An Investigation of the lasting effects of thoracic manipulation and rib raising on spirometric measurements of asymptomatic participants

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Abstract

Although research has been undertaken into the effects of manual intervention on common respiratory conditions, very little research has been undertaken into whether manual therapy can produce a significant improvement in the respiratory function of asymptomatic volunteers one week after the manual intervention. To test whether a relationship exists between the effects of thoracic HVLA and rib raising (RR) on the pulmonary function of asymptomatic volunteers one week after the manual intervention, 38 participants [males = 25, females = 13; mean age = 28.63 ± 10.42] were randomly assigned to either a HVLA (n = 11), RR (n = 14) or a HVLA + RR group (n = 13). Statistically significant increases were observed in both FVC ($p = 0.005$) and FEV_1 ($p = 0.002$) within each of the three groups over time (pre-test, post-test, 1 week). However, no significant increases were found neither in the chest diameter values within the three treatment groups with respect to time nor between the three groups at any of the three time periods. The greatest increases in percentage change occurred in FEV_1 and FVC values at the 1 week time period, particularly for the HVLA + RR and the RR group in which respective FEV_1 increases of 10.5% and 7.41% occurred. The results of this study suggest that HVLA and rib raising ought to be equally effective in improving the pulmonary function of asymptomatic individuals, given that no statistically significant difference was found between the mean FEV_1 and FVC values within the three groups over time. Since previous research shows that rib raising produces within subject increases in both FEV_1 and FVC over time that are statistically significant in asthmatics, it may be possible to infer that HVLA may be as useful an adjunct as rib raising in the long-term management of stable asthma.

Key Words:

Manual Therapy, Rib Raising, High Velocity – Low Amplitude Technique (HVLA), Spirometry, Osteopathy

Introduction

High velocity low amplitude (HVLA) is one of the oldest and most commonly used osteopathic manipulative therapy (OMT) for the treatment of intervertebral joint dysfunction, however little research has been conducted into the long-lasting effects of HVLA. The short-term effects of HVLA on joint function and somatic structures has been extensively described in the literature. These studies have demonstrated a temporary increase in joint range of motion (ROM)[1-3], a reflex relaxation of muscles [4-5], and an alteration of spinal reflex thresholds [6]. However, only one study has ever researched the longer term effects of HVLA on joint ROM. This study by Stodolny et al [7] examined the effect of HVLA on cervical ROM seven days post treatment, and concluded that there was a statistically significant increase in cervical joint ROM.

It is well described that HVLA can produce short-term sympathoexcitatory effects which are technique specific and superior to placebo and control interventions [8-10]. Some of these short-term sympathetic effects of HVLA on asymptomatic participants include changes in blood pressure [11], an increase in heart rate [8], a decrease in respiratory rate [14, 16], and alterations in sudomotor activity as evidenced by changes in skin resistance / conductance [13].

The majority of the research into the short-term effects of HVLA into the autonomic functions governed by the sympathetic nervous system (SNS) (i.e., blood pressure, heart rate, respiratory rate, sudomotor activity) are marred by poor power analysis [12, 15] or a failure to mention group sizes [17-18], a lack of satisfactory controls [14, 16] or a double-blinded method [12, 14-18]. The relevance of many older research projects [12, 14-18] into the physiologic effects of HVLA on pulmonary function in pathologies such as asthma or COPD is affected by the fact that no FEV_1, FVC or FEV_1/FVC data was collected. Nowadays, these parameters are considered to be the basic spirometric measures in the diagnosis of obstructive or restrictive lung dysfunctions [19], and FEV_1 is considered especially important since it is the most reproducible – and therefore the most accurate – value derived from spirometry [20].

More recently, a series of well-controlled, randomised, double-blinded studies have confirmed that physiotherapeutic techniques such as a Grade III posterior-anterior mobilisation have sympathetic effects on skin temperature, blood pressure, heart rate and respiratory rates [8, 25, 31], while other physiotherapeutic techniques such as lateral glide mobilisation of the cervical spine[26] produced increases in blood pressure, heart rate and respiratory rates that were significantly greater than that of placebo and control conditions. HVLA is equivalent to a Grade V posterior-anterior mobilisation on the Maitland scale, therefore one would expect that the results of these studies would apply equally well to the effects of HVLA on the SNS.

Osteopathic research suggests that OMT can produce at least short-term gains in pulmonary function in healthy individuals. For instance, Murphy's analysis of the influence of thoracic mobilization on pulmonary functions in healthy individuals show that mobilisation can increase tidal volumes and respiratory rates while decreasing functional residual capacity (FRC) [17]. Murphy's subsequent research into the effects of thoracic mobilisation on the distribution of Iodine-131 in the lungs showed that blood flow distribution in the lungs was improved [21]. In healthy individuals, blood flow distribution may reflect the distribution of ventilation, since ventilation usually matches perfusion in healthy subjects. The improvement in blood flow distribution in the lungs suggests that enhanced movement of the chest arising from thoracic mobilisation leads to improved ventilation and perfusion, and improved lung gas exchange.

It is possible that a sympathoexcitatory technique like HVLA may reinforce the improvement in pulmonary blood distribution as theorized by Murphy since the sympathetic efferents to the bronchi are vasoconstrictor and bronchodilator [22]. The vasoconstriction effect of SNS stimulation would encourage increased blood flow from areas of high blood pressure to areas of low blood pressure. The effect of this may be to increase blood flow throughout the pulmonary capillary bed, thereby increasing the ventilation/perfusion ratio. The bronchodilatory effect of SNS stimulation, according to Murphy's theory, may alter the distribution of ventilation, thereby also altering the distribution of pulmonary blood flow, at least in healthy individuals. Kuchera and Kuchera's [23] unvalidated claim that thoracic HVLA produces short-term excitation of the SNS followed by a long-term inhibition of the SNS does not seem so logical given that Murphy's study examined only the short-term effects of thoracic mobilisation.

Masarsky et al's [24] research into the effect of chiropractic manipulation on pulmonary function remains the only study so far to include a long-term assessment of the effects of manipulation on pulmonary function into its study design. A significant increase in FEV_1 values ($p < 0.05$) and a significant increase in FVC ($p < 0.01$) were reported with adequate power. However, there were also significant flaws in the design of the Masarsky research. There were no pre-treatment spirometric values reported, making it impossible to determine whether the increases in lung function were more significant immediately post-treatment or over the period of time between the post-treatment and follow-up sessions. There was no consistency at all in the timing of the follow-up pulmonary function test measurements, and the chiropractic treatment was applied to different parts of the body and was determined by the present needs of the patients which may have been unrelated to the objectives of the study. None of the participants were asked to keep an activity diary, making it difficult to differentiate gains in FEV_1 and FVC resulting from lifestyle changes from those resulting from the manual intervention.

Strong evidence exists for manual therapy [8-10, 25-26], in particular HVLA[11] and rib raising [27], to have a short-term influence on SNS function. Neurological [30] and mechanical [27] models have been proposed to explain the effects of OMT on the SNS. The neurological model states that spinal manipulation to T2-T4 leads to a short-term increase in sympathetic outflow to the organs that are embryonically related to these levels, namely the trachea and bronchi [37]. The vasoconstrictor effect of this sympathetic outflow occurs because of stimulation of C-fiber receptors in the pulmonary blood vessels [32], leading to an increase in pulmonary blood flow. The bronchodilator effect of this sympathetic outflow occurs because of stimulation of β_2 receptors in the bronchial smooth muscle, leading to an increase in ventilation [33]. The mechanical model states that an improvement in lung function may be the result of the mechanical effect of stretching the soft tissues in the upper thoracic region [27].

The first aim of this research was to determine lung function changes in three separate groups of individuals: one that receives only a rib raising (RR) technique, a second group that receives only a HVLA, and a third group that receives both a HVLA ad RR. The second aim was to examine whether the lung function changes measured for each of the different procedures on the three groups are sustained up to one week after the procedures have been performed.

Methods

Subjects

Healthy non-smoking volunteers (N = 44) with no history of previous or current respiratory, cardiac or vascular conditions; degenerative joint disease; inflammatory spondyloarthropathies; neoplasms; osteoporosis; corticosteroid or recreational drug use were recruited in the study and randomly assigned to either HVLA, RR or HVLA and RR groups. Eleven volunteers [7 males, 4 females; aged 25 ± 8.4 yrs; mass 69.1 ± 12.7 kg; height 174.3 ± 11.2 cm] were randomly assigned to HVLA group; Fourteen volunteers [11 males, 3 females; aged 29.7 ± 10.4 years; mass 72.3 ± 9.6 kg; height 173.9 ± 8.4 cm] were randomly assigned to the RR group. Thirteen volunteers [7 males, 6 females; aged 30.54 ± 11.9 years; mass 76.05 ± 17.4 kg; height 174.4 ± 7.9] were randomly assigned to the HVLA and RR group. Six volunteers were withdrawn due to non-compliance, receiving osteopathic HVLA treatment during the testing period or contracting upper respiratory tract infections in the days leading up to the second testing session. The study was approved by the Victoria University Human Ethics Committee and all volunteers gave informed consent prior to inclusion in the study. All volunteers completed a medical history questionnaire which asked for details of the pathologies and lifestyle issues listed above for exclusion purposes

Procedures

Measurement of pulmonary function before and after the intervention was conducted using a Wedgebellows spirometer (Vitalograph). Spirometric measures included FEV_1, FVC, and the FEV_1 / FVC ratio

Prior to attendance at the measurement sessions participants were requested to abstain from any stimulants such as alcohol, tea or coffee, or exercise for at least 2 hours. Pre-intervention anthropometric measurements were taken and all subjects were then required to rest supine for 10 minutes. Female participants were requested to remove their bras and any tight-fitting underwear from the upper body, and were provided with a clinic gown to wear for the duration of the testing session. Height and mass were measured with a stadiometer (calibrated to ± 0.5 cm) and an August Sauter E 1200 electronic scale (calibrated to ± 0.005 kg), respectively. Chest diameter was also measured using a tailor's tape. Either the HVLA, RR or combined HVLA and RR interventions were then applied. Spirometric measurements and chest diameter were re-taken immediately after the intervention and then one week later. In the periods between the follow-up spirometric assessments, patients were instructed to not vary their normal daily routine, and to record their daily activities over the one week period in an 'activity diary'.

Pulmonary Function measures were obtained using the American Thoracic Society's (ATS) guidelines [34]. The standard instruction protocol was to give a demonstration and familiarisation trial to the participant. A minimum of three technically acceptable expiratory manoeuvres were performed, and a maximum of eight manoeuvres were allowed if there as a large variability between expiratory breaths. The highest FEV_1 value had to be within 0.2L of the second highest. The lung function was recorded using a spirometer with the participant seated, and the nose occluded by a nose peg. The end of the FVC test is determined by a constant volume of at least one second after an exhalation time of six seconds had elapsed.

The HVLA procedure used was a spinal manipulation applied to T2-T4 with the patient in the supine position [35]. The rib raising technique used was adapted from Wallace [36] and involved having the participant seated and the practitioner contacting bilaterally the rib angles of the second, third and fourth ribs and applying a lateral traction at the rib angle while pulling the participant towards him. The treatment period was timed at 2 minutes and a rate of 25 cycles per minute for each participant.

Statistical Analysis

All data is reported as mean ± SD. Values were also converted to percentage changes to assess which intervention or which group produced the greatest change in pulmonary function. A 3 × 3 mixed design SPANOVA was performed on the interactions between time and group as well as a between group analysis of the groups with planned comparisons between groups over time. A one-way anova was performed on the chest diameters of the HVLA participants, which was deemed appropriate given that there was significant overlap between the mean and standard deviations of all three groups. SPSS for Windows, Version 11.0 (Microsoft U.S.A) was used to analyse the data. Significance was set at $p \leq 0.05$.

Results

There was no significant difference between the 3 treatment groups in terms of FEV_1 values ($F_{(38, 2)} = 0.157$, $p = 0.855$), FVC values ($F_{(38, 2)} = 0.219$, $p = 0.804$), FEV_1 / FVC values ($F_{(38,2)} = 1.327$, $p = 0.278$), or chest diameter measurements ($F = 0.018$, $p = 0.982$). Mean values for FEV_1 , FVC, and FEV_1 / FVC are reported for pre- intervention, post-intervention, and 1 week in Tables 1 and 2.

Table 1: Mean + Standard Values for FEV_1 and FVC.

Group	FEV_1			FVC		
	Pre-Int M + SD	Post-Int M + SD	1 week M+ SD	Pre-Int M + SD	Post-Int M + SD	1 Week M + SD
HVLA	4.1 ± 0.88	4.16 ± 0.88	4.31 ± 0.88	4.79 ± 1.01	4.84 ± 1.04	5.06 ± 1.11
RR	4.1 ± 1.13	4.19 ± 1.08	4.28 ± 0.85	5.00 ± 1.29	5.10 ± 1.11	5.20 ± 0.95
HVLA + RR	3.88 ± 0.93	3.95 ± 0.84	4.22 ± 0.69	4.71 ± 1.29	4.78 ± 1.11	5.02 ± 0.98

Table 2: Mean + Standard Values for FEV_1 / FVC and Chest Diameter

Group	FEV_1 / FVC			Chest diameter		
	Pre-Int M + SD	Post-Int M + SD	1 week M + SD	Pre-Int M + SD	Post- Int M + SD	1 Week M + SD
HVLA	85.09 ± 4.46	85.73 ± 3.82	85.36 ± 7.19	95.73 ± 8.91	95.73 ± 8.84	96.36 ± 9.24
RR	81.57 ± 8.54	81.43 ± 7.48	81.36 ± 3.69	98.43 ± 7.09	98.29 ± 7.28	98.39 ± 7.32
HVLA + RR	82.69 ± 7.58	83.00 ± 7.70	84.23 ± 6.82	96.63 ± 12.27	96.79 ± 12.44	97.41 ± 12.61

Within-group significant differences were found in each of the three different treatment groups with respect to time in terms of FEV_1 values [$F_{(38, 2)} = 9.461$, $p = 0.002$, power =

0.909] and FVC values [$F_{(38, 2)}$ = 8.090, p = 0.005), power = 0.830]. However, no significant differences were found in the FEV_1 / FVC [$F_{(38, 2)}$ = 0.212, p = 0.690, power = 0.075] or chest diameter values within the three treatment groups with respect to time.

The planned comparison test for the three groups over time revealed that the significant increases in FEV_1 values occurred between pre-intervention and follow-up (p = 0.002) and between pre-intervention and post-intervention (p = 0.022). When FEV_1 results were interpreted as percentage change, the greatest increases were noted at the 1 week time period, particularly for the HVLA + RR and the RR group in which respective increases of 10.5% and 7.41% occurred.

The planned comparison also revealed that the significant increases in FVC also occurred between pre-intervention and follow-up (p = 0.020) and between pre-intervention and post-intervention (p = 0.005). When FVC results were interpreted as percentage change, the greatest increases were also noted at the 1 week period particularly for the HVLA and the RR group in which respective increases of 6.5% and 6.92 % occurred. Only moderate increases of between 0.7 – 3.3 % were noted in the 3 groups at the post-intervention time period (Table 3).

Table 3: Mean + Standard Values for % FEV_1 and FVC.

Group	% FEV_1			% FVC		
	% Pre-Int M + SD	% Post-Int M + SD	% 1 week M+ SD	Pre-Int M + SD	Post-Int M + SD	1 Week M + SD
HVLA	100 ± 0.00	101.58 ± 5.02	106.35 ± 13.67	100 ± 0.00	100.71 ± 2.58	106.52 ± 13.96
RR	100 ± 0.00	103.07 ± 8.74	107.41 ± 14.45	100 ± 0.00	103.31 ± 7.81	106.92 ± 15.05
HVLA + RR	100 ± 0.00	102.33 ± 3.70	110.53 ± 12.65	100 ± 0.00	102.30 ± 3.62	98.77 ± 30.76

Discussion

All treatment interventions showed a significant difference over time for FEV_1 and FVC values, especially in the time period between post-intervention and follow-up. The results of this study show that statistically significant increases in both FEV_1 and FVC were sustained for a period of one week, although only within groups over time. No significant differences either between groups or within group were found for chest diameter or FEV_1 / FVC.

The improvement in FVC and FEV_1 values may be due to either the treatment intervention or psychosocial factors enunciated by Masarsky and Weber [24]. These include: the subjects having an improved understanding of the spirometry procedures during the progress examination which is reflected in their performance; subjects breathe more easily at the progress examination because they are more familiar, and therefore less anxious, with a laboratory environment; subjects may sense that the researcher expects or wants an improved performance at the progress examination, so they try harder. This study attempted to address some of these factors by using familiarisation trials and obtaining an initial baseline value after a minimum of three exhalations.

The results of this study have implications for previous studies which show that rib raising produces within subject increases in both FEV_1 and FVC over time that are statistically significant in symptomatic subjects [27]. These imply that HVLA and rib raising ought to be equally effective in improving the pulmonary function of symptomatic individuals, given that both procedures affect the pulmonary system via the same neurological mechanism and given that the results of this study show no statistically significant difference between the mean FEV_1 and FVC values within the three groups over time.

The results of the Wheatley et al [27] study on rib raising treatment in asthma sufferers and no-asthmatic controls showed that rib raising produced a greater, though not statistically significant, effect on FEV_1 and FVC in asthmatics than in the control group. Therefore, it may be possible to infer that HVLA may be as useful an adjunct as rib raising in the long-term management of stable asthma since previous studies have shown that rib raising produce significant increases in the FEV_1 and FVC values of asthmatics [27] and the results of this study show significant within group increases in FEV_1 and FVC over time in all three groups.

It is possible to theorise that neurological mechanisms rather than mechanical causes have caused improvements in lung function in each of the three groups over time since no statistical significance was found between the chest diameters either within each group over time or between groups. No nerve conduction measures were undertaken in this study, therefore it is not possible to definitely state that the increases in FEV_1 and FVC over time in all three groups were due to the neurological model.

Improved pulmonary performance is an issue not only for asthmatics and for patients with chronic obstructive pulmonary disease, but also for sportspeople or anyone interested in improving their general health. The results of this study suggest that either rib raising or HVLA may improve lung performance for up to one week. It is interesting to note that both HVLA and rib raising were shown to be equally effective in increasing FEV_1 and FVC over time, since those individuals who disapprove of manipulation can select a less invasive technique like rib raising.

Topics for further research arising from this study include optimal time periods for the application of rib raising in order to improve lung function. The time period employed in this study was 2 minutes, 25 cycles per minute. Whether or not a shorter time period would have produced a comparable effect has never been researched.

Conclusion

This study demonstrated that rib raising and HVLA are equally effective in improving lung function within each group over time, as measured by FEV_1 and FVC in an asymptomatic population one week after the manual intervention. No significant improvement in lung function between the groups was measured. Given that rib raising has been shown to improve ventilatory function in asthmatics, it may well be possible that HVLA may also be a useful adjunct in the treatment of asthma. Neurological rather than mechanical factors may be responsible for the improved lung function within each group over time. The results of this study should be of interest to sportspeople keen to improve their performance, or anyone keen to improve their general health. Rib raising is as effective as manipulation at improving lung function over a one week period for those patients who eschew manipulation.

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