated ribs. This study reported that participants who 21 received chiropractic manual therapy showed a significant increase in forced vital capacity (FVC) and forced expiratory volume in the first second (FEV1) in respiratory function and concluded that manual therapy appeared to increase the respiratory function in normal individuals.

Bockenhauer *et al*[21] studied the reliability of the inch tape measure technique in 6 healthy male subjects by measuring thoracic excursion at two level of chest that is on 3rd intercostals space and xiphoid process with a tape measure. It is a very simple and quick method for the assessment of chest mobility and including that the tape measurement method of measuring thoracic excursion at two levels could be highly high intertester and intra tester reliability reliable and useful in a clinical setting.

Result of the power analysis showed that our primary outcome measures i.e lung function FVC, FEV1 and FEV1/FVC ratio has got 90% power to reject the null hypothesis. This was because we eliminated the threats of the internal validity by doing a blind observer recorded both the baseline and post intervention data. Threats of external validity were also reduced by set a strict inclusion criteria and all the participants in the both groups showed same demographic and baseline characteristics. It is found from the analysis that the healthy subjects who received one session thoracic spine thrust manipulation have shown significant short term effect on improving chest expansion and lung function. This is basically highlighting the fact that manipulation was responsible for an immediate significant increase in chest expansion and lung function in healthy subjects.

Clinical Implication

This study will help to significantly the essential clinical relevance in cardiopulmonary rehabilitation and musculoskeletal rehabilitation program for their management and hence should be more routinely used for therapeutic techniques aimed at improving these measures were needed for better patient care in the clinical setup.

Limitation

These prior studies are limited by the lack of a control group that received no treatment or a sham-treatment group. As the measurements were taken in chest expansion manually. So, there may be a chance of error. Subjects were only exposed to thoracic spine thrust manipulation in one thrust a session and also the subjects were healthy. So, one thrust would probably not have been adequate to affect a change.

Future Suggestions

A course of thrust manipulation over a several days or weeks may be required to elicit a positive response in future study. For more valid result, a long term study must be carried out.

CONCLUSION

This study measured the immediate short-term effect on the chest expansion and lung function of a physical therapeutic thrust manipulation targeting the thoracic spine region. Based on the results of the research conclude that a single thrust manipulation to the thoracic spine of healthy subjects causes a significant enhancement in chest wall expansion and lung function values. This study also demonstrates the effect altering the biomechanical structure has on the lung function values. These observations suggest that the thoracic spine thrust manipulation under certain physiological conditions could influence directly or indirectly regulated biological responses.

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