THE EFFECTS OF SLOW RIB RAISING ON HEART RATE, BLOOD PRESSURE, RESPIRATION RATE AND PAIN PRESSURE THREASHOLD.

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ABSTRACT

Background

Mobilization techniques are commonly employed by manual therapists to treat spinal pain or spinal dysfunction. Many authors postulate different mechanisms by which mobilization techniques can produce positive outcomes involving the sympathetic nervous system, however supporting evidence remains scarce.

Objective

To determine whether rib raising over the costotransverse joints at a slow rate (0.5hz, 30/min) can affect indicators of SNS function by producing changes in heart rate, respiratory rate, blood pressure and pain pressure threshold.

Design

Randomized, cross-over, single blind, placebo controlled design in which participants experienced all three treatment conditions (rib raising treatment, placebo treatment and control treatment).

Subjects

Thirty asymptomatic and apparently healthy participants (age 22.4 ± 2.75yrs) were voluntarily recruited from the Victoria University Osteopathic Medicine Student Clinic.

Method

Participants were randomly allocated to receive a treatment condition for three sessions with weekly intervals between treatment sessions. All treatment modalities were experienced by the participants.

Baseline measures for heart rate (HR), respiratory rate (RR), systolic blood pressure (SBP), diastolic blood pressure (DBP) and pain pressure threshold (PPT) were recorded initially and repeated after two treatment interventions and after two rest periods.

Results

Analysis with five separate one way analysis of variance (ANOVA) with *a priori* comparisons revealed stastically significant interactions between groups for RR ($F_{(2,87)}$= 7.02, P= 0.001), DBP ($F_{(2,87)}$= 3.51, P= 0.03) and PPT ($F_{(2,87)}$= 3.51, P=0.03). Increases were also observed for HR and SBP although these results were not stastically significant.

Conclusions

Mobilization of the ribs 1-6 at a slow rate (0.5hz, 30 cycles per minute) in asymptomatic patients produced stastically significant increases in RR, DBP and PPT. These changes were compared to the control and placebo groups in which little to minimal changes were observed.

Keywords

Rib Raising, Mobilization, Osteopathy, Sympathetic Nervous System

INTRODUCTION

Mobilization or articulation techniques such as rib raising are commonly employed by manual therapists to treat spinal pain or spinal dysfunction, which is defined as an impairment or disturbance of normal spinal function.[1] Mobilisation application and the reporting of its effects have been largely based on clinical observation and theories rather than understanding of the physiological process involved.[2] A number of theories describing biomechanical, biochemical and physiological mechanisms of actions on the sympathetic nervous system (SNS) have been hypothesized. These theories centre around affecting either local tissues at the site of treatment application or the display of a more systemic influence.[3-6] A trend in manual therapy research is to examine physiological changes mediated by the sympathetic nervous system (SNS) after manual intervention.[2-6] The majority of the research investigating the effect of manual therapy techniques on cardiovascular and respiratory indicators of SNS function have involved the use of manual therapy mobilisation.[2,3,5-9]

Previous publications by authors have suggested that manual therapy can have a direct effect on the SNS.[2-6,8,9] Possible mechanisms for these effects on the SNS include direct local effects on sympathetic fibers within the joint capsule, ligaments or tissues,[3] neurophysiological effects involving the dorsal periaquaductal grey (dPAG) region of the midbrain[2] or a non-specific placebo effect.[2] Previous research has suggested that local stimulation of sympathetic fibers during a treatment procedure at a specific vertebral level is possible due to the close anatomical relationship of sympathetic ganglia and tracts.[2,6] Bulbulian et al[10] and Fryer et al[11] suggest that passive joint mobilisation activates a central control mechanism and mechanoreceptors via a facet joint capsule stretch reflex-mediated inhibition. This is in conjunction with afferent discharges from cutaneous receptors, muscles spindles, mechanoreceptors and free nerve endings found in the annulus fibrosis and ligaments of the spine. This will cause activation of the spinal gate control mechanism and provide pain relief. This theory is also documented by Wright (1995) in which an emphasis is placed on neuronal input in inhibiting nociceptive afferent input at the spinal cord level.[12]

A neurophysiological effect on the SNS is a hypothesis described by many authors that has become more widely accepted.[2-4, 8] Recent studies into the effect of manual therapy techniques on the SNS have demonstrated immediate hypoalgesic effect which is specific to mechanical nociception, rather than thermal nociception.[2] Increased SNS activity also occurs concurrently with the hypoalgesic effect and it has been reported that a strong correlation may exist between the two.[3] These findings of hypoalgesia and increased SNS activity seem to be similar to the findings produced by stimulation of the dPAG of the midbrain in animal research studies.[13,14]

The production of initial hypoalgesia accompanied by a sympathoexcitatory effect is a common observation by previous authors following manual spinal techniques.[2-6] A number of manual therapy techniques such as mobilisation and manipulation have demonstrated these SNS changes. A central postero-anterior grade III mobilisation performed at the C5 level has been demonstrated to stimulate the SNS over a short period of time.[6] When performed at two rates, slow at 0.5hz and fast at 2.0hz, the faster yielded a significantly greater increase in skin conductance on comparison to the slow. However, these authors failed to compare the effects of this technique on other measurable outcomes of SNS activity or at other spinal levels.

A left lateral glide mobilization technique to C5 in asymptomatic patients has been demonstrated to produce an increase in respiration rate (RR), systolic blood pressure (SBP), diastolic blood pressure (DBP) and heart rate (HR)[2,3], an increase in skin conductance and a decrease in skin temperature.[2,6] An increase in pain pressure threshold (PPT) over the lateral epicondyle in patients suffering from lateral epicondylitis was also observed after application of the same lateral glide mobilisation which indicates a distal hypoalgesic response.[5] Vincenzino et al[5] reported an increase in sudomotor activity was observed in conjunction with a decrease in cutaneous vasomotor activity after administering this treatment technique. Although mobilization and manipulation are different techniques that influence the SNS, it can not be assumed that the same SNS effects will be seen. A wide range of research has been documented on the SNS changes following manipulation[2,3,5,7-10] but little has been documented on the effects following mobilization. Osteopaths have reported observable changes to the SNS following the use of mobilization techniques such as rib raising[15] but little scientific evidence has been produced to support these claims.

The aim of this study was to determine whether rib raising over the costotransverse joints, which are closely related anatomically to the descending sympathetic chain at the levels of T 1-6, at a slow rate (0.5hz, 30/min) can affect indicators of SNS function by producing changes in heart rate, respiratory rate, blood pressure and pain pressure threshold.

METHOD

Participants

Thirty asymptomatic and apparently healthy participants (N=30) (age 22.4 ± 2.75yrs) were voluntarily recruited from the Victorian University Osteopathic Medicine Student Clinic to take part in this study. Participants provided signed informed consent and the study was approved by the Victoria University Human Research Ethics Committee.

All potential participants completed a medical history questionnaire to ensure all volunteers were asymptomatic and healthy. Participants were excluded from the study if they presented with current thoracic spine pain, disc bulge or herniation, costovertebral joint sprain, rib or vertebral fractures, diagnosed cardiac disorders, uncontrolled asthma, neurological pathologies affecting the autonomic nervous system, degenerative joint disease, any inflammatory spondyloarthropathies and any participant on a high dosage of corticosteroid use or currently undertaking concurrent osteopathic treatments.

Procedures

This study utilized a randomized, cross-over, single blind, placebo controlled design in which participants experienced all three treatment conditions (rib raising treatment, placebo treatment and control treatment). Participants were randomly allocated to receive a treatment condition for three sessions with weekly intervals between treatment sessions to allow for a wash-out period for treatment effects. Random allocation of treatment conditions was determined by a computer algorithm. Participants were requested to refrain from smoking, ingestion of caffeine products and exercise for two ours prior to treatment.

PPT was measured over the forth thoracic vertebrae as it lies between the range of ribs 1-6 and the neural supply to the heart and lung tissue is from the thoracic nerve levels 1-5.[16] The forth thoracic vertebrae has also been reported by Keating et al[17] to have an average pain pressure threshold of 324 kPa/cm^2. A visible skin pencil marker was placed over the T4 spinous process after identification using the palpatory technique outlined by Greenman.[18] Participants were offered a gown to wear as all upper body clothing, excluding bras, were required to be removed. This allowed for normal thoracic cage motion whilst breathing and also easy access to the rib angles for the treatment intervention.

Measures

Whilst the participant was supine, heart rate and respiratory rate were recorded using the AMLAB system (ADInstruments) and analysed using Powerlab ADInstuments Chart version 3.4 (ADInstruments 1994-1999). Blood pressure was recorded using a calibrated manual sphygmomanometer and stethoscope by a single operator. Pain Pressure threshold was recorded over the forth thoracic spinous process while the patient was supine using a hand held electronic pressure algometer (Somedic Algometer Type 2, Sweden) equipped with a one centimeter probe. Two recordings were taken with direct pressure applied posteriorly down onto the T4 spinous process with a ten second rest interval occurring between each reading. An average of these two recordings was then calculated.

At each session, participants were positioned lying supine and were attached to the AMLAB system via a band around the rib cage at the level of T7 for respiration rate and via a gel transmitter on the second digits finger pad on the left hand for heart rate. Baseline measures for heart rate and respiratory rate were taken over a two minute period. Following this, initial recordings for blood pressure and pain pressure threshold were taken during an initial two minute rest period.

The treatment conditions (rib raising (0.5Hz), control and placebo) were determined by computer algorithm. The rate of rib raising was dictated by a visual electronic metronome in which was only observable by the treating osteopath. Following the initial rest period a treatment condition was firstly administered for a one minute period followed by a one minute rest period and concluded by a one minute treatment period

Heart rate and respiratory rate were continuously recorded through out the treatment. Recordings for blood pressure and pain pressure threshold were taken immediately following all treatment intervention periods. The treating registered osteopath was blind to the results of each measurement and the researchers were blind to the treatment condition received.

Interventions

Rib Raising Technique

Rib raising was administered bilaterally to the rib angles one to six at a rate of 0.5Hz (30 cycles per minute). The participant was asked to relax as the osteopath administered the technique. The procedure was adopted from the treatment presented by Ward[19] in which participants lie supine throughout the research procedure with the practitioner placed at the head of the table facing the participant. Reaching under the participant's back, practitioner extended bilateral forearms and hands with palms positioned upwards. Fingertips engaged the paired upper ribs of one to six near their angles on each side of the midline. The practitioner gently pulled in a cephalad direction at a rate of 0.5Hz. Local inhibitory pressure was also applied to the overlying erector spinae muscle. The procedure was applied over a period of one minute.

Placebo

Participant and practitioner were positioned in the same as for the rib raising procedure. The practitioner contacted the participant's rib angles but applied no movement to the joints being contacted.

Control

Participant lay supine with the practitioner seated at the head of the table. No physical contact between the practitioner and the participant occurred.

Statistical Analysis

All data for the dependent variables were converted to maximum percentage change from baseline. The data analysis method allowed comparison with previously reported research[2-5] on the effects of mobilization treatment on physiological variables. Results were statistically analysed using SPSS for Windows (Version 11.0). Results are reported as mean ±SD for all directly measured values.

The results were analysed inferentially using a five separate one way analysis of variance (ANOVA) with *a priori* comparisons between groups for each of the independent variables. A P value of ≤ 0.05 was set as the arbiter of significance.

RESULTS

A statistically significant interaction between groups ($F_{(2,87)}$= 7.02, P= 0.001) for respiratory rate was observed with an increase from baseline of 31.3% (Figure 1) during the rib-raising treatment intervention. This was compared to an increase in the control of 3.9% and the placebo of 10.3%. A statistically significant difference of 26.4% was demonstrated between the rib raising treatment and control conditions for respiration rate (P= 0.001) and a 19% change between the rib raising treatment and placebo conditions (P= 0.01) (Table 1). A partial eta squared value of 0.12 was also demonstrated, indicating a large effect between groups.

(Insert Figure 1 near here)

A significant main effect of treatment condition for diastolic blood pressure ($F_{(2,87)}$= 3.51, P= 0.03) was also demonstrated. The increase from rest on DBP during the rib raising treatment condition was 5.4% compared to the control group which increased 2.9% and the placebo group which decreased 0.4%. A-priori comparisons revealed a significant difference between the slow and placebo groups (P= 0.03) and a partial eta squared value of 0.07 representing a medium effect between groups. Comparisons between other groups were not significant.

(Insert Table 1 near here)

A significant interaction for pain pressure threshold ($F_{(2,87)}$= 3.51, P=0.03) was also demonstrated with an increase of 22.6% from rest for the rib raising treatment group. A significant difference of 15.3% was observed between the rib raising treatment and placebo groups and an insignificant 10.4% change between the treatment and control groups. A-priori comparisons revealed a significant change between the treatment and placebo groups (P=0.03) with a partial eta squared value of 0.07 representing a medium effect between groups. No other significant differences were found between other groups (Table 1).

Findings regarding heart rate and systolic blood pressure were inconclusive with no significant differences found (Table 1). Increases in heart rate of 2.4% for the rib raising treatment from baseline were seen. This was in conjunction with increases of 4.7% between the rib raising treatment and placebo groups and 1.7% between the rib raising treatment and control. These findings were mirrored by the results produced for DBP, however, they were not significant ($F_{(2,87)}$= 1.05, P= 0.36). Similar increases in SBP were observed with an increase of 0.4% from rest in conjunction with a 0.7% increase between treatment and control and a 1.2% increase between treatment and placebo (Table 1).

DISCUSSION

This study has demonstrated that the application of rib raising at a slow rate (0.5hz, 30 cycles per minute) to the rib angles of ribs 1-6 resulted in a statistically significant increase in respiration rate (RR), diastolic blood pressure (DBP) and a decrease in pain pressure threshold (PPT). Increases in heart rate (HR) and systolic blood pressure (SBP) were also demonstrated however these results were not statistically significant.

A significant increase in RR of 31.3% was seen for the treatment intervention when compared to baseline. A cervical mobilization study by McGuiness at al[2] reported an overall greater change in respiratory function compared to cardiovascular functions. RR increased 44% which runs parallel to the findings in the current study in which an increase of 31.3% was seen. This was also comparable to results reported by Vincenzino et al[3] in which an overall increase in RR of 36% was seen. The respiratory changes in our current study can also be compared to findings demonstrated by Wheatley et al[20] showing an improvement in short-term lung function following a rib raising technique application in both asthmatic and non-asthmatic participants. Compared to the control group, FEV_1 and FEV values significantly increased 9.5 times and 2.8 times respectively following the treatment intervention. The authors attributed the changes observed to cutaneo-visceral reflexes in the upper 6-7 thoracic vertebrae and ribs resulting in sympathetic stimulation. Manual treatment of the cervical and thoracic spines have highlighted an increase in RR and lung function which has been confirmed by the current study.

McGuiness et al[2] also reported changes in cardiovascular function with increases of 10.5% for HR and 12.5% for BP. Results produced by the current study demonstrated DBP being the only variable with any significant increases, while insignificant increases were observed for HR and SBP. The results produced by DBP and HR were near identical with similar increases in RR treatment, control and placebo from rest (figure 1). The current study demonstrated an increase from rest for DBP (5.4%) and heart rate (2.4%). These findings were concurrent with increases on SBP and DBP of 14% were reported by Vincenzino et al[3] in conjunction with increases in HR of 13%.

Conflicting results regarding short term changes to the SNS have been reported by Knutson[8] and McKnight et al[9] in which SBP decreased 7.3% and 1.4% respectively following a cervical spine adjustment technique. Decreases in DBP of 0.3% were also reported by McKnight in which it was hypothesized that these results were due to the presence of a cervical subluxation being adjusted in their study. Celender et al[21] states soft tissue manipulation to the upper thoracic segments led to a decrease in blood pressure in almost all subjects. Similar studies reported conflicting results to the previous study in which decreases in SNS activity following manipulative techniques to the spine were seen.[22,23] Driscoll et al[22] reported one session of a chiropractic manipulation to a cervical symptomatic area produced decreases in the SNS activity with no significant changes to blood pressure. Following the forth and sixth treatments, the SNS activity was seen to increase.[22] These changes were demonstrated using one subject repeatedly throughout the trial period compared to thirty subjects in the current study.

A significant 22.6% increase from rest was demonstrated for PPT following the rib raising treatment. Increases were also seen between the treatment and placebo groups (15.3%) and between the treatment and control groups (10.4%). Parallel findings were reported by Sterling et al[4] in which an increase in a mean increase in PPT with the treatment condition of 22.5% was seen between the treatment and control groups and the treatment and placebo groups. These results were also supported by Fryer et al[11] where PPT demonstrated a mean increase of 28.42kPa compared to 11.99kPa (42.2%).

Peterson at al[24] and Chiu et al[6] reported significant increase to skin conductance following a C5 central postero-anterior grade III mobilisation technique. Smaller increases to skin temperature were also demonstrated although these were insignificant. These changes indicated a stimulatory effect to the SNS activity following the mobilisation technique to the cervical spine which was similar to the findings in the current study in which increases in all sympathetic measures were seen following a mobilisation technique to the thoracic spine.

An immediate increase in the RR, DBP and PPT post-treatment lends support to the theory that rib raising could possibly produces its initial effects in part through activation of the local sympathetic fibers or receptors within the joint capsule, local tissues, ligaments or connective tissues.[3,4,7,20] These changes may be due to the direct stimulation of local sympathetic fibers by the movement of the rib heads due to their close anatomical relationship of the thoracic sympathetic ganglia. Beal[16] describes a viscerosomatic reflex where visceral afferent stimuli synapse at the dorsal horn of the spinal cord to transmit the stimulus to the sympathetic and peripheral motor efferents. This results in sensory and motor changes in somatic tissue, viscera, blood vessels and skin. This close anatomical relationship of the sensory input at the dorsal horn of the spinal cord allows for possible communication between the visceral and somatic systems and the higher centres. As neural supply to the heart and lung tissue is from the thoracic nerve levels 1-5, direct stimulation of these levels may cause direct stimulation of the neural supply to these structures.[16] From the results obtained, it is possible that an immediate sympthoexcitatory effect was produced which in is accordance with the findings by Chiu et al[6] which evaluated a cervical mobilization technique.

Local stimulation of the sympathetic fibers may directly or indirectly activate the dPAG mechanisms.[3] Previous studies for cervical manipulation or mobilisation on asymptomatic and symptomatic patients have suggested that sympathetic changes occur through activation of descending pathways projecting from the dorsal periaquaductal grey (dPAG) region of the midbrain.[3-7] The studies into the effects of manual therapy have demonstrated sudomotor changes, cutaneous vasomotor stimulation, cardiac and respiratory changes as well as hypoalgesia.[2-7] Previous research used this theory to explain treatment to the cervical spine influencing the cardiovascular system and PPT.[2-4,6] Majority of the projections from the dPAG terminate at the level of C7 with the remaining few fibres terminating at T1-2 in the spinal cord[25] and are therefore unlikely to be influenced in the current study with mobilisation of ribs 1-6. This suggests that the findings of the current study are inconsistent with previous research into the dPAG theory and therefore this theory is an unlikely explanation for what is observed lower than the T2 level.

Articulation is a procedure that utilizes a slow rate of repetitive movements in the same direction compared to manipulation that involves a single fast thrust to a specific spinal segment. McGuiness et al[2] suggested that that magnitude of the sympathetic response elicited by mobilization may be specifically related to the movement component of the technique applied. The rhythm of mobilization may be varied from a sharp movement to a slow sustained technique.[6] It may be expected the two forms of treatment techniques produce similar changes to sympathetic activity however McGuiness at al[2] suggested that the two forms of stimulation are quite different and it is possible that they produce different effects on SNS function. Further research is required to formulate a comparison between the effects of mobilization and manipulation techniques.

Intensity, location and duration of the stimulus has been proposed to lead to different SNS responses.[7] The use of mobilization technique in previous research applied to the cervical spine was at an unknown rate[2-4] as opposed to a mobilization technique applied to the thoracic spine at a controlled rate as in the current study. Results produced from cervical mobilization indicated significant increases in all sympathetic measures (HR, RR, SBP and DBP).[2-6] Different rates of mobilization were adopted by Chui et al[6] in which rates of 0.5hz and 2.0hz were applied to produce a significant increase in skin conductance indicating the stimulation of the SNS. In the current research, not all measures of SNS activity were significant. Chiu et al[6] suggested that a slow rate mobilization at 0.5hz induces less movement of the costotransverse joints over a period of time and therefore limits the amount of stimulation produced. This results in a smaller response from the SNS afferents and may account for the limited stimulation of the SNS observed in the current study. This suggests that intensity of application of the technique may directly influence the amount of SNS stimulation.

The time course of therapeutic effects following mobilization treatment remains to be evaluated. Treatments periods of thirty seconds with rest periods of sixty seconds was utilized by Vincenzino et al[3] while one minute treatment intervals with one minute rest periods were employed by other studies.[2,6] A further study employed two minute intervals treatment and rest intervals.[4] The current study utilized treatment periods of one minute followed by rest periods of one minute. Immediate SNS effects were observed in the current study and previous studies but any possible long term effects to the SNS are yet to be determined. Further research is required to determine the long term effect on the SNS after manual therapy techniques.

CONCLUSION

Mobilisation of the ribs 1-6 at a slow rate (0.5hz, 30 cycles per minute) in asymptomatic patients produced stastically significant increases in RR, DBP and PPT. These changes were compared to the control and placebo groups in which little to minimal changes were observed. Further research is necessary to clarify these findings and to investigate the effects of other mobilization techniques and rates of application on similar indicators of SNS activity. Rates producing an inhibitory effect to the SNS should also be investigated. Further investigation into the comparison between mobilization and manipulation techniques and their effects on the SNS is also required. Ultimately, research performed in this area will ensure that application of manual therapy techniques within the practice of osteopathy is based upon sound scientific information of the effects of such treatments.

Table 1 *P* values and partial eta squared values obtained from A-priori comparisons comparing condition means for each of the dependent variables

GROUP	P VALUE	PARTIAL ETA SQUARED
RR	0.001	0.12
DBP	0.03	0.07
PPT	0.03	0.07
HR	0.36	0.02
SBP	0.61	0.001

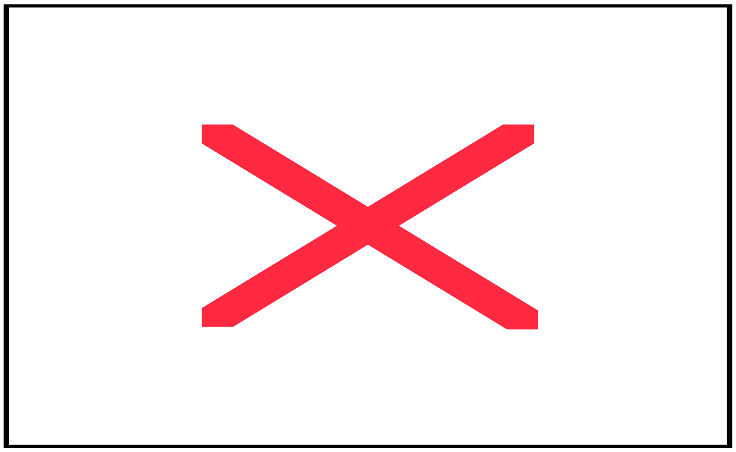

Figure 1- Percentage change in each of the dependent variables following the application of rib raising (treatment), a placebo condition and a control condition.

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