The Impact of Cervical Manipulation on Heart Rate Variability

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***Abstract* – Heart Rate variability (HRV) is the inter-beat variability in heart rate and is moderated by the balance of sympathetic and parasympathetic divisions of the autonomic nervous system. Electrocardiography (ECG) can be utilized to obtain Low frequency (LF) to high frequency (HF) ratios that represent sympathetic to parasympathetic response, respectively and these ratios may be increased in people with chronic pain. Spinal manipulation is often used to manage musculoskeletal disorders such as neck pain. This study assesses the influence of cervical manipulation on HRV using LF/HF ratio. Ten subjects without neck pain formed the control condition and passive head movement (PHM) condition during which their head was flexed, extended and rotated. Ten subjects with subclinical neck pain underwent the same conditions. A separate session was performed for an actual manipulation. LabChart™ software was utilized to collect and analyze five minute pre and post R-R intervals. Repeated measures of ANOVA demonstrated significant interaction effect on HRV (F (1, 18) = 6.841, p = 0.018) following manipulation vs. PHM. Subsequent analysis showed a significant decrease in the ratio during manipulation condition (p = 0.0316), that was not seen in any other conditions, suggesting a significant autonomic nervous system alteration. This study may lead to new techniques to assess the effectiveness of various treatment interventions.**

I. Introduction

There have been many studies that have utilized heart rate variability (HRV), which is a beat-to-beat variation in the heart rate or the R-R interval to explain the contribution and the dominance of sympathetic or the parasympathetic division of the autonomic nervous system and various clinical conditions [1]. This variability can be measured through the use of electrocardiography (ECG) which produces a wave complex that includes atrial depolarization (P wave), ventricular depolarization (QRS complex) and ventricular repolarization (T wave) when the heart contracts and the intervals between consecutive beats are analyzed [7]. Heart rate is variable which depends on an individual's health status, condition and may decrease during resting periods which indicates an increased vagal (parasympathetic) response [7].

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HRV measurements have involved various methods of analysis that include spectral analysis that are represented by low frequency (LF), high frequency (HF) and their ratio which correspond to the sympathetic and parasympathetic efferent activity and their balance, respectively [3], [9].

There has been relative work in the field of HRV in which similar technique has been used to determine the relationship between HRV, waking and sleeping in healthy adults which has shown that the parasympathetic activity (HF) predominates during non-rapid eye movement (NREM) sleep and the sympathetic activity (LF) is increased during rapid eye movement (REM) sleep which was also demonstrated in their LF/HF ratio [6].

Many studies have also explored the effects of spinal manipulation on the sympathetic and parasympathetic response, but the term 'spinal manipulation' may include a range of related procedures [2], [3], [4]. Cervical manipulation has been used extensively in the chiropractic field as a treatment option to manage musculoskeletal disorders such as neck pain [2]. This has shown to affect the autonomic nervous system (ANS) which includes the sympathetic (SNS) and parasympathetic nervous system (PNS) [3]. Subclinical neck pain is a reoccurring neck dysfunction such as pain, ache or stiffness that may result from prolonged improper posture without a history of neck trauma [8].

An earlier study demonstrated [3] that healthy adults without any neck or cervical pain undergoing cervical manipulation showed an increase in the sympathetic response and an increase in the balance between sympathetic to parasympathetic output to the heart when compared pre- to post-manipulation. Since the previous study was conducted on a healthy population with no history of neck pain in a supine position, the present study was intended to determine the effects of cervical manipulation on HRV in a sitting position using spectral analysis to obtain LF/HF ratio or sympathetic to parasympathetic ratio to determine which system is more dominant.

II. Methods

Informed and written consent was obtained for all the participants involved in the study and ethical approval was

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received from the Research Ethics Board of UOIT. All the subjects were included based on the following criteria:

- No caffeinated beverages (i.e. coffee, tea) prior to the experiments;
- No large meals prior to the experiments;
- No fatigue;
- No spinal injury or contraindications to manipulation;
- Not in an acute exacerbation of the ongoing neck pain

All the subjects also completed Neck Disability Index and Neck pain Mini-Questionnaire to assess their history of pain and categorize subjects. Consent for neck manipulation was also received by the subclinical neck pain subjects. The ECG data was collected during a one (1) hour session for subjects (n=10, three women and seven men), aged 18-30 (mean age 21.7) with no neck pain that included ten (10) minute intervals for acclimatization pre and post the control condition with no intervention, as well as passive head movement (PHM) condition. The same one (1) hour procedure was also performed for subjects (n=10, five women and five men), aged 18-30 (mean age 23.3) with a history of reoccurring neck stiffness and/or pain without acute onset of pain in order to effectively assess the outcomes of cervical manipulation [7] which included both control and PHM conditions. On a separate day, a thirty (30) minute session was performed by a registered chiropractor for an actual manipulation.

The experiment utilized ML856 PowerLab 26T by ADInstruments which included the MLA2540 shielded Bio Amp cable. LabChart™ 7 software with HRV Module v1.4.2 for Chart™ from ADInstruments was used to collect the ECG data at a 1000 samples per second (1 kHz) to generate R-R intervals and perform spectral analysis. The surface electrodes used were foam electrodes by Covidien™ that constituted a conductive adhesive hydrogel for better conduction and increased surface area and a MLAYDG dry earth strap by ADInstruments was also used for grounding purposes.

The skin was prepped through light abrasion and alcohol wipes were used prior to electrode application in order to minimize noise by removing debris and oils. Two chest surface electrodes were placed just below the left and right mid-clavicular region, respectively, to decrease movement artifacts and the wrist strap was used on the left hand [1]. The data was collected throughout the experiment, but five (5) minute intervals were analyzed [2], [10], pre and post control, PHM and manipulation conditions and extracted from the ECG data which required the subjects to sit comfortably while instructed to remain stationary. During the control condition, subjects were constantly asked if they were feeling drowsy, as drowsiness can affect HRV measurement [7] and were also asked if they were feeling restlessness, anxiety or nervousness. They were also asked if they were feeling any pain due to constant sitting. In order to counteract any drowsiness effects from the control condition and to simulate the beginning of the control condition where the subjects walked in and sat in the chair, all the subjects were asked to walk for approximately one (1) minute prior to continuation of the PHM condition which was conducted just after the control condition. During PHM, the subjects head was laterally flexed, slightly extended, and rotated by the researcher to positions that mimicked the positioning of a cervical manipulation.

The manipulation condition was performed by a registered chiropractor with 24 years of experience after determining the areas of joint dysfunction in the cervical spine. The subclinical neck pain participants were reclined to a semi-supine position to aid in the treatment process. High-velocity low-amplitude manipulation was delivered to the areas of restricted movement and is a treatment commonly used by many clinicians such as physiotherapists and chiropractors and has been used in previous studies [3].

Since the neck pain subjects were reclined during the manipulation condition, the five (5) minute data post manipulation was collected approximately one (1) minute after reclining back to a sitting position in order to minimize the effects of position change [4]. The HRV module was calibrated to export the R-R Intervals by establishing a threshold for every subject with the application of a 45 Hertz (Hz) low-pass filter to remove high-frequency noise in the signal.

The R-R intervals were also classified on an individual basis from the default setting in order to include normal intervals that may be otherwise classified as ectopic or artifact. The five minute intervals were then analyzed through spectral analysis by adjusting the Fast Fourier Transform (FFT) size to 1024 and selecting a Hann window which provided the power spectrum i.e. low-frequency (LF, 0.04-0.15 Hz), high frequency (HF, 0.15-0.4 Hz) and the ratio of LF/HF [3]. Three way ANOVA was then performed for the healthy and subclinical neck pain groups that included the comparison between the control and PHM conditions of each group and the

comparison of 5 minute interval pre- and post-condition to determine if there was any interaction among the groups, conditions and the pre- and post-intervals. Two way repeated measures ANOVA was then performed for the manipulation group. Pre- and post-treatment values were then compared via the paired t-test where the data was normally distributed.

III. Results

Due to the variability in the heart beat intervals of all the subjects, the ECG data differed as some subjects had larger R-R intervals than others and it may also suggest the variability of the heart rate between subjects. Measures of the HRV before and after the control and PHM conditions for healthy control subjects is presented in Fig 1. Measures of the HRV before and after the control, PHM and manipulation condition for subclinical neck pain subjects is presented in Fig 2.

A three way repeated measures ANOVA (healthy vs neck pain); (control vs PHM conditions and the pre- and post- changes in LF/HF ratio) showed no significant changes overall and there were no significant interactions between the groups or control and PHM conditions and LF/HF ratio. The control condition and the PHM condition showed no significant change in either group. A Two way repeated measures of ANOVA comparing manipulation vs PHM in the subclinical neck pain group showed a significant interaction of HRV versus the sub clinical neck pain group (F (1, 18) = 6.841, p = 0.018). Post-hoc paired t-test indicated that the significant change occurred following manipulation during which the LF/HF ratio decreased by 32% (p=0.031) with no change in the PHM condition.

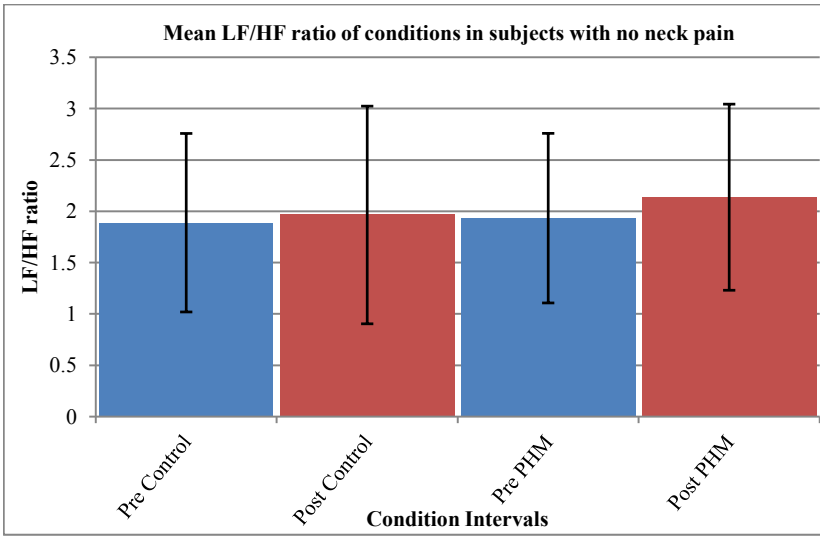

Figure 1. Mean LF/HF ratio (± standard deviation) for healthy subjects in control and PHM conditions.

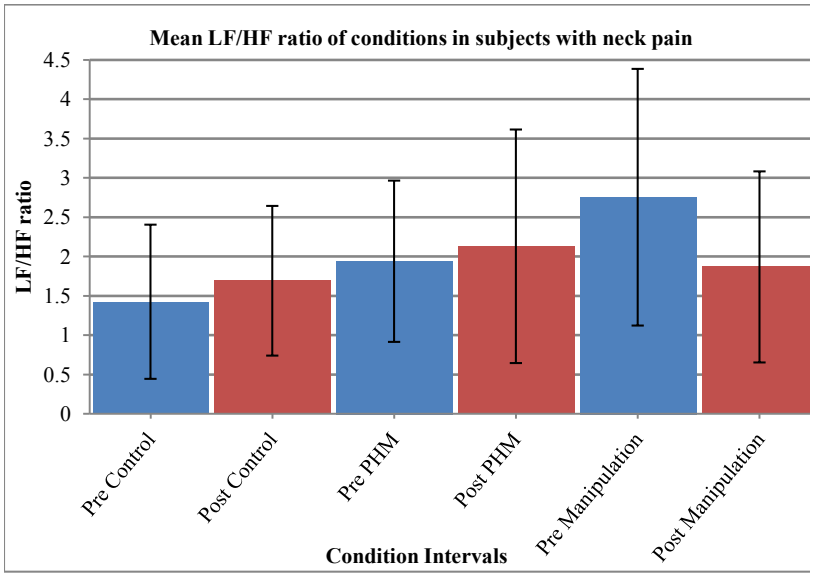

Figure 2. Mean LF/HF ratio (± standard deviation) for subclinical neck pain subjects in control, PHM and manipulation conditions.

Given that LF/HF ratio is dependent on the sympathetic to parasympathetic response, their reciprocity where one component increases and the other component decreases may explain the observed result. It was also interesting to note that the every subject's LF/HF ratio was different as some subjects had a higher ratio compared to others that may account for their variability.

IV. Discussion

In the subclinical neck pain group described herein, cervical manipulation was associated with changes in the heart rate variability, which was not seen in the other conditions. There were distinguishing features associated with cervical manipulation such as high-velocity, low amplitude thrust both passive head movement and manipulation involved movement of the neck and the head through flexion, extension, lateral flexion and lateral rotation, although manipulation also involves a higher velocity which generally results in an audible popping sound due to cavitation of the gases dissolved in the synovial fluid when the joint is gently tractioned as part of the manipulation. This may provide the subject with the

confirmation of an actual manipulation which may have a psychological effect on the individual leading to the observed physiological effects [3]. Subclinical subjects also reported that they felt better after the manipulation as if they were more relaxed due to a decrease in muscle tension which may have led to both physiological and psychological induced decreases in sympathetic drive.

A second mechanism that may also need consideration is the function of cervical mechanoreceptors which may also attenuate the sympathetic activity and augment the parasympathetic or vagal response which may lead to the observed results, Previous work suggests that these receptors may have a role to play in decreasing the LF/HF ratio [4] which has been shown in a previous study that involved myofascial trigger-point massage to the head, neck and shoulders that decreased HR, blood pressure and also augments parasympathetic tone which was measured by assessing HRV and LF/HF ratio [5].

A possible limitation to the study may be due to the sensitivity of ECG to motions and change in positions as the subjects become restless due to prolonged sitting that may affect the results. The use of a 12-lead ECG may help isolate any noise and may provide a clearer data which may be present as the subject moves. Another limitation may be due to the reclining of the chair to a semi-supine position during manipulation in order to help with manipulation which may affect HRV. But, since the actual data collection took place when the subject was sitting up and after one (1) minute of manipulation, any effect from the change in position should not have impacted the results.

V. Conclusion

Cervical manipulation has shown that it can significantly affect HRV by reducing the sympathetic tone and increasing the parasympathetic response. These effects were not seen in either the control or PHM conditions. Multiple factors such as high-velocity, low-amplitude thrust and the stimulation of mechanoreceptors may have produced the observed effects through psychological and physiological changes. The decrease in joint tenderness following the manipulation may also have led to the observed results. The application of this research in the future can lead to the optimization of the application of HRV research that investigates changes in sympathetic and parasympathetic drive in clinical conditions such as pain. This study may also lead to new techniques to assess the effects of various treatment interventions and risk factors for pain development by assessing the pre- and post-effects of the treatment on HRV.

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