The Immediate Effects of Cervicothoracic Manipulation versus Stretching on Upper Trapezius Pressure Pain Thresholds and Range of Motion in Individuals without Neck Pain

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THE IMMEDIATE EFFECTS OF CERVICOThoracic MANIPULATION VERSUS STRETCHING ON UPPER TRAPEZIUS PRESSURE PAIN THRESHOLDS AND RANGE OF MOTION IN INDIVIDUALS WITHOUT NECK PAIN

By

Kevin Carr
Morgan King
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Brendan Parry

A doctoral project submitted in partial fulfillment of the requirements for the

Doctorate of Physical Therapy

Department of Physical Therapy
School of Allied Health Sciences
The Graduate College

University of Nevada, Las Vegas
May 2015
We recommend the doctoral project prepared under our supervision by

Kevin Carr, Morgan King, Erin Oelklaus, and Brendan Parry

entitled

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is approved in partial fulfillment of the requirements for the degree of

Doctor of Physical Therapy
Department of Physical Therapy

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May 2015
ABSTRACT

Background and Purpose: Myofascial pain may be considered one of the most common clinical findings in patients with neck pain (NP). Motor aspects of myofascial pain include disturbed motor function and muscle weakness secondary to motor inhibition, muscle stiffness, and restricted range of motion (ROM). Currently, it is unclear which interventions may have the greatest immediate impact on pressure pain sensitivity and ROM. Several studies have demonstrated improved pressure pain thresholds (PPT) after cervical manipulation; however, it is not clear if manipulation targeted to the cervicothoracic (CT) junction will have a similar effect. Others recommend stretching as a method to reduce muscle soreness; however, the immediate effects of passive stretching to the upper trapezius on PPT and ROM have not been studied. The purpose of this project was to evaluate the influence of CT manipulation and passive stretching to the upper trapezius on PPT and ROM in individuals without recent complaint of NP.

Subjects: Ninety (90) subjects without current complaint of NP were enrolled into the study.

Methods: PPT was assessed on both the right and left upper trapezius musculature. Cervical range of motion (CROM) was assessed in the frontal, sagittal, and transverse planes. Subjects were randomized into one of three groups for intervention (CT manipulation, passive upper trapezius stretching, or control). CROM was reassessed immediately after the intervention. PPT levels were reassessed at 5 and 10 minutes post intervention by a blinded examiner. Mean and standard deviations for PPT and ROM were calculated. Repeated measures two-way ANOVA was used to assess within group (pre- and post- treatment) differences as well as difference among treatment conditions (Control, CT Manip, and Stretch groups). Post-hoc one-way ANOVA tests were used to examine the effects of group assignment/time points in the event of significant interactions between time and group assignment. Statistical significant was set at p <0.05.
Results: The two-way ANOVA test showed that there was a significant interaction between time and group assignment for CROM in the sagittal and transverse planes, however the post-hoc comparisons did not reveal a significant difference among 3 treatment group or among 3 time points. ANOVA also showed that there was not a difference in frontal plane CROM between time and group assignment. Similarly, although the two-way ANOVA test revealed a significant interaction between time and group assignment for PPT, post-hoc analyses showed that there was no difference between the 3 groups or among 3 time points for either side of the upper trapezius.

Discussion: No significant difference in any plane of motion CROM or PPT pre-treatment to post-treatment between treatment groups brings into question the cause of the improved measures with time. Trends found with increased CROM and PPT over time are clouded by increased measures in the control group. The need for further research exists to better understand the relationship between CT manipulation and upper trapezius stretching and their effects on pain pressure thresholds and CROM.

Conclusion: Upper trapezius stretching and CT manipulation may both be viable options for treatment by improving CROM and increasing PPT. Further high powered studies focusing on reducing the learning effects between measures and lowering participant uneasiness with research methods could produce clearer results.
ACKNOWLEDGEMENTS

This clinical trial was made possible by contributions from the UNLVPT Student Opportunity Research Grant. The authors would like to thank Szu-Ping Lee, BSPT, Ph.D., Kai-Yu Ho, MSPT, Ph.D and Merrill Landers, PT, DPT, Ph.D, OCS for their assistance with the statistical analysis of this trial. The authors would also like to thank Emilio Puentedura, PT, DPT, Ph.D., OCS, FAAOMPT, for his mentorship in the design, composition, and authorship of the trial.
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INTRODUCTION

Myofascial pain is considered to be one of the most common clinical findings in patients with musculoskeletal disorders.\(^1\) A recent study showed that myofascial pain was the most common diagnosis affecting 95.5\% of patients with chronic low back pain.\(^2\) Myofascial pain has been shown to activate cortical structures including the anterior cingulate gyrus and feature motor, sensory, and autonomic components.\(^3,4\) Motor aspects of myofascial pain include disturbed motor function and muscle weakness secondary to motor inhibition, muscle stiffness, and restricted range of motion (ROM). Sensory aspects may include peripheral and central sensitization. Peripheral sensitization is a reduction in threshold and increase in responsiveness of the peripheral ends of nociceptors. Central sensitization is an increase in the excitability of neurons within the central nervous system (CNS). Clinical signs of sensitization (peripheral and central) include allodynia (pain due to a stimulus that would not normally provoke a pain response) and hyperalgesia (an increased response to a stimulus that would normally perceived as painful).

There does appear to be a clinical relationship between myofascial pain and joint impairments.\(^5-7\) Cervical manipulation has demonstrated positive effects on neck pain (NP), range of motion (ROM) and pressure pain thresholds (PPT).\(^8-11\) Oliveira-Campelo et al\(^10\) found that atlanto-occipital thrust manipulation led to an immediate increase in PPT over latent trigger points (TrPs) in the masseter and temporalis muscles, and an increase in maximum active mouth opening. Also, cervical spine manipulation directed at the C3 through C4 segments created changes in pressure pain sensitivity in latent myofascial TrPs in the upper trapezius muscle.\(^11\) de Camargo et al\(^12\) found an increase in PPT over those tissues innervated by the manipulated segment after the manipulative procedure. This is similar to the findings of Fernandez-de-Las-Penas et al\(^9\) who reported C7-T1 manipulation lead to changes in PPT in both right and left C5-C6 zygapophyseal joints in healthy subjects. Currently, there are no studies analyzing the effects
of manipulation performed at the CT junction and PPT in the upper trapezius on those who do not have NP. Because of the purported neurophysiological effects of manipulation, we believe that manipulation will have an effect regardless of whether or not the subject has NP and for this reason have chosen to find subjects without NP. However, it is still not clear if manipulation targeted to the CT junction will have any influence on the irritability of myofascial tenderness of the upper trapezius muscle.

Stretching can be used for a variety of purposes. Some have recommended stretching as a method to reduce muscle soreness or prevent injury.\textsuperscript{13-16} Stretching has also been recommended as a treatment for patients with NP.\textsuperscript{17,18} Ylinen et al\textsuperscript{19} compared manual therapy to stretching in 125 female patients who received low velocity mobilization 2 times per week, and a second group that completed select stretches 5 times a week, and found no significant difference between groups. Both groups demonstrated a significant decrease in NP and disability at four week follow-up. Hakkinen et al\textsuperscript{20} reported similar findings. Both studies report that a stretching program is beneficial and equally as effective in decreasing NP when compared to manual therapy. Hakkinen et al\textsuperscript{21} later compared strength training and stretching to stretching alone in 101 subjects with chronic NP. They reported finding no statistically significant difference in NP and disability after each intervention.

Pain sensitivity seems to be influenced by different treatment approaches, including manipulation and stretching. Currently, it is not clear what the effects of CT junction manipulation and stretching would be on PPT and cervical ROM (CROM). The proposed project seeks to evaluate these variables in individuals without recent complain of NP. It is hypothesized that both CT junction manipulation and upper trapezius stretching will significantly increase PPT and CROM.
METHODS

Subjects

Ninety-five subjects were recruited through word of mouth and posted flyers from the main campus of the University of Nevada, Las Vegas (Table 1). Five subjects were excluded from participation in the study; four due to current NP and one not being medically cleared to participate. See figure 1 for flow diagram of subject recruitment, allocation and assessment. Subjects were included in this study if they currently had no NP and were between the ages of 18 and 70 years old. They also needed to be able to lie on their back or stomach without difficulty, and be willing to participate in the study.

Subjects were excluded from this particular study if there were any ‘red flag’ items (contraindications to manipulation) found after completion of the Neck Medical Screening Questionnaire. These items included, but were not limited to, history of a tumor, bone fracture, metabolic diseases, Rheumatoid Arthritis, osteoporosis, severe atherosclerosis, and prolonged history of steroid use. Subjects presenting with NP, or a history of neck symptoms within the last 6 months were also excluded. Further exclusion criteria included those who were pregnant or thought they might be pregnant, had dizziness (vertigo or nausea), history of neck whiplash injury, prior surgery to the neck or upper back, a medical condition which may influence assessment of pain or pressure pain thresholds (i.e. taking analgesics, sedatives, history of substance abuse, or cognitive deficiency), or a diagnosis of fibromyalgia syndrome.

Outcome Measures

CROM - Cervical Range of Motion

The CROM is a clinical tool to assess ROM in the cervical spine. The CROM measures ROM for cervical flexion, extension, lateral flexion right, lateral flexion left, rotation right, and
rotation left to the nearest degree. (Figure 4) The subjects were positioned in a seated upright
to the nearest degree. position and the CROM apparatus was placed on their head. They were given instructions to
move into each of the designated directions ‘as far as possible’. Test-retest reliability of
measurements for CROM using the CROM device demonstrated ICCs ranging between 0.89 and
0.98. The standard error of measurement (SEM) ranged from 1.6 degrees to 2.8 degrees and the
minimal detectable change (MDC) ranged from 3.6 degrees to 6.5 degrees.22

**Pressure Pain Threshold**

The Commander Algo meter handheld digital algometer with a linear response force
between 0 and 111 N in 0.1 N increments was used. It has a 1 cm² round rubber-covered tip. The
value was recorded as the maximum force applied prior to subject stating that their pain threshold
had been reached. (Figure 5) The subject was in a seated position and a mark was applied to the
midpoint between C7 and the acromion along the upper trapezius muscle belly, to ensure
consistent application of the pressure algometer. Instructions were given to the subject by stating,
“I am going to begin applying pressure to your muscle. I want you to tell me the moment the
sensation changes from comfortable pressure to slightly unpleasant pain.” The pressure
algometer was applied to the previously determined mark. The pressure was applied slowly (at a
rate of 5 N/s) until the subject said “now.” The pressure was then read directly from the
algometer. Three measurements of PPT were taken on both the right and left sides with a 20 s
time between measurements. This was performed by the same researcher and the means were
considered in the analysis. At both 5 and 10 minutes post-intervention, the same procedure of
PPT measurements was performed. (Figure 6) Interrater reliability was substantial to near perfect
(ICC = 0.79-0.90)23 SEM & MDC: SEM = 0.205 N/cm². MDC = 0.472 N/cm². The mean PPT at
the upper trapezius muscle measurement site was 23.9 N/cm², with a standard deviation of 1.21
N/cm² and a 95% CI of 2.01 to 2.76 N/cm².23
Training for all researchers included research procedures, confidentiality and application of assessments and treatments. Researchers underwent training in order to apply assessments in a standardized manner.

**Procedures**

A researcher reviewed the informed consent with each subject and allowed adequate time to review. Once each subject had reviewed all materials and had all questions answered, he/she was asked to sign the consent form, which designated formal entry into the study.

Once entered into the study, a researcher assigned a research packet to the subject with an associated subject ID number. This packet included all research related documentation for the individual subject as well as an opaque envelope indicating which group the subject was assigned to. These opaque envelopes were randomly assigned to each packet and denoted assignment to one of three groups (upper trapezius stretch; cervicothoracic manipulation; and no intervention). The subject completed the enclosed demographics form and outcome measures. The subject then went behind a curtain and a blinded first researcher, measured cervical ROM (flexion, extension, side-bending right, side-bending left, rotation right, and rotation left) using the CROM device (Performance Attainments Associated “Lindstrom, MN). A second blinded researcher measured PPT using a Commander Algometer (JTECH Medical, Salt Lake City, UT) for the right and left upper trapezius.

Once the initial measurements were taken, another researcher opened the opaque envelope reading Group 1 (CT Manip), Group 2 (Stretch) or Group 3 (Control). No notation was made regarding the type of intervention that was administered. The subject then went to an isolated area away from the researchers to receive their appropriate treatment. Each treatment will be further described hereafter.

**Cervicothoracic Manipulation**
A skilled physical therapist with over 25 years clinical experience with manipulation and a Fellow of the American Academy of Orthopedic Manual Physical Therapists performed all of the CT manipulation procedures. The therapist was blinded to all measurements. The CT manipulation was performed first on the right side, and then performed on the left.

The following is a description for a CT manipulation on the right side. The subject lay prone, and the manipulating therapist stood on the subject’s left side facing towards their head. The therapist’s left hand made contact with the thumb on the left side of the spinous process of the first thoracic vertebra. The therapist’s right hand supported the head making contact on the zygomatic arch of the temporal bone. The head/neck was gently rotated to the right and laterally flexed to the left, until slight tension was palpated in the tissues. A high velocity low amplitude thrust was applied towards the subjects’ right side. If cavitation did not occur (an audible pop) the subject was repositioned and the procedure was repeated a second time. Following the right CT manipulation maneuver, the same technique was applied to the left side. A maximum of two attempts was performed for each side. (Figure 2)

**Upper Trapezius Stretch**

Upper trapezius stretch was performed by a researcher who was also blinded to all measurements. The following is a description of an upper trapezius stretch to the right side. The subject was in the supine position. The researcher passively placed the subject’s head into slight flexion, side-bending to the left and rotation towards the right until the muscle barrier was met. The researcher depressed the subject’s right shoulder with 100 Newtons of force measured with a Micro FET pressure dynamometer (Hoggan Health Industries, Salt Lake City, UT). (Figure 3) Once this pressure amount was achieved, the stretch was held for 30 seconds. This was performed initially on the subjects right trapezius and then on the left trapezius.

**Control Group**
Subjects assigned to the control group received no intervention. They stayed behind the curtained research area for approximately 3 minutes in a seated position. They then returned to the assessment room for reevaluation of the assessment variables. Regardless of group assignment, CROM was assessed immediately after each intervention, and PPT levels were assessed at 5 and 10 minutes post intervention by examiners blinded to group allocation.

**Statistical Analyses**

Mean and standard deviations for PPT and CROM (combined sagittal plane, combined frontal plane, combined transverse plane) were calculated. Mean PPT values measured pre-intervention, 5 minutes post intervention, and 10 minutes post intervention on the right, left, and more sensitive side were used. The more sensitive side was determined to be the side, either right or left, that tolerated the least amount of pressure at baseline. The sum of flexion and extension measurements was recorded as the combined sagittal plane ROM. The sum of left lateral flexion and right lateral flexion measurements was recorded as the combined frontal plane ROM. The sum of left rotation and right rotation measurements was recorded as the combined transverse plane ROM.

Two-way ANOVAs with repeated measures was used to compare outcome measures between groups and between time points. Post-hoc one-way ANOVAs were planned to be used in the event of significant interactions between groups. If a post hoc ANOVA was found to be significant, then a second level of post hoc testing was employed (paired t tests with a Bonferroni correction). All data were analyzed using the IBM statistical package for Social Sciences version 20 for Windows. A normal distribution of quantitative data was assessed by means of the Kolmogorov-Smirnov test. Within group effect sizes were calculated using Cohen’s d coefficient. An effect size greater than 0.8 was considered large, approximately 0.5 was considered moderate, and less than 0.2 was considered small. Statistical analysis was
conducted at a 95% confidence level. P value less than 0.05 was considered statistically significant.

RESULTS

CROM

Two-way ANOVAs with repeated measures showed that there was a significant interaction between time and group assignment for CROM in the sagittal and transverse plane (p<0.001, p=0.039 respectively) (Table 2). However, post-hoc one-way ANOVA analyses did not reveal a significant difference in CROM for the sagittal and transverse planes among the 3 treatment groups (sagittal plane F=1.129, p=0.328; transverse plane F=0.929, p=0.399) (Table 3). Two-way ANOVA with repeated measures showed that there was not a statistical significance between time and group assignment for CROM in the frontal plane (p=0.095) (see Table 2).

Similarly, post-hoc one-way ANOVA demonstrated there was not a statistical difference in CROM of the sagittal and transverse planes among the 3 time points. Although no statistically significant effects of intervention on pre-treatment and post-treatment CROM were found, positive trends can be seen with increased CROM in all planes for both stretching and manipulation groups post-treatment compared to controls (see Figures 7, 8, 9).

PPT

Two-way ANOVAs with repeated measures showed that there was a significant interaction between time and group assignment for PPT (p<0.001). As such, post-hoc one-way ANOVA were performed among the 3 groups and the 3 time points. Comparisons between pre and post PPT levels both 5 and 10 minutes after treatment applied to the left side found no significant difference between the three groups, (F(2,87)=1.982, p=0.144)(see Table 5). Likewise, comparisons between pre and post PPT levels on the right side both 5 and 10 minutes after treatment found no statistically significant difference between the three groups (F(2,87)=2.268, p=0.110)(see Table 5). Comparisons between pre and post PPT levels both 5 and 10 minutes
after treatment applied to the more sensitive side at baseline found no significant difference between the three groups, (F(2,87)= 2.293, p=0.107)(see Table 4). It should be noted that, though not statistically significant, PPT was affected by both stretching and manipulation with a positive trend (see Figure 10 and Figure 11).

DISCUSSION

There was a statistically significant increase in CROM pre-treatment to post-treatment in two planes of motion, indicating a contributing factor to improved CROM. However, there was no statistically significant difference between the treatment groups and time, begging the question as to what lead to the change in CROM pre and post treatment for these two planes. Observation of trends may display effects from the differing treatments. Both Two-way ANOVA and Post-hoc analysis results showed a significant interaction between time and group assignment in the sagittal and transverse planes. Specifically, when compared to the control group, it seems that the sagittal and transverse combined ROMs were higher post-treatment. An observation of increases in two planes of CROM in the control group suggests that a learning effect with the CROM may have occurred in the time between measurements, particularly in the two planes that are induced during a CT manipulation. This increase between measures in CROM in the control group could also have been due to comfort with the measurement process and decreased testing anxiety leading to less tension in the neck musculature and therefore, a greater willingness to move further into range. As all groups improved significantly from pre-treatment to post-treatment in two planes of motion, it is clear that the intervention type may not have been the main factor for change in CROM. It is not fully clear as to why only two of the three planes of motion demonstrated changes. Due to the greater soft tissue involvement with lateral flexion, it can be harder to self-determine end CROM, and therefore, the results might not be as reliable.

Results showed that PPT was not significantly affected by either CT manipulation or upper trapezius stretching compared to controls. Strong positive trends exist nearing significant
levels for increased PPT measures both five and ten minutes after both CT manipulation and upper trapezius stretching. With resolution of some of the limitations of this study, these results are likely to reach significance levels and further analysis comparing CT manipulation and upper trapezius stretching can be conducted. Though these results are not statistically significant, notable trends solidify the need for further research to better understand the relationship between CT manipulation and stretching and their effects on pain pressure thresholds.

Post-hoc analysis results showed a significant interaction between time and group assignment in both right and left sided PPT at five minutes and ten minutes post treatment. Specifically, when compared to controls, it seems that the PPT on both the right and left side increased in both the manipulation and stretching groups after 5 minutes. These increases seem to remain plateaued after 10 minutes. The findings of this study are similar to those reported by Ruiz-Saez et al\textsuperscript{11} who found that cervical manipulation demonstrated statistically significant changes in PPT in regards to time, and a trend towards an increase in PPT in those who received cervical manipulation.

Our PPT results may have been affected for a number of different reasons which should be addressed in future studies. The predetermined location of the PPT testing was located directly in the middle of the trapezius muscle of every subject to allow for more uniform testing. However, this did not necessarily account for potential trigger points within the subject’s muscle. As the location was uniform, had the pressure algometer been placed on a trigger point, the discomfort the subject would have experienced might have skewed the subject’s reporting of PPT and thus hindering a true understating of the relationship between the PPT and the treatment. Additionally, another factor that may have been affected was the way in which the subjects interpreted the directions. Therefore, a more objective manner of applying the pressure algometer should be determined. Though pain is subjective, a potential way to make the directions more uniform would be to add a 1-10 pain rating scale, therefore helping clarify the level to which the pressure algometer should be applied before being removed.
For both CROM and PPT, we found that time was statistically significant with group assignment. This implies that, as time progressed, the subjects demonstrated a statistically significant improvement with both CROM and PPT, regardless of group assignment. This may have occurred for a number of different reasons. It is likely that the subjects were uneasy at the initial pre-test assessments, and as testing occurred, they grew more comfortable with the research procedures, resulting in increased PPT and CROM relative to time. Therefore, in order to eliminate these potential variables, it is important for future studies to not only clarify the instructions, such as adding a more objective measuring assessment for pain, but to also include an additional testing day. This additional testing day would assist the subjects in becoming more comfortable with the testing procedure and therefore more likely to respond exclusively to the treatments, rather than to the stressors of the new environment.

In addition to increasing objectivity of pain and increasing subject comfort with this study, other limitations include the lack of test-retest reliability. Though inter-rater error was eliminated via the same researcher conducting the same intervention with every subject, data was collected over a period of days, and therefore, the potential for decreased intra-rater reliability increased. This means that, though the same researcher conducted the same intervention, there is still potential for the individual to have self-variability. To compensate for this, future studies should incorporate test-retest assessments to ensure greatest intra-rater reliability, or if research is conducted on the same day, occasionally retest every couple of subjects to allow for the most accurate assessment.

An additional limitation to this study includes the subject population. Despite the wide age range for the inclusion criteria, the majority of subjects who participated in this study were of college age, and primarily with university degrees emphasizing physical activity. This may have had an impact on our results, as these subjects do not necessarily represent the population as a whole, but rather, this particular subset or community. Further research should address this
limitation, and attempt to seek out participants of all age ranges. This is especially important, as a large portion of individuals who report neck and back pain are middle aged, and therefore the sample needs to reflect this age group.

Additionally, the career emphasis of physical activity may have also affected our results. This could potentially be attributed to the mentality of “physical pain” or “physical discomfort”, which may be different in these individuals relative to the general population. A majority of our subjects had competed in various athletic events and sports training. This may have resulted in the higher-than-expected PPT results. As was previously mentioned, further studies should address the manner in which the PPT concept is portrayed, and additionally, should attempt to recruit subjects with a variety of backgrounds to help eliminate this potential limitation.

CONCLUSION

In summary, upper trapezius stretching and manipulation may both be viable options for treatment in individuals who have cervical range of motion limitations. No significant differences were found when assessing CROM in multiple planes or PPT comparing pre-treatment to post-treatment. Further research is needed to identify whether specific groups of patients stand to benefit from these interventions more than others. A more highly powered study could assist in transferring the trends found in this study to significant results. Upper trapezius stretching and CT manipulation may be viable options for relieving pain in the trapezius musculature by increasing a patient’s pain tolerance. Further research is needed to determine which patients would have the greatest benefit from the use of these treatment techniques.
### APPENDIX A-Tables

#### Table 1. Subject characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Control Group (n=30)</th>
<th>Stretch Group (n=30)</th>
<th>Manipulation Group (n=30)</th>
</tr>
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<tbody>
<tr>
<td>Age (years)</td>
<td>Mean ± SD</td>
<td>23.9 ± 3.37</td>
<td>24.6 ± 4.88</td>
</tr>
<tr>
<td>Gender</td>
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<td>Male</td>
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<td>15</td>
<td>19</td>
</tr>
<tr>
<td>Female</td>
<td>18</td>
<td>15</td>
<td>11</td>
</tr>
<tr>
<td>Hand Dominance</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>28</td>
<td>25</td>
<td>29</td>
</tr>
<tr>
<td>Left</td>
<td>2</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Height (meters)</td>
<td>Mean ± SD</td>
<td>1.69±0.09</td>
<td>1.69±0.08</td>
</tr>
<tr>
<td>Weight (kilograms)</td>
<td>Mean ± SD</td>
<td>68.3±14.6</td>
<td>68.2±15.2</td>
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</tbody>
</table>

#### Table 2. Interaction between time and group assignment by ROM plane

<table>
<thead>
<tr>
<th>Plane</th>
<th>Time and Group Assignment Interaction (p-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sagittal Plane</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Frontal Plane</td>
<td>0.095</td>
</tr>
<tr>
<td>Transverse Plane</td>
<td>0.039</td>
</tr>
</tbody>
</table>

#### Table 3. Combined planar range of motion (ROM) pre-treatment and post-treatment with p-value for significant effect of group assignment for each plane of motion

<table>
<thead>
<tr>
<th>Plane</th>
<th>Pre-Treatment ROM (degrees)</th>
<th>Post-treatment ROM (degrees)</th>
<th>Effect of Group Assignment (p-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sagittal Plane</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control Group</td>
<td>119.1±19.1</td>
<td>119.5±16.4</td>
<td>0.328</td>
</tr>
<tr>
<td>Stretch Group</td>
<td>119.9±17.4</td>
<td>126.3±14.9</td>
<td></td>
</tr>
<tr>
<td>Manipulation Group</td>
<td>120.8±14.7</td>
<td>130.3±18.2</td>
<td></td>
</tr>
<tr>
<td>Transverse Plane</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control Group</td>
<td>138.7±12.2</td>
<td>139.9±12.0</td>
<td>0.399</td>
</tr>
<tr>
<td>Stretch Group</td>
<td>139.2±15.2</td>
<td>143.9±12.8</td>
<td></td>
</tr>
<tr>
<td>Manipulation Group</td>
<td>140.7±12.0</td>
<td>146.6±13.3</td>
<td></td>
</tr>
</tbody>
</table>
Table 4. Altered PPT

<table>
<thead>
<tr>
<th>Altered PPT</th>
<th>Time and Group Assignment Interaction (p-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline to 5 minutes post-treatment</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>5 minutes post-treatment to 10 minutes post-treatment</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Table 5. Pressure pain thresholds pre-treatment, five minutes post-treatment, and 10 minutes post-treatment with p-value for significant effect of group assignment for the left and right upper trapezius along with the more sensitive side (side with lowest PPT at baseline)

<table>
<thead>
<tr>
<th>Side of Upper Trapezius</th>
<th>Pre-treatment PPT (N)</th>
<th>Five Minutes Post-treatment PPT (N)</th>
<th>Ten Minutes Post-treatment PPT (N)</th>
<th>Effect of Group Assignment (p-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control Group</td>
<td>41.7 ± 14.8</td>
<td>43.3 ± 13.8</td>
<td>43.6 ± 18.2</td>
<td>0.144</td>
</tr>
<tr>
<td>Stretch Group</td>
<td>48.6 ± 22.6</td>
<td>53.7 ± 23.4</td>
<td>53.8 ± 23.6</td>
<td></td>
</tr>
<tr>
<td>Manipulation Group</td>
<td>42.2 ± 14.4</td>
<td>49.7 ± 14.9</td>
<td>48.6 ± 15.3</td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control Group</td>
<td>42.0 ± 13.6</td>
<td>40.4 ± 15.0</td>
<td>43.6 ± 18.1</td>
<td>0.110</td>
</tr>
<tr>
<td>Stretch Group</td>
<td>49.4 ± 21.0</td>
<td>51.9 ± 21.8</td>
<td>51.9 ± 22.6</td>
<td></td>
</tr>
<tr>
<td>Manipulation Group</td>
<td>46.3 ± 14.6</td>
<td>50.0 ± 14.9</td>
<td>46.8 ± 12.9</td>
<td></td>
</tr>
<tr>
<td>More sensitive</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control Group</td>
<td>38.7 ± 12.6</td>
<td>38.7 ± 14.5</td>
<td>41.4 ± 17.4</td>
<td>0.107</td>
</tr>
<tr>
<td>Stretch Group</td>
<td>46.1 ± 21.4</td>
<td>50.1 ± 22.2</td>
<td>49.4 ± 22.3</td>
<td></td>
</tr>
<tr>
<td>Manipulation Group</td>
<td>39.4 ± 12.1</td>
<td>45.8 ± 13.0</td>
<td>43.8 ± 12.0</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX B-Figures

Figure 1. Flow diagram of subject recruitment, allocation and assessment

Figure 2. Cervicothoracic manipulation
Figure 3. Upper trapezius stretch

Figure 4. CROM device
**Figure 5.** Pressure algometer

![Pressure algometer](image)

**Figure 6.** Pressure pain threshold

![Pressure pain threshold](image)
**Figure 7.** Combined sagittal plane range of motion (ROM) pre-treatment and post-treatment by intervention group with p-value representing difference between groups

![Graph of combined sagittal plane range of motion](image)

- Control
- Stretch
- Manip

$p=0.328$

**Figure 8.** Combined frontal plane range of motion (ROM) pre-treatment and post-treatment by intervention group with p-value representing difference between groups

![Graph of combined frontal plane range of motion](image)

- Control
- Stretch
- Manip

$p=0.260$
Figure 9. Combined transverse plane range of motion (ROM) pre-treatment and post-treatment by intervention group with p-value representing difference between groups.

Figure 10. Left-sided pressure pain threshold outcomes pre-treatment, five minutes post-treatment, and ten minutes post-treatment by intervention group with p-value representing difference between groups.
**Figure 11.** Right-sided pressure pain threshold outcomes pre-treatment, five minutes post-treatment, and ten minutes post-treatment by intervention group with p-value representing difference between groups.

![Graph showing pressure pain threshold outcomes](image)

- Control
- Stretch
- Manip

$p=0.110$
APPENDIX C-Data Collection Form

Demographic Information

**Group** A B C

**Sex** M F

**Age:** _____

**Hand Dominance:** Right/Left

<table>
<thead>
<tr>
<th></th>
<th>Pre Intervention</th>
<th></th>
<th>Post Intervention</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Did cavitation occur?</td>
<td>☐ Yes ☐ No ☐ N/A</td>
<td></td>
</tr>
<tr>
<td>Pressure algometry (lbs)</td>
<td></td>
<td></td>
<td>Pressure algometry (lbs)</td>
<td></td>
</tr>
<tr>
<td>trial 1: __________</td>
<td></td>
<td>trial 1: __________</td>
<td>trial 1: __________</td>
<td></td>
</tr>
<tr>
<td>trial 2: __________</td>
<td></td>
<td>trial 2: __________</td>
<td>trial 2: __________</td>
<td></td>
</tr>
<tr>
<td>trial 3: __________</td>
<td></td>
<td>trial 3: __________</td>
<td>trial 3: __________</td>
<td></td>
</tr>
</tbody>
</table>

**Cervical Range of Motion**

|                          | Flexion: ______ | Flexion: ______ | Extension: ______ |
| Side-bending right: ______ | Extension: ______ | Side-bending right: ______ |
| Side-bending left: ______  | Side-bending left: ______ | Side-bending left: ______ |
| Rotation right: ______    | Rotation right: ______ | Rotation right: ______ |
| Rotation left: ______     | Rotation left: ______ | Rotation left: ______ |
APPENDIX D-Informed Consent

INFORMED CONSENT
Department of Physical Therapy

TITLE OF STUDY: Effects of cervicothoracic manipulation and passive stretching to the upper trapezius muscle on pressure pain thresholds and cervical range of motion on healthy individuals.

INVESTIGATOR(S): Dr. E. Louie Puentedura, PT, DPT, PhD, OCS, FAAOMPT; Kevin Carr, SPT; Morgan Clement, SPT; Erin Oelklaus, SPT; and Brendan Parry, SPT.

CONTACT PHONE NUMBER: (702) 895 1621

Purpose of the Study
You are invited to participate in a research study. The purpose of the study is to see if range of motion in the neck and perception of pain/discomfort is affected by joint manipulation or passive muscle stretching.

Participants
You are being asked to participate in the study because you have reported that:
1. You do not currently have any pain in your neck
2. You are aged 18 – 70
3. You would be able to lie on your back or on your stomach without difficulty

You also do not have any of the following criteria that would exclude you from safely participating in this study:
1. ‘Red flag’ items indicated in your Neck Medical Screening Questionnaire such as history of a tumor, bone fracture, metabolic diseases, Rheumatoid Arthritis, osteoporosis, severe atherosclerosis, prolonged history of steroid use, etc.
2. History of neck whiplash injury
3. Diagnosis from your physician of cervical spinal stenosis (narrowing of spinal canal) or presence of symptoms (pain, pins and needles, numbness) down both arms
4. Presence of central nervous system involvement such as exaggerated reflexes, changes in sensation in the hands, muscle wasting in the hands, impaired sensation of the face, altered taste, and presence of abnormal reflexes
5. Evidence of neurological signs consistent with nerve root entrapment (pinched nerve in the neck)
6. Prior surgery to your neck or upper back
7. A medical condition which may influence assessment of pain or pressure pain thresholds (i.e. taking analgesics, sedatives, history of substance abuse, or cognitive deficiency)
8. Diagnosis from your physician of fibromyalgia syndrome
9. Currently pregnant, or could be pregnant

**Procedures**
If you volunteer to participate in this study, you will be asked to do the following: 1) complete a series of questionnaires about your health status and undergo physical screening of your neck to make sure that manipulation and stretching will not be harmful in your case; 2) have the range of motion of your neck assessed with a measurement device; 3) have your pain pressure threshold assessed with a measurement device (a small rubber-tipped plunger will be slowly pressed into the muscles on the side of your neck until you tell the examiner that the sensation has changed from one of ‘pressure’ to one of ‘pain or discomfort’; 4) receive one of 3 randomly assigned interventions; and 5) repeat the range of motion and pain pressure threshold measurements.

The 3 randomly assigned interventions are: cervicothoracic manipulation, upper trapezius stretching, or seated waiting. If you are assigned the manipulation, you will lie face down and the trained therapist will move the joints between your neck and upper back in a short and sharp manner which may produce a slight ‘pop’ or ‘click’. If you are assigned the trapezius stretching, you will lie on your back and the trained therapist will move your head and neck to one side and apply two 30 second stretches using a hand-held pressure gauge on the top of your shoulder. If you are assigned the seated waiting, you will be asked to sit quietly for 3 minutes.

**Benefits of Participation**
There may or may not be direct benefits to you as a participant in this study. You may receive one of two physical therapy interventions that have been shown to provide immediate short-term feelings of relaxation in people who do not have any neck pain. If you receive the seated waiting intervention, you may not notice any difference in the way you feel. It may also be of interest to you to know how far you can comfortably move your neck and how many pounds of force it takes for you to notice when ‘pressure’ changes to ‘pain/discomfort’ in the muscles of your neck.

**Risks of Participation**
There are risks involved in all research studies. This study should include only minimal risks. You will be pre-screened for known risk factors for manipulation and upper trapezius muscle stretching and will only be allowed to continue in this study if you do not have any of these factors. Following the manipulation or muscle stretching, you may experience some mild soreness in your joints and muscles. You may experience some temporary soreness or headache (no more than an hour or two) following the manipulation technique. Muscle soreness from the stretching is more likely but should also resolve quickly within hours and not leave any lasting effects. Following the pressure pain threshold testing, you may experience some tenderness or notice some redness at the points tested. If so, it should only be for less than 24 hours following the study.

**Cost/Compensation**
There will not be financial cost to you to participate in this study. The study will take about 1 hour of your time. You will be offered $15.00 cash as compensation for your time if you are successfully enrolled to participate in the study.
Contact Information

If you have any questions or concerns about the study, you may contact Dr. Puente at (702) 895 1621. For questions regarding the rights of research subjects, any complaints or comments regarding the manner in which the study is being conducted you may contact the UNLV Office of Research Integrity – Human Subjects at 702-895-2794.

Voluntary Participation

Your participation in this study is voluntary. You may refuse to participate in this study or in any part of this study. Deciding not to participate in this study will not affect your participation in your program of study (if any) in the University in any way. If you decide to participate in the study and then have a change of mind, you may withdraw at any time without prejudice to your relations with the researchers and university. You are encouraged to ask questions about this study at the beginning or any time during the research study.

Confidentiality

All information gathered in this study will be kept completely confidential. No reference will be made in written or oral materials that could link you to this study. All records will be stored in a locked facility at UNLV for 5 years after completion of the study. After the storage time the information gathered will be destroyed.

Participant Consent:

I have read the above information and agree to participate in this study. I am at least 18 years of age. A copy of this form has been given to me.

________________________________________  ________________________
Signature of Participant                     Date

Participant Name (Please Print)

Participant Note: Please do not sign this document if the Approval Stamp is missing or is expired.
# APPENDIX E-Neck Pain Medical Screening Questionnaire

**Neck Pain Medical Screening Questionnaire**

Subject ID: __________________________ Date: __/__/____

Please select one answer and complete specific questions as necessary:

1. Do you have or have you had any disease process such as osteoarthritis, rheumatoid arthritis, osteoporosis, diabetes, heart disease, stroke, or cancer?  
   If “Yes,” please specify: ____________________________________________

<table>
<thead>
<tr>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
</table>

2. Have you had a recent trauma (motor vehicle accident, blow or injury to the neck or head)?
   | No | Yes |

3. Have you had a significant past trauma (motor vehicle accident, blow or injury to the neck or head)? If “Yes,” please specify:

   | No | Yes |

4. Have you recently lost more than 10 pounds?  
   If “Yes,” was the weight loss intentional (ie, due to dieting, exercise, or both)?

   | No | Yes | n/a |

5. In the past 2 months, have you experienced:  
   a. Difficulty falling asleep because of the pain?  
   b. Pain that wakes you up from sleep?  
      i. If “Yes,” can you return to sleep in less than 30 minutes?  
   c. Fever, chills, or night sweats?  
   d. Shortness of breath?  
   e. Chest pain?  
   f. High blood pressure?  
   g. Abdominal pain or problem (eg, ulcer, heartburn, hiatus hernia, or gallbladder problem)?  
   h. Bowel or bladder irregularities?  
      i. If “Yes,” please specify: ______________________________
   j. Pain and difficulty with jaw movement?  
   k. Pulsating headache?  
   l. Nausea or vomiting?  
   m. Fainting or blackout episodes?  
   n. Dizziness or lightheadedness aggravated by neck motion?  
   o. Double vision or blurred vision?  
   p. Pain, tingling, or numbness in and around your face?  
   q. Ringing sound in the ear?  
   r. Difficulty swallowing or speaking?  
   s. Problems with balance when you walk?  
   t. Tingling or numbness in both of your arms, hands, or legs?

   | No | Yes | n/a |

If you answered “Yes” to any item in question 5, are you currently under a doctor’s care for this or these problems?  

6. Are you or have you recently taken anticoagulation medication (eg, Coumadin)?  
   | No | Yes |

7. Are you or have you consistently taken steroidal medications (eg, Prednisone)?  
   | No | Yes |

8. Have you ever had surgery for your neck?  
   If “Yes,” please specify: ____________________________________________

   | No | Yes | n/a |
REFERENCES


12. de Camargo VM, Alburquerque-Sendin F, Berzin F, Stefanelli VC, de Souza DP, Fernandez-de-las-Penas C. Immediate effects on electromyographic activity and pressure pain


Curriculum Vitae

Kevin Carr
160 Bridle Path Terrace, Reno, NV 89441
(775) 233-2923; kcarr035@gmail.com

EDUCATION

Doctorate of Physical Therapy
University of Nevada, Las Vegas, Las Vegas, NV
May 2015

Bachelor of Science: Community Health Sciences
University of Nevada, Reno, Reno, NV
May 2012

PROFESSIONAL EXPERIENCE

Outpatient Clinical Intern
Sports Therapy and Rehabilitation, Carson City, NV
July 2013-Aug. 2013
- Provided in-service on current evidence and techniques of dry needling to decrease myofascial trigger points

Outpatient Clinical Intern
Tim Soder Physical Therapy, Las Vegas, NV
July 2014-Sept. 2014
- Provided in-service on subjective complaints and associated objective findings with common shoulder pathologies

Inpatient Rehabilitation Clinical Intern
Renown Rehabilitation Hospital, Reno, NV
- Provided in-service on best evidence-based treatment for patients with Amyotrophic Lateral Sclerosis in an acute setting

Acute Inpatient Clinical Intern
St. Mary’s Regional Medical Center, Reno, NV
Jan. 2015-Apr. 2015
- Updated and created various handouts for patients including spinal precautions, hip precautions, and bed level exercises

RESEARCH EXPERIENCE

Student Investigator of Mentored Group Research Project
University of Nevada, Las Vegas, Las Vegas, NV
May 2015
- Research Title: The immediate effects of cervicothoracic manipulation vs. stretching on upper trapezius pressure pain thresholds and range of motion in individuals without neck pain
- Received 2013 UNLVPT Student Opportunity Research Grant

PROFESSIONAL MEMBERSHIPS/CERTIFICATIONS

APTA Member, Research Section
May 2012-Present
- Attended 2014 APTA Combined Sections Meeting

Healthcare Provider CPR and AED Certified
Aug. 2010-Present

VOLUNTEER EXPERIENCE

Student Athletic Training Intern
Aug. 2010-May 2012
- Assisted Head Athletic Trainer with ensuring safety and preparation of the University of Nevada, Reno Women’s Volleyball team
Curriculum Vitae

Morgan King
5616 East Garnet Avenue, Mesa, AZ 85206
(480) 254-8762, morgan13king@gmail.com

EDUCATION

Doctorate of Physical Therapy
University of Nevada, Las Vegas, Las Vegas, NV
May 2015

Exercise and Wellness, BS
Arizona State University, Tempe, AZ
May 2012

PROFESSIONAL EXPERIENCE

Outpatient Clinical Intern
Physiotherapy Associates
July 2013-Aug. 2013
- Provided information on sensitivity/specificity of special tests for use during differential diagnosis

Inpatient Acute Clinical Intern
Southern Hills Hospital, Las Vegas, NV
July 2014-Sept. 2014
- Provided in-service on patients who have had strokes and the signs and symptoms associated dependent upon location

Inpatient Rehabilitation Clinical Intern
HealthSouth Valley of the Sun Rehabilitation Hospital, Glendale, AZ
- Provided information about pain neuroscience and the effects chronic pain has on patient progression

Outpatient and Acute Rehabilitation Clinical Intern
Wickenburg Community Hospital, Wickenburg, AZ
Jan. 2015-Apr. 2015
- Provided in-service on cervical manipulation, clinical prediction rules, and clinical application in patients with neck pain

RESEARCH EXPERIENCE

Student Investigator of Mentored Group Research Project
University of Nevada, Las Vegas, Las Vegas, NV
May 2015
- Research Title: The immediate effects of cervicothoracic manipulation vs. stretching on upper trapezius pressure pain thresholds and range of motion in individuals without neck pain
- Received 2013 UNLVPT Student Opportunity Research Grant
- Completed UNLV Graduate College Research Certificate Program

PROFESSIONAL MEMBERSHIPS/CERTIFICATIONS

APTA Member, Research Section
May 2012-Present
- Attended 2013 & 2014 APTA Combined Sections Meeting

Therapeutic Neuroscience Education
March 2013/April 2014
- Presented by Adriaan Louw for physiology of chronic pain

Healthcare Provider CPR and AED Certified
2011-Present

VOLUNTEER EXPERIENCE

Wickenburg High School
January 2015-March 2015
- Provided care in training room for after school sports
- Provided care at Girl’s Softball Tournament hosted by Wickenburg High School
Curriculum Vitae

Erin Oelklaus
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EDUCATION

Doctorate of Physical Therapy
University of Nevada, Las Vegas, Las Vegas, NV
May 2015

Kinesiology and Honors BS
Physiology Minor
University of Wyoming, Laramie, WY
May 2012

PROFESSIONAL EXPERIENCE

Outpatient Clinical Intern
Physiotherapy Associates, Knoxville, TN
July 2013-Aug. 2013
• Provided in-service on anterior vs. posterior total hip replacements and evidence based treatments

Outpatient Clinical Intern
Juneau Physical Therapy, Juneau, AK
July 2014-Sept. 2014
• Provided in-service on anterior vs. posterior should injuries and evidence based treatments

Inpatient Rehabilitation Clinical Intern
Sunrise Hospital, Las Vegas, NV
• Provided in-service on best evidence-based practice of acute CVA treatments

Inpatient Acute Clinical Intern
University Medical Center, Las Vegas, NV
Jan. 2015-Apr. 2015
• Provided in-service on evidence based CVA treatments throughout Brunstrom scale

RESEARCH EXPERIENCE

Student Investigator of Mentored Group Research Project
University of Nevada, Las Vegas, Las Vegas, NV
May 2015
• Research Title: The immediate effects of cervicothoracic manipulation vs. stretching on upper trapezius pressure pain thresholds and range of motion in individuals without neck pain
• Received 2013 UNLVPT Student Opportunity Research Grant
• Completed UNLV Graduate College Research Certificate Program

PROFESSIONAL MEMBERSHIPS/CERTIFICATIONS

APTA Member, Research Section
May 2012-Present
• Attended 2014 APTA Combined Sections Meeting
• Participated in 5 NPTA Meetings Since 2012

Healthcare Provider CPR and AED Certified
Dec. 2011-Present

American Council on Exercise Certified Personal Trainer
January 2011-Present

VOLUNTEER EXPERIENCE

UNLV Chair Member for UNLVPT Community Fundraiser Golf Tournament
• Assisted local charity with golf-tournament fundraiser team recruitment and donor finding
Curriculum Vitae

Brendan Parry
7521 Curlands Cove Dr., Las Vegas, NV 89117
(702) 785-3484; brendanparry@yahoo.com

EDUCATION

Doctorate of Physical Therapy
University of Nevada, Las Vegas, Las Vegas, NV
May 2015

Exercise Physiology BS
University of Utah, Salt Lake City, UT
June 2012

PROFESSIONAL EXPERIENCE

Outpatient Clinical Intern
RehabAuthority, Caldwell, ID
July 2013-Aug. 2013
• Provided in-service on current evidence and overutilization of examining low back pain through use of MRI

Inpatient Acute Clinical Intern
Spring Valley Hospital, Las Vegas, NV
July 2014-Sept. 2014
• Provided in-service on prevalence, recognition, and treatment of patients with depression in the acute hospital setting

Inpatient Rehabilitation Clinical Intern
HealthSouth Desert Canyon Rehabilitation Hospital, Las Vegas, NV
• Provided in-service on best evidence-based practice of bodyweight supported treadmill gait training for patients with stroke

Outpatient Clinical Intern
Scott Pensivy Orthopedic Rehabilitation Therapy Services, Las Vegas, NV
• Provided in-service on usage of video motion apps to assess and treat movement dysfunction in the outpatient setting

RESEARCH EXPERIENCE

Student Investigator of Mentored Group Research Project
University of Nevada, Las Vegas, Las Vegas, NV
May 2015
• Research Title: The immediate effects of cervicothoracic manipulation vs. stretching on upper trapezius pressure pain thresholds and range of motion in individuals without neck pain
• Received 2013 UNLVPT Student Opportunity Research Grant
• Completed UNLV Graduate College Research Certificate Program

Laboratory Research Assistant
Zimmerman & Weyrich Lab, Dept. of Molecular Medicine, University of Utah, Salt Lake City, UT
Oct. 2009-July 2010

PROFESSIONAL MEMBERSHIPS/CERTIFICATIONS

APTA Member, Research Section
May 2012-Present
• Attended 2014 APTA Combined Sections Meeting
• Participated in 5 NPTA Meetings Since 2012

Healthcare Provider CPR and AED Certified
Dec. 2011-Present

VOLUNTEER EXPERIENCE

Student Curriculum Committee Member
• Analyzed UNLV DPT curriculum through formal questionnaire of current graduate students
• Prepared results and presented findings to Faculty Curriculum to improve and evolve curriculum