BIOMECHANICAL ASSESSMENT OF KINEMATIC MEASURES ASSOCIATED WITH AN OSTEOPATHIC CERVICAL DIAGNOSIS AND TREATMENT TECHNIQUE

By

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ABSTRACT

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The purpose of this research was to evaluate the differences in motions within an examiner, across examiners and between active and passive motions using three-dimensional kinematic data collected during a standard manual cervical diagnostic. Additionally, kinematic differences before and after a manual treatment were evaluated for subjects experiencing pain.

Kinematic data of healthy individuals (n=22) and individuals experiencing neck pain (n=19) were obtained using motion capture, and assessed through Euler angles. The motions from passive evaluations performed by two blinded osteopathic physicians as well as active motions performed independently by the subjects were analyzed. Analyses included cervical ranges of motion for lateral flexions (primary motion) and axial rotations (secondary motion), the rate at which lateral flexions were performed, and the root mean square error of multiple trials.

Statistical evaluations demonstrated that diagnostic motions were performed consistently within an examiner but not across examiners, active range and rates of motion were greater than passive motions, healthy subjects performed motions more symmetrically and at larger ranges of motions than subjects experiencing neck pain, and the effects of treatment were present and reduced longitudinally.

This thesis is dedicated to my family and friends for their unwavering support.

In memory of Carl Coppola

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NOMENCLATURE

3D	Three-Dimensional
BDRL	Biomechanical Design Research Laboratory
CT	Computed Tomography
HVLA	High-Velocity Low-Amplitude
MRI	Magnetic Resonance Imaging
NPDS	Neck Pain and Disability Scale
RMSE	Root Mean Square Error
ROM	Range Of Motion
VAS	Visual Analog Scale
WAD	Whiplash-Associated Disorder
Ex.	Examiner
Exp.	Experimental
Cont.	Control
n	frame number
tsv	Tab Separated Value
$\hat{\imath}$	local coordinate direction horizontally from subject left to right
$\hat{\jmath}$	local coordinate direction horizontally from subject posterior to anterior
$\hat{k}$	local coordinate direction vertically from subject inferior to superior
X	global coordinate direction horizontally from subject left to right
Y	global coordinate direction horizontally from subject posterior to anterior
Z	global coordinate direction vertically from subject inferior to superior
θ_1	angle of rotation about y-axis (lateral flexion)

θ_2	angle of rotation about z-axis (axial rotation)
θ_3	angle of rotation about x-axis (flexion/extension)
[R]	rotation matrix

INTRODUCTION

Musculoskeletal dysfunctions have been reported by more persons in the United States than any other health condition. For example, in the most recent assessment, these human structural problems were estimated to cost $510 billion annually in treatment for patients, equivalent to 4.6 percent of our gross domestic product (Andersson and American Academy of Orthopaedic Surgeons, 2008). More specifically, in the United States cervical/neck pain accounted for 16.4 million annual health care visits, second only to lower back pain (Andersson and American Academy of Orthopaedic Surgeons, 2008). Nonspecific musculoskeletal spinal dysfunctions have accounted for 80-85% of reported cases and included disorders of the muscles, nerves, intervertebral discs, joints, cartilage, tendons and ligaments of the neck and back (World Health Organization, 2003). In most industrialized countries, incidence of nonspecific spinal disorders has been between 4-5% annually with lifetime prevalence between 60 and 85% (World Health Organization, 2003). Consistently high occurrences of cervical dysfunction have been reported throughout multiple decades (National Institute for Occupational Safety and Health, 1997), demonstrating a need for research to assess the causes of cervical spine dysfunctions as well as improve diagnosis and treatment techniques.

Cervical dysfunction is prevalent in a wide variety of populations, often due to osteoarthritis associated with aging. Cervical dysfunctions are commonly induced through traumatic incidences such as whiplash (Loudon et al., 1997, Bogduk and Yoganandan, 2001, Grifka et al., 1998), injury due to sports (Junge and Dvorak, 2004, Junge et al., 2004, McIntosh, 2005a, McIntosh, 2005b, McIntosh and McCrory, 2005), and long term repetitive work involving movement of the head, arm, and shoulder (National Institute for Occupational Safety and Health, 1997). In addition, several studies have provided evidence that prolonged static loads

or extreme working postures involving the neck and shoulder muscles have strong associations with cervical musculoskeletal dysfunctions (National Institute for Occupational Safety and Health, 1997).

The prevalence of neck dysfunction due to injury associated with traumatic events and physical over-exertion has been well documented throughout literature. It has been reported that 62% of patient visits to an emergency room following a motor vehicle accident complain of neck pain (Deans et al., 1986). Additionally, up to 6% of patients with whiplash injuries do not return to work for a time greater than one year (Evans, 1992). Recent studies have shown that the occurrence of neck sprains and contusions for sports such as football, soccer, hockey, and rugby range from 2.6% to 7.5% (McIntosh, 2005a, McIntosh, 2005b, McIntosh and McCrory, 2005, Junge and Dvorak, 2004, Junge et al., 2004).

In a prospective cohort study, Ariens et al. (2001) found a significant positive association between sitting at work for more than 95% of the working time and neck pain as well as a strong positive relationship between neck flexion angle and neck pain. Similarly, Viikari-Juntura et al. (2001) reported associations between the duration of work with a hand above shoulder lever and radiating neck pain.

Accurate diagnoses of neck pain are often difficult, requiring various techniques to determine the specific cervical dysfunction causing the pain. Medical imaging technology such as magnetic resonance imaging (MRI), computed axial tomography (CT scan) and radiography (x-ray) have shown success with assisting in the diagnosis of specific spinal disorders such as intervertebral disc herniation and vertebral fractures (Holmes et al., 2002, Klein et al., 1999, LeVine, 2010). Although medical imaging typically involves analysis of static postures, dynamic musculoskeletal assessments using MR and CT imaging techniques are rapidly advancing.

Disadvantages to dynamic medical imaging assessments include high costs, lower resolutions, and limited accessibility to advanced MRI and CT scanners. As a result, imaging technology is typically limited to static assessments and therefore many functional cervical disorders cannot be assessed through these techniques.

Currently, diagnosis of cervical dysfunctions that cannot be assessed through medical imaging can be successfully accomplished using manual palpatory analyses. Various manual diagnostic techniques have been developed and refined, and all involve the physical interaction between a physician and a patient to assess dynamic factors such as motion qualities, tissue texture, and joint stability. While manual medicine is commonly practiced throughout most medical societies, current diagnosis and treatment techniques are dependent primarily on the subjective analysis of the physician based on his or her education and experience.

Although manual diagnostic and treatment techniques are widely accepted in the medical field, there is a lack of objective data to support their efficacy (Seffinger et al., 2004). Therefore, the purpose of this research was to quantify the kinematic motions during a standard manual cervical diagnostic technique to evaluate the following:

1. Consistency of motion patterns during the manual diagnostic motion within an examiner.
2. Consistency of motion patterns during the manual diagnostic motion across examiners.
3. Differences between cervical lateral flexion conducted passively by an examiner and actively by the subject.
4. Differences in kinematic patterns between individuals free of neck pain and individuals experiencing neck pain.

5. Differences in kinematic patterns between subjects pre- and post- manual treatment.
6. Differences in kinematic patterns between pre-treatment, post-treatment, and a 72-hour post-treatment for a subset of subjects.

LITERATURE REVIEW

The cervical spine has been researched from many different perspectives and for a vast amount of reasons. For example, the causes and effects of cervical spine dysfunction as well as spinal stability and motion accuracy have been examined by several studies (Loudon et al., 1997, McNair et al., 2007, Armstrong et al., 2008, Feipel et al., 2006, Swinkels and Dolan, 1998). Additionally, clinical procedures have been researched to confirm aspects of the diagnoses and the effectiveness of treatment for individuals experiencing a wide range of cervical somatic dysfunctions (Burns and Wells, 2006, Bush and Vorro, 2008, Bush et al., 2010, Pool et al., 2004, Schops et al., 2000, Cleland et al., 2005, Cleland et al., 2007, Fernandez-de-las-Penas et al., 2007). This review of literature is divided into five sections discussing *Anatomical Terms & Definitions*, *Technology to Quantify Anatomical Positions & Angles*, *Proprioception*, *Cervical Range of Motion (ROM)*, and *Manual Medicine Diagnosis & Treatment*.

Anatomical Terms & Definitions

A basic understanding of general anatomical terminology and the anatomy of the spine must be acquired to assess the musculoskeletal function of the cervical spine. Anatomical terms are used to describe the position and orientation of structures in relation to features on the human body. For this research, clinical terms are frequently used and therefore are presented here rather than as an appendix.

Imaginary anatomical planes that intersect the body (Moore and Agur, 2007), as seen in Figure 1, are used to define specific regions of the body and include:

- **Median (median sagittal) plane**: A vertical plane that passes through the center of the body, separating the body into equal left and right halves.
- **Sagittal planes**: Vertical planes that pass through the body parallel to the median plane.
- **Frontal (coronal) planes**: Vertical planes passing through the body perpendicular to the median plane, separating the body into anterior (front) and posterior (back).
- **Transverse planes**: Horizontal planes passing through the body perpendicular to both the median and frontal planes, separating the body into superior (upper) and inferior (lower).

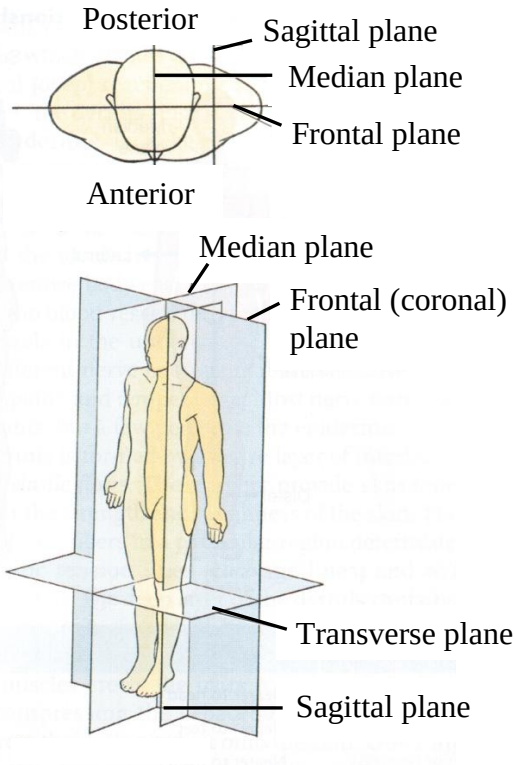

Figure 1. Imaginary anatomical planes for describing regional references on the human body (Moore and Agur, 2007). ***For interpretation of the references to color in this and all other figures, the reader is referred to the electronic version of this thesis.***

More specific anatomical terms used to describe relative position and orientation for individuals standing with their feet together, arms to their side, palms and head facing forward (Moore and Agur, 2007) are shown in Figure 2 and include:

- **Anterior**: Toward the front of the body, separated by the frontal plane.
- **Posterior**: Toward the back of the body, separated by the frontal plane.
- **Superior**: Toward the head (above), separated by the transverse plane.
- **Inferior**: Toward the feet (below), separated by the transverse plane.
- **Medial**: Toward the median plane of the body.
- **Lateral**: Away from the median plane of the body.
- **Proximal**: Nearer to the trunk or point of origin.
- **Distal**: Farther from the trunk or point of origin.
- **Ipsilateral**: On the same side with respect to the median plane.
- **Contralateral**: On the opposite side with respect to the median plane.

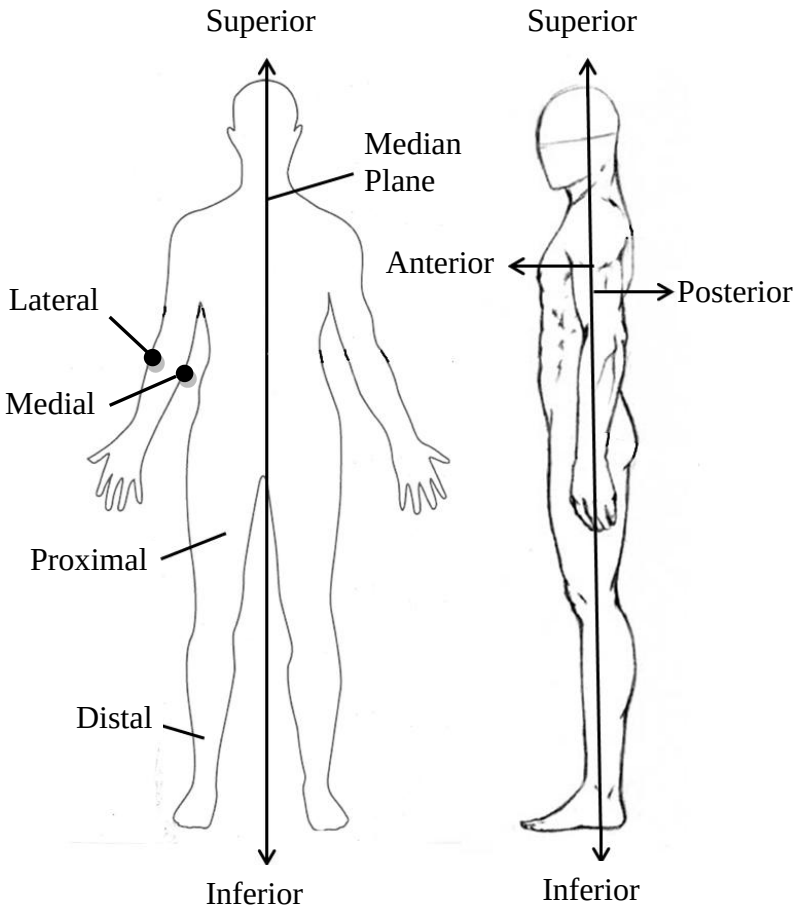

Figure 2. Anatomical terms of location and direction

The human spine consists of four separate regions shown in Figure 3: the cervical, thoracic, lumbar, and sacral regions. The cervical region specifically contains seven vertebrae (C1-C7) with an intervertebral disc separating each vertebra inferior from C2. This interface between rigid vertebral bodies and a resiliently deformable intervertebral disc allows for a high level of mobility while still maintaining structural rigidity (Moore and Agur, 2007). While the structure of the cervical spine allows for movement of the head and neck, the motion itself is a function of the musculoskeletal system working in concert with controls from the nervous system.

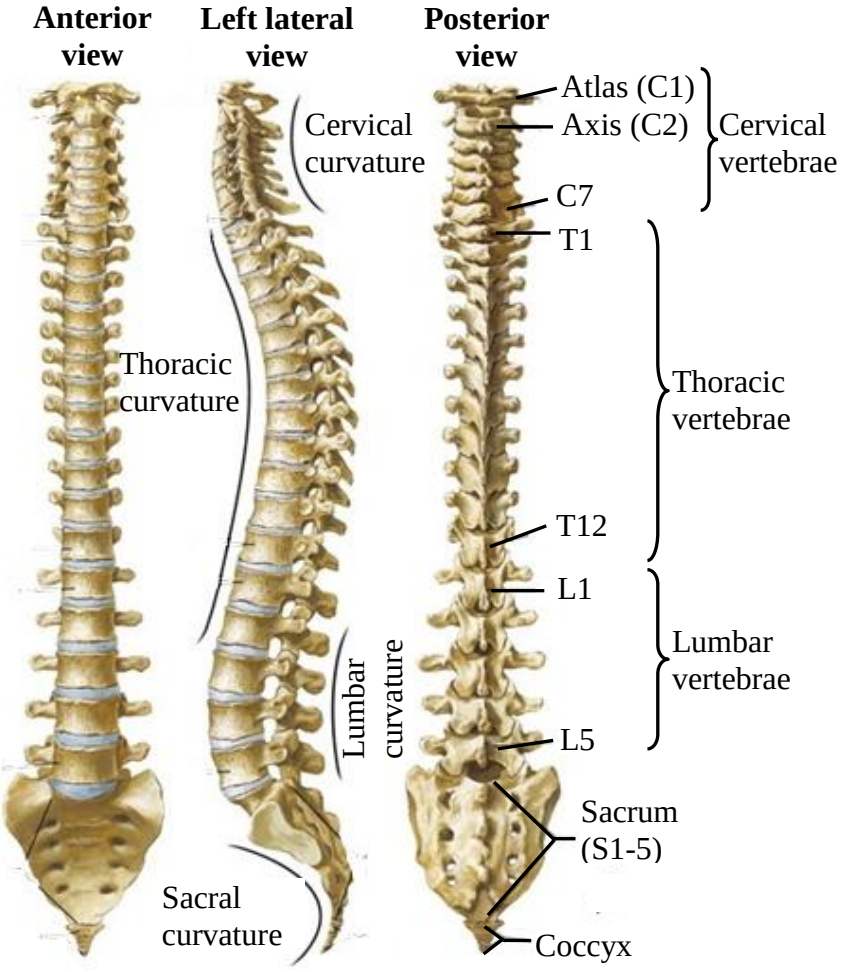

Figure 3. The human spinal column separated by the cervical, thoracic, lumbar, and sacral regions (Netter, 2006)

Movement of the head and neck is permitted due to the functionality of the cervical spine. The primary movements of the head are described as axial rotation, lateral flexion, and flexion/extension as demonstrated in Figure 4.

Axial rotation Lateral flexion Flexion/extension

Figure 4. Primary movements of the head including axial rotation, lateral flexion, and flexion/extension (RelayHealth, 2009)

Technology to Quantify Anatomical Positions & Angles

Significant advancements in technology associated with quantifying static and dynamic human motions have occurred as research and medicine has demanded more precise and accurate measurements. Specifically the regional and/or segmental range of motion (ROM) of the spine has been an area of interest. Regional motion refers to the gross movement of the cervical, thoracic, or lumbar sections of the spine, while segmental motion is the motion of an individual vertebra with relation to the inferior or superior vertebrae. The quantitative methods utilized in research include but are not limited to the use of goniometers, inclinometers, radiographs, magnetic resonance imaging (MRI), computerized axial tomography (CAT or CT scan), and three-dimensional (3D) motion capture (LeVine, 2010).

The goniometer and inclinometer have been used by physicians and physical therapists to quantify the cervical range of motion (ROM) of a patient. The use of these devices is fairly simplistic and quantifies the cervical ROM of a subject at static positions. A goniometer operates much like a protractor; the origin of the goniometer placed at the joint's center of motion, and by extending the two rigid linkages of the device along the bones leading from the joint, an angle can be determined. For example, a goniometer could be used on a knee joint to obtain the angle between the thigh and lower leg. An inclinometer can be used to determine the angle of lateral flexion or flexion/extension by determining the tilt of the inclinometer attached to the subjects head with respect to gravity. However, since this measurement requires gravity to be acting in the direction of the movement, the inclinometer can only measure lateral flexion of the head when attached to the frontal plane and flexion/extension when attached to the sagittal plane on a seated or standing individual. Several studies still use these means to quantify the cervical ROM of the cervical spine (Rosenfeld et al., 2000, Fernandez-de-las-Penas et al., 2007). While these instruments are advantageous in the sense that they are non-invasive and easy to implement, errors associated with these devices are often high due to instrument accuracy and sensitivity as well as the high potential for user error.

A second set of tools used to evaluate cervical motion are medical imaging technologies. Imaging technologies are useful tools for quantifying regional as well as the segmental cervical spine motions; however the equipment often requires static measurements. The most widely utilized medical imaging technologies include:

- *Radiography*: The use of a heterogeneous beam of X-rays to construct a 2D representation of musculoskeletal structures of the human body based on varying tissue densities and compositions.

- *Magnetic Resonance Imaging (MRI)*: The use of a powerful magnetic field and radio frequency pulses to construct 2D images of the scanned area of the body, providing contrast between various tissues types.
- *X-Ray Computed Tomography (CT)*: The use of X-rays to construct a large series of 2D images taken around a single axis of a human body segment with a high- resolution.

While these medical imaging techniques allow cervical motions to be assessed based upon specific in-vivo anatomical landmarks, they are often limited to static measurements, produce two-dimensional images, and can't accommodate a range of postures (Klein et al., 1999, Holmes et al., 2002, LeVine, 2010).

A third measurement tool used to assess human kinematics is a motion capture system. Three-dimension (3D) motion capture is used to measure dynamic motions through a multi-camera setup that determines where passive markers, attached superficially to a subject's body, are located in three dimensional space. Over time, these systems have acquired the ability to take 3D marker positions at high sampling rates (greater than 1000 Hz) and resolutions (greater than four megapixels). The accuracy and dynamic capabilities of modern motion capture systems have led these systems to be widely used in spinal research studies.

While this technology boasts dynamic measurements at a high level of marker resolution, there is often concern for measurement accuracy when determining segmental motion as opposed to regional motion. To determine the gross regional motion of the cervical spine, many researchers apply markers to the head and thorax in order to determine the overall movement of the head relative to the thorax and thus determine the motion of the cervical region (Bush et al., 2010, Bush and Vorro, 2008, Grip et al., 2007). Segmental motion often requires the examiner to place markers superficially on the spinous processes of the vertebrae in order to assess the

kinematic motions of individual vertebra of a region. While criticism of this method has arisen due to the concern of markers shifting with the skin over the bony landmarks, several studies have shown that the relative movement between the markers placed on the skin and the bony landmark of the spinous process through ranges of motion is minimal (Wu et al., 2007, Engsberg et al., 2008, Morl and Blickhan, 2006). Thus, the use of motion capture can accurately determine the gross regional motion of the cervical spine through monitoring of the head motion relative to the thorax (Seffinger et al., 2004, Bush et al., 2010).

Proprioception

Proprioception is the ability humans have to sense body orientations in three-dimensional space. Specifically, researchers have attempted to link cervical dysfunction to the ability a person has to accurately position and reposition his or her head during functional tasks (Loudon et al., 1997, Grip et al., 2007, Sterling et al., 2004, Revel et al., 1991, Heikkila and Wenngren, 1998, Rix and Bagust, 2001, Armstrong et al., 2005). Typically these studies analyze proprioceptive capability of an individual through position-matching tasks involving instructions for an individual to move his or her head to a specific location, move away from that location, and then return to the first location (Armstrong et al., 2005, Loudon et al., 1997, Revel et al., 1991, Heikkila and Wenngren, 1998, Rix and Bagust, 2001). The difference between the initial position and the return to that position were documented and termed repositioning errors in these studies.

Since injuries to soft-tissue structures of the cervical spine can lead to proprioceptive deficits (Armstrong et al., 2008), analysis of cervical dysfunction based up an individual's head

and neck position sense has been widely investigated as a potential assessment technique. In a study conducted by Revel et al. (1991), significant impairment of 30 patients with chronic neck pain was documented in comparison to an age-matched group of healthy individuals with repositioning errors of 6.11° and 3.50° respectively. Similarly, Heikkila and Wenngren (1998) reported significantly greater error in whiplash groups (3.71°) when compared with a healthy control group (2.79°). In a smaller study of eleven subjects with a history of whiplash injury compared to eleven age-matched healthy individuals, Loudon et al. (1997) found a larger mean position-sense error in the whiplash group of 5° in comparison to 1.8° for healthy individuals.

In contrast, several studies were unable to document significant differences between healthy and impaired individuals. For a group of 20 subjects with cervical pain related headaches in comparison to a healthy control group, De Hertogh et al. (2008) reported an insignificant difference in absolute error scores of 4.2° and 3.4° respectively. As well, Rix and Bagust (2001) observed no significant differences in repositioning accuracy between a group of subjects with chronic and non-traumatic neck pain (6.3°) and a healthy control group (4.6°). Due to the contradictive findings, these proprioceptive techniques cannot be scientifically accepted as a conclusive technique for identifying cervical dysfunction.

Cervical Range of Motion (ROM)

Cervical range of motion is often evaluated by the maximum angles achieved in the primary movement direction (flexion/extension, lateral flexion, or rotation) during active or passive motions. Passive motion involves an examiner guiding the subject's head through the primary motions, while active motion requires the subject to move his or her head in prescribed

motions independent of an examiner. Quantification of cervical ROM is the most commonly reported objective measure used to assess cervical dysfunction (Gross et al., 2007, Gross et al., 1996, Borghouts et al., 1998, Kjellman et al., 1999, Nordin et al., 2008, Strimpakos, 2011).

Active versus passive motion

While most studies evaluate cervical range of motion through similar procedures, variability is often observed in the use of passive or active cervical motion. Several studies indicate that passive and active cervical motion differ (Lantz et al., 1999, Christensen and Nilsson, 1998, Dvorak et al., 1992, Wong and Nansel, 1992, Castro et al., 2000). Through extensive systematic reviews of published literature, Chen et al. (1999) and Kelvin Jordan (2000) identified several studies that reported passive motion tests resulted in greater cervical ROM values and higher reliability estimates than active movement tests. Wong and Nansel (1992) found that end-range values for active motion tests were approximately five degrees less than passive tests on the most restricted side and approximately 10 degrees less on the least restricted side. Castro et al. (2000) and Dvorak et al. (1992) both published similar findings with passive motion tests resulting in larger range of motion angles and smaller standard deviations than active motion tests. In contrast, Johnston et al. (1985) found no significant differences between active and passive cervical range of motion values in both normal and affected subject pools.

Due to geometric constraints between cervical vertebrae and vertebral joint orientation, most cervical motion involves coupled movement patterns. Pure cervical lateral flexion is nearly impossible to physically perform and is coupled with an ipsilateral rotation due to the orientation of the facet joints between vertebrae as documented in several studies (Dall'Alba et al., 2001,

Jordan et al., 2003, Trott et al., 1996, Feipel et al., 1999). If motions are not kept in the plane of motion, a secondary motion could be introduced resulting in range of motion angles larger than those achieved if only primary motions are allowed. In studies performed by Malmström et al. (2006) and Jordan et al. (2003), findings suggest that larger coupled rotation was accompanied by larger primary lateral flexion suggesting a larger performance range with use of coupled movements. While inconsistencies are prevalent between published results on active versus passive motions, no protocol seems to yield significantly superior results, suggesting that both active and passive testing can be used in evaluation of cervical motion (Strimpakos et al., 2005, Nordin et al., 2008).

Healthy individuals versus individuals with neck pain

Assessment of an individual's cervical range of motion is commonly used as a criterion for evaluating neck pain and cervical dysfunction (Kjellman et al., 1999, Nordin et al., 2008, Strimpakos, 2011). The relationship between reduction of cervical ROM and neck pain is well documented and supported through previous studies (Dall'Alba et al., 2001, Bush et al., 2010, Grip et al., 2007, Prushansky et al., 2006). In a study comparing the active cervical ROM in all three primary directions (flexion/extension, lateral flexion, and rotation) for 89 asymptomatic and 114 symptomatic individuals with persistent whiplash-associated disorders (WAD), Dall'Alba et al. (2001) demonstrated a significant effect for groups ($p<0.001$) in all primary cervical ROM directions. In comparison to the asymptomatic group, patients with persistent WAD demonstrated a reduction in cervical ROM in all primary movement directions. Similarly, Grip et al. (2007) compared the active cervical ROM in flexion/extension and axial rotation

between three subject groups: a non-specific neck pain group (n=21) with pain lasting longer than 3 months, a WAD group (n=22) with symptoms lasting longer than 3 months, and a control group (n=24) with no head, neck, or back pain in the past 3 months. From this study, significant differences ($p<0.05$) were found between groups for all cervical ROM directions. Prushansky et al. (2006) produced comparable findings from an investigation of active cervical ROM in all movement directions between healthy individuals (n=75) and patients with chronic WAD (n=101). A significant reduction ($p<0.0001$) in cervical ROM in patients with chronic WAD was documented, with an average reduction of 23.6 degrees in the primary movement directions.

Analysis of cervical ROM for healthy individuals and those experiencing neck pain is less common for passive motion evaluations. In an investigation of the kinematics during passive motion tests, Bush et al. (2010) found significant differences ($p<0.10$) between the lateral flexion ROMs of asymptomatic (n=10) and symptomatic (n=9) groups.

Manual Medicine Treatment & Diagnosis

Nonspecific neck pain is highly prevalent, with approximately 85% of reported neck pain attributed to acute or repetitive neck injuries or chronic musculoligamentous stresses and strains (Narayan and Haid, 2001). Diagnosis of nonspecific neck pain often cannot be conducted through medical imaging technologies, and invasive treatment procedures are not applicable to nonspecific cervical dysfunctions. Several disciplines including osteopathic, chiropractic, physical therapy, and allopathic professions utilize manual medicine techniques to diagnose and treat musculoskeletal disorders (Seffinger et al., 2003). For these professions, the diagnosis of spinal musculoskeletal dysfunctions through palpation is a pre-requisite for the application of

manual treatment and palpation is essential for assessing the effectiveness of the intervention (Seffinger et al., 2004, Seffinger et al., 2003).

Inter and intra-examiner reliability of diagnosis

Manual assessments of individuals with neck pain are often based on diagnostic criteria such as the quantity and quality of regional and segmental joint motion, symmetry of bony landmarks, and soft tissue abnormalities (Seffinger et al., 2004). While these diagnostic parameters are common across manual medicine professions, the diagnostic evaluation is often dependent on the health care provider's education, training and experience (Carey et al., 1995). This is apparent through many studies reporting low levels of inter-examiner agreement (across multiple examiners) and moderate to high levels of intra-examiner agreement (within a single examiner) for palpatory assessments of the cervical spine (Pool et al., 2004, Stochkendahl et al., 2006, Seffinger et al., 2004, Fjellner et al., 1999, Deboer et al., 1985, Mior et al., 1985).

Inter and intra-examiner reliability of diagnosis is most often reported through Kappa scores ranging from -1 to 1, with a score of 0.4 or greater signifying acceptable reliability. However, evaluations of inter and intra-examiner reliability through Kappa scores are often based upon diagnostic statements recorded by the examiners as opposed to objective measures. Research studies conducted by Stochkendahl et al. (2006), Mior et al. (1985), and DeBoer et al. (1985) determined through Kappa scores that intra-examiner palpatory assessments of the cervical spine have acceptable reliability with poor inter-examiner reliability. From a subject pool of 47 symptomatic and asymptomatic subjects, Fjellner et al. (1999) documented acceptable agreement between examiners during regional passive motion assessments of the cervical spine

but poor reliability for intersegmental passive motion assessments. Pool et al. (2004) found through a group of 32 patients with neck pain that the reproducibility of cervical mobility assessments was highly variable between examiners. Similarly, through a systematic review of 49 articles on spinal palpation, Seffinger et al. (2004) found that intra-examiner reliability is better than inter-examiner reliability and regional cervical ROM tests are more reliable than segmental cervical ROM tests. With regard to measurement of inter- and intra-examiner differences, Seffinger et al. (2004) concluded that "in general, the quality of the research on inter- and intrareliability of spinal palpatory diagnostic procedures needs to be improved."

Effectiveness of manual treatment

Methods used in the treatment of cervical disorders vary between and within manual medicine disciplines. Through an evaluation of 955 questionnaires submitted by osteopathic physicians on the use of 11 manual treatment techniques, Johnson et al. (2003) found that the top four treatment techniques reportedly used "often" or "very often" include soft tissue therapy (71.7%), high-velocity low-amplitude (63.4%), muscle energy (60.9%), and myofascial release (40.3%).

Several studies have investigated the effects of high-velocity low-amplitude (HVLA) manipulation on individuals (Cleland et al., 2005, Cleland et al., 2007, Fernandez-de-las-Penas et al., 2007, Martinez-Segura et al., 2006). From a subject pool of 36 patients with mechanical neck pain, Cleland et al. (2005) found significant support ($p<0.001$) that those subjects who received a HVLA manipulation experienced immediate improvements in pain scores reported pre- and post-treatment. In comparison, subjects who received a sham treatment without HVLA manipulation

did not see a significant effect from treatment. Similarly, Fernandez-de-las-Penas et al. (2007) found a significant reduction in pain ($p<0.001$) immediately and 48 hours post HVLA manipulation treatment as well as a trend towards an increase in active cervical ROM in a group of 70 patients with neck pain.

The effects of muscle energy treatment on active cervical ROM in asymptomatic subjects was investigated by Burns et al. (2006). Pre-treatment, there were no significant differences in the cervical ROM values between the muscle energy treatment group ($n=18$) and the sham treatment group ($n=14$). Post-treatment assessments found a significant difference between groups ($p<0.001$) for the magnitude of difference between pre- and post-treatment cervical ROMs. Additionally for lateral flexion ROMs following treatment, the muscle energy treatment group saw a significant increase in cervical ROM while the sham treatment group saw a significant decrease in cervical ROM ($p<0.05$).

Currently, there is limited research on the effects of manual treatment techniques which are often evaluated based on improvements in subjective pain scores as opposed to objective measures. Further, investigation on the effects of treatment during active and passive motions needs to be conducted with the use of objective measures.

METHODS

This study had several components including the collection of three-dimensional kinematic data during diagnostic examinations by multiple physicians, two subject groups, manual treatment, and tests of passive and active motions. Figure 5 demonstrates the process through a flow chart. Following this figure, the *Methods* chapter will detail the *Subject Screening & Selection, The Cervical Diagnosis Technique used in Osteopathic Manual Medicine*, *Equipment, Subject Testing Protocol,* and *Data Analysis*.

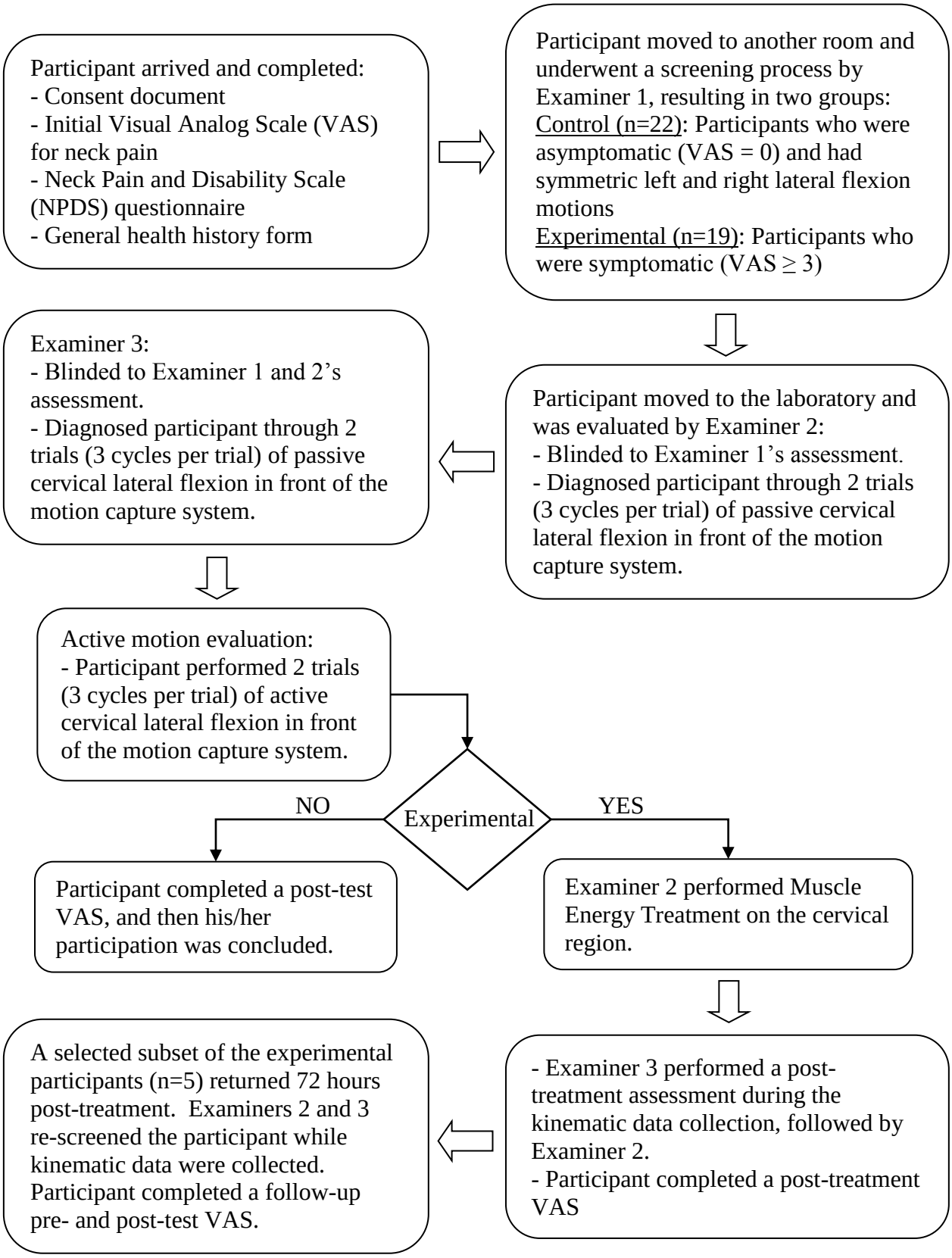

Figure 5. A flow chart of the test protocol

Subject Screening & Selection

Screening to obtain test groups

Volunteers for this study were recruited from Michigan State University's (MSU) student and faculty and staff population as well as MSU's Clinical Center. Advertisements were posted seeking individuals with acute or chronic neck pain as well as healthy, pain free individuals. Upon arrival to the Biomedical Design Research Laboratory (BDRL), the experiment was explained and participants were asked to read and sign the consent form. Following the subject's written consent (IRB# 06-464), three questionnaires were administered to document levels of pain and overall health. The first questionnaire was a Visual-Analog Scale (VAS) (Magee, 2002) where subjects documented their pain in the neck region on a ten centimeter scale with "0" signifying no pain and "10" indicating severe pain (Appendix A1). The second questionnaire was the Neck Pain and Disability Scale (NPDS) (Wheeler et al., 1999) entailing twenty questions regarding the ability of the participant to complete daily tasks based upon levels of pain experienced in the neck region (Appendix A2). The third questionnaire was a Lifestyles Questionnaire (Appendix A3) containing seven questions on physical attributes and health. A summary of subjects' questionnaire responses can be found in the *Results* chapter, with subject specific data found in Appendix A4. Following the completion of these questionnaires, subjects were escorted into another room where an osteopathic physician (Examiner 1) performed a palpatory cervical diagnosis (detailed in *Diagnosis technique*) while blinded to the subject's health, pain and disability scores. From the VAS and initial screening, subject groups were established as:

Control: Asymptomatic – No documented pain (VAS = 0) and symmetric left and right lateral flexion motion as determined by Examiner 1.

Experimental: Symptomatic – Documented pain (VAS ≥ 3).

Subject pool

Based on the screening of 131 total volunteers, only 41 subjects, 19 Experimental (14 males and 5 females) and 22 Control (16 males, 4 females, and 2 'not reported'), were selected for kinematic testing with an average age of 27.5 years (±13.1 years) and 19.9 years (±1.9 years) respectively. Physiological data for subject's average height, weight, and age were collected and summarized in the *Results* chapter with subject specific data found in Appendix A4.

The Cervical Diagnosis Technique used in Osteopathic Manual Medicine

The cervical palpatory diagnostic technique utilized during subject screening and testing was a highly practiced, standard clinical diagnostic motion test, common to osteopathic manual medicine (Johnston and Friedman, 1995). The diagnostic procedure was followed by all three examiners, who had each been practicing physicians for over ten years. The procedure was as follows:

1. The examiner aligned himself/herself posterior to the seated subject and asked the subject to remain in an erect posture with his/her arms crossed across his/her chest and eyes closed, while remaining passive to the examiners' motions during testing. The subject's

head position prior examiner-subject contact was established as the subject specific neutral location.

2. The examiner placed his/her right hand gently on the subject's head such that the hand was shaped to the vertex of the subject's head. The contralateral hand was placed lightly over the ipsilateral posterior thoracic midline to stabilize the shoulders as shown in Figure 6.
3. The examiner slowly guided the subject's head with his/her right hand in lateral flexion to the right, bringing the right ear toward the ipsilateral shoulder until a palpable sense of end-range of motion was achieved. End-range of motion was defined as the point where tissue texture change required a substantial increase in pressure to continue the lateral flexion motion.
4. The subject's head was then guided back to the neutral location, and the examiner hand placement was switched such that his/her left hand was placed on the vertex of the subject's head and the right hand placed on the ipsilateral posterior thoracic midline.
5. The examiner slowly guided the subject's head in left lateral flexion, bringing the left ear towards the ipsilateral shoulder until a palpable sense of end-range of motion was achieved.
6. The subject's head was guided back to the neutral location again, and steps 2-5 were repeated two more consecutive times resulting in six lateral flexions (three right lateral flexions, and three left lateral flexions). This was considered a single trial. Two trials were conducted with each subject.

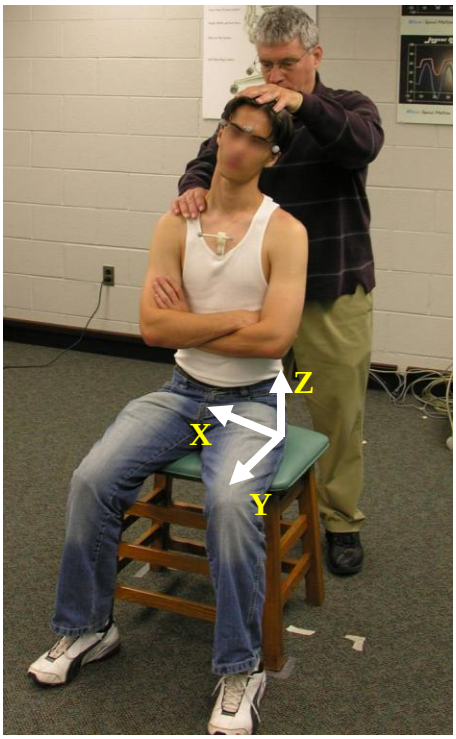

Figure 6. Examiner conducting a cervical palpatory diagnosis on a subject while collecting kinematic data

Following the cervical palatory diagnostic procedure, examiners made their clinical evaluations based upon the following pre-defined assessment criteria (Johnston and Friedman, 1995, Magee, 2002),

1. A visual and proprioceptive evaluation of the magnitude and symmetry of left and right cervical lateral flexion.
2. A palpatory assessment with the primary moving hand during lateral flexion to determine quality of motion, where quality of motion was evaluated on:
    a. Smoothness of motion during the entire passive testing protocol.

b. Tissue resistance (end-feel) evaluated by palpation of the cervical spine at the end-range of motion. End-feel was considered as any resistance to movement as the subject reached the end of the joint's motion range.
    i. Normal end-feel for cervical lateral flexion is tissue stretch or firmness at the end-range of motion in the form of elastic resistance.
    ii. Abnormal end-feel for cervical lateral flexion, suggesting dysfunction, include hardness or bone-to-bone contact (typically abrupt, hard and painful), muscle spasm or hard capsular sensation (increased tissue resistance sooner than expected), empty motion (motion stops due to pain), and springy block motion (similar to tissue stretch but occurring at a point in the cervical range of motion not anticipated).

Equipment

Experimental setup

Eligible subjects were escorted into the Biomechanical Design Research Laboratory where retro-reflective markers were attached to the skin via medical adhesives so that 3D kinematic motion data could be captured. A six-camera Qualysis Motion Tracking System (Gothenburg, Sweden) was used to gather the 3D kinematic data. Two markers placed on each temple lateral to the creases of the eyes, and one marker centered on the forehead 2.5cm superior to the brow (Figure 7) captured the head motions. Three additional markers were used in a rigid triad configuration and adhered to the subject's sternum centered 5cm inferior to the sternal

notch to capture the movement of the subject's torso (Figure 7). Based on pilot tests, a sampling frequency of 20 Hz was used for obtaining motion data.

Figure 7. Retro-reflective passive markers applied to the forehead, left and right temple, and a triad configuration on the sternum

Through calibration of the motion capture system, a global Cartesian coordinate system was generated within the testing space. The coordinate system was oriented such that the X-axis progressed horizontally from the subject's left to right, the Y-axis from posterior to anterior, and the Z-axis vertically from inferior to superior. The global origin of the system was established to be the left posterior corner of the clinical examining stool in relation to the subject. The system was calibrated each day prior to testing with the coordinate system the same for all subjects. The camera configuration can be seen in Figure 8.

Figure 8. Motion capture system camera configuration with global coordinate system origin on the left, posterior stool corner relative to the subject

Motion capture system accuracy

The Qualysis six-camera motion capture system was assessed for measurement accuracy through the use of three rigid linear "wands" with a passive marker attached to each end and a right triangle with a passive marker attached to each vertex. Measurements were manually taken with calipers to determine the distance between the centroids of the markers on each "wand". The distance between the centroids of the markers on each vertex of the 45°- 45°- 90° triangle were measured manually and used to compute the internal angles. After the system was properly calibrated, each object was individually moved through the calibrated space while 3D kinematic data were obtained for the centroid of each marker. Each specimen was tested three times over two days with a calibration of the system established each day prior to testing.

From the 3D kinematic data obtained for the markers on each specimen, the length of each wand and the internal angles of each vertex could be calculated and compared to the manual measurements. Accuracy of the Qualysis motion capture system was determined through a comparison of the manually measured data to the mean and standard deviation of values obtained from the motion capture system (Appendix A5). The average standard deviation for all three trials of a specimen never exceeded ±2 mm or ±1 degree.

Subject Testing Protocol

Passive motion tests

Two different examiners conducted the motion tests in front of the motion capture system. Examiners were blinded to subject pain scores and each other's assessments. Further, the order in which the examiners performed testing was controlled. Examiner 2 was called into the testing space and aligned posterior to the subject. Examiner 2 performed two separate trials of palpatory cervical diagnoses consisting of three left and right lateral flexion's (Left-Right-Left-Right-Left-Right) per trial. Data were collected for 30-65 seconds during each testing trial; each trial starting with a three second period in which the subject was instructed to remain still and facing forward to establish a subject specific neutral location prior to the examiner initiating the diagnosis procedure. Following Examiner 2's testing, Examiner 3 was called into the testing space while Examiner 2 recorded his diagnosis. The same testing protocol was used for Examiner 3, with two trials and each trial containing three cycles of cervical lateral flexion. Both trials were conducted in front of the motion capture system. The written diagnosis sheets were

immediately collected and filed by a test assistant to ensure proper blinding of each examiner to the others' diagnoses.

Active motion tests

The final test in the series was that of active motion. Written instructions for active motion testing were provided to the participant and were as follows:

1. Sit with your feet flat on the ground, hands crossed in front of your chest with your back in a comfortably erect posture.
2. Start the motions with your head in a comfortable neutral position (looking straight forward) and with your eyes closed.
3. Hold the starting position for a count of three seconds and then begin moving your right ear slowly towards your right shoulder, keeping your torso as still as possible.
4. When you reach your "comfortable end range" moving to the right, reverse direction. Then begin moving your head to the left at the same pace (speed) until a comfortable end range is reached to the left.

This procedure was re-iterated verbally prior to testing, instructing the subject to perform three left and right lateral flexion's (Left-Right-Left-Right-Left-Right) during two separate trials. Following the initial testing, Control subjects were asked to complete a post-test VAS concluding their participation while Experimental subjects moved to the treatment phase.

Treatment technique

All subjects qualifying for inclusion in the Experimental group were treated by Examiner 2 after the first set of kinematic tests. The primary mode of treatment conducted on all subjects was the muscle energy technique. Treatment was performed with the subject in a supine position and the examiner seated superior to the subject as shown in Figure 9.

Figure 9. Muscle energy treatment performed on a study participant

The muscle energy treatment technique is a common osteopathic manipulative treatment method used to treat somatic dysfunction, especially restricted range of motion, asymmetry, increased muscle tension and pain. This treatment technique uses isometric muscle contraction to lengthen potentially shortened cervical muscles and fascia to normalize gross cervical range of motion (Burns and Wells, 2006). Myofascial release was used in coordination with the muscle energy technique. Myofascial release involves the stretching and releasing of soft tissues along with manipulation of deep tissues by pressure application to balance the muscles involved in cervical motion.

Post-treatment evaluation

The post-treatment testing protocol was conducted in an identical manner as the pre-treatment testing protocol; however Examiner 3 led the testing procedure followed by Examiner 2 and then active motion. Following post-treatment testing, Experimental subjects were asked to complete a post-test VAS, concluding their participation.

Longitudinal evaluation

Five of the 19 Experimental subjects, selected on availability and willingness to participate, were asked to return 72 hours for additional testing and deemed the Longitudinal group. The 72-hour follow-up tests were conducted in the same manner as the pre-treatment testing. Upon return to the BDRL, subjects were asked to complete another consent form as well as the VAS and NPDS. The same motion tests were performed as discussed in *Passive motion tests* and *Active motion tests.* The testing protocol was conducted with Examiner 2 leading the testing procedure, followed by Examiner 3 and finally active motion testing. Again, both examiners were blinded to each other's testing, diagnoses, and the subject's pain scores. Following the 72-hour testing the five Experimental subjects completed a post-test VAS, concluding their participation.

Data Analysis

Raw kinematic data processing

Raw motion files were opened on a trial by trial basis and the six markers used during testing were labeled (forehead, left temple, right temple, middle sternum, left sternum, and right sternum) and checked for discontinuities with any artificial markers discarded. Once the appropriate markers were identified, the raw frame-by-frame motion data for each marker were exported as a "tab separated value" (.tsv) file. Raw data contained within the .tsv file were copied to an Excel file that separated data by marker and coordinates (x, y, z) as well as provided a time value (seconds) for each frame.

Angles of motion for the head relative to the thorax

A Matlab toolbox program, KineMat (Reinschmidt and Bogert, 1997), that utilized Euler angles was used to compute the angles of the head relative to the thorax. Each Excel file containing the raw kinematic motion data was saved into a folder containing seven separate Matlab function files (.m): Cardan, Marker, Rad2Deg, Run, Ryzxsolv, Screw, Soder. These Matlab function files, combined to form the KineMat toolbox, were used to compute the cervical angles of rotation for each trial. The angles of rotation were determined using Euler (Cardan) angle rotations in the order of rotation about the y-axis (lateral flexion), z-axis (axial rotation), and then x-axis (flexion and extension). The order of rotation was chosen based upon the study by Whittle and Walker (2004) who determined that the accuracy of primary and secondary rotations were greatest when rotations were calculated around the respective axes in that order.

The KineMat software was validated through manual calculation of the angles of rotation for lateral flexion, axial rotation, and flexion/extension via Euler angle rotation calculations. First, local Cartesian coordinate systems were established on the head and thorax in the form of unit vectors (î, ĵ, k̂). These coordinate systems were generated from the coordinates of the markers on the head (forehead, left temple, right temple) and the sternum (middle sternum, left sternum, right sternum). These local coordinate systems were then aligned with respect to the global coordinate system. Based upon the unit vectors for a local coordinate system at frame 'n' and frame 'n+1', the rotation matrix between the two frames could be calculated and thus the angles of rotation could be determined. The rotation matrix based upon a rotation sequence of YZX was determined from the summation of the rotation matrices for rotation around the y-axis, z-axis, and x-axis independently as follows:

$$R_y(\theta_1) = \begin{bmatrix} \cos\theta_1 & 0 & \sin\theta_1 \\ 0 & 1 & 0 \\ -\sin\theta_1 & 0 & \cos\theta_1 \end{bmatrix}$$

$$R_z(\theta_2) = \begin{bmatrix} \cos\theta_2 & -\sin\theta_2 & 0 \\ \sin\theta_2 & \cos\theta_2 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$R_x(\theta_3) = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\theta_3 & -\sin\theta_3 \\ 0 & \sin\theta_3 & \cos\theta_3 \end{bmatrix}$$

$$R(\theta_1,\theta_2,\theta_3) = R_Y(\theta_1)R_Z(\theta_2)R_X(\theta_3) = [R]$$

$$[R] = \begin{bmatrix} \cos\theta_1 \cos\theta_2 & \sin\theta_1 \sin\theta_3 - \cos\theta_1 \cos\theta_3 \sin\theta_2 & \cos\theta_1 \sin\theta_2 \sin\theta_3 + \cos\theta_3 \sin\theta_1 \\ \sin\theta_2 & \cos\theta_2 \cos\theta_3 & -\cos\theta_2 \sin\theta_3 \\ -\cos\theta_2 \sin\theta_1 & \cos\theta_1 \sin\theta_3 + \cos\theta_3 \sin\theta_1 \sin\theta_2 & \cos\theta_1 \cos\theta_3 + \sin\theta_1 \sin\theta_2 \sin\theta_3 \end{bmatrix}$$

Where θ_1 was the angle of rotation about the y-axis (lateral flexion), θ_2 was the angle of rotation around the z-axis (axial rotation), and θ_3 was the angle of rotation around the x-axis (flexion and extension).

The rotation matrix, $R(\theta_1, \theta_2, \theta_3)$, was then multiplied with the unit vectors of the local coordinate system at the original frame, X_n, to determine the location of the local coordinate system in the next frame, X_{n+1}, such that:

$$X_{n+1} = R(\theta_1, \theta_2, \theta_3) * X_n$$

$$\begin{bmatrix} \hat{i} \\ \hat{j} \\ \hat{k} \end{bmatrix}_{n+1} = [R] * \begin{bmatrix} \hat{i} \\ \hat{j} \\ \hat{k} \end{bmatrix}_n$$

From the known values (î, ĵ, k̂) of the local coordinate systems at frame ‘n’ and ‘n+1’ and the rotation matrix derived above, the values for lateral flexion (θ_1), axial rotation (θ_2), and flexion/extension (θ_3) can be determined for the head and thorax independently. Rotation values for the thorax are then subtracted from values of rotation of the head to account for thorax rotation during testing.

To assess the accuracy of KineMat, manual Euler angle calculations were conducted on three subjects over two trials. From the maximum left and right lateral flexion angles, the full range of cervical motion for each cycle (left to right lateral flexion) within a trial was compared to values obtained via KineMat. For the three subjects, the average difference between KineMat and the manual Euler angle calculations for full range of cervical motion was 0.9 degrees (±0.7 degrees). This validated the use of KineMat as an efficient means to determine angles of rotation for the data set.

Minimum and maximum lateral flexion

The maximum right (negative) and left (positive) lateral flexion values were determined through Excel. Each maximum lateral flexion value was identified through Excel 'If' statements requiring that the magnitude of a maximum value was greater than ten degrees ($\theta_n > 10°$), greater than the previous ten values ($\theta_n > \theta_{n-1} > \theta_{n-2} > \ldots > \theta_{n-10}$), and greater than the following ten values ($\theta_n > \theta_{n+1} > \theta_{n+2} > \ldots > \theta_{n+10}$). All angles were based upon a subject selected neutral position (zero degree angle) obtained during the first three seconds of motion capture tests. Secondary ROM values were determined as the axial rotation values at the corresponding frames identified for maximum lateral flexion values. All values were visually checked to ensure the proper values were obtained for maximum right and left lateral flexion.

Root mean square error and angular velocity calculation

To investigate the kinematic differences between trials within a subject for a given examiner, a root mean square error (RMSE) calculation (Franks et al., 1982) was conducted on each individual lateral flexion motion as well as the complete time series data. In order to perform the RMSE calculation on each lateral flexion motion individually, the cycles had to be identified and dissected from the complete time series data. An individual lateral flexion cycle was defined as the kinematic data associated with the start of a cycle to the maximum lateral flexion value for that cycle. This was done by first identifying each maximum left and right lateral flexion value through the methods previously discussed, requiring that the value be larger than ten degrees and greater than the previous or following ten frames. Each cycle was then defined as all frames previous to the maximum value that were greater than two degrees and constantly increasing, with the start of the cycle identified as having a minimum of five frames constantly increasing by at least 0.25 degrees, as shown in Figure 10. With each lateral flexion cycle identified (three right and three left) for both trials, all of the lateral flexion values for the cycles were dissected from the complete time series with the twelve individual cycles separated in a new Excel worksheet. The time series of each cycle was then normalized such that they ranged from zero to one.

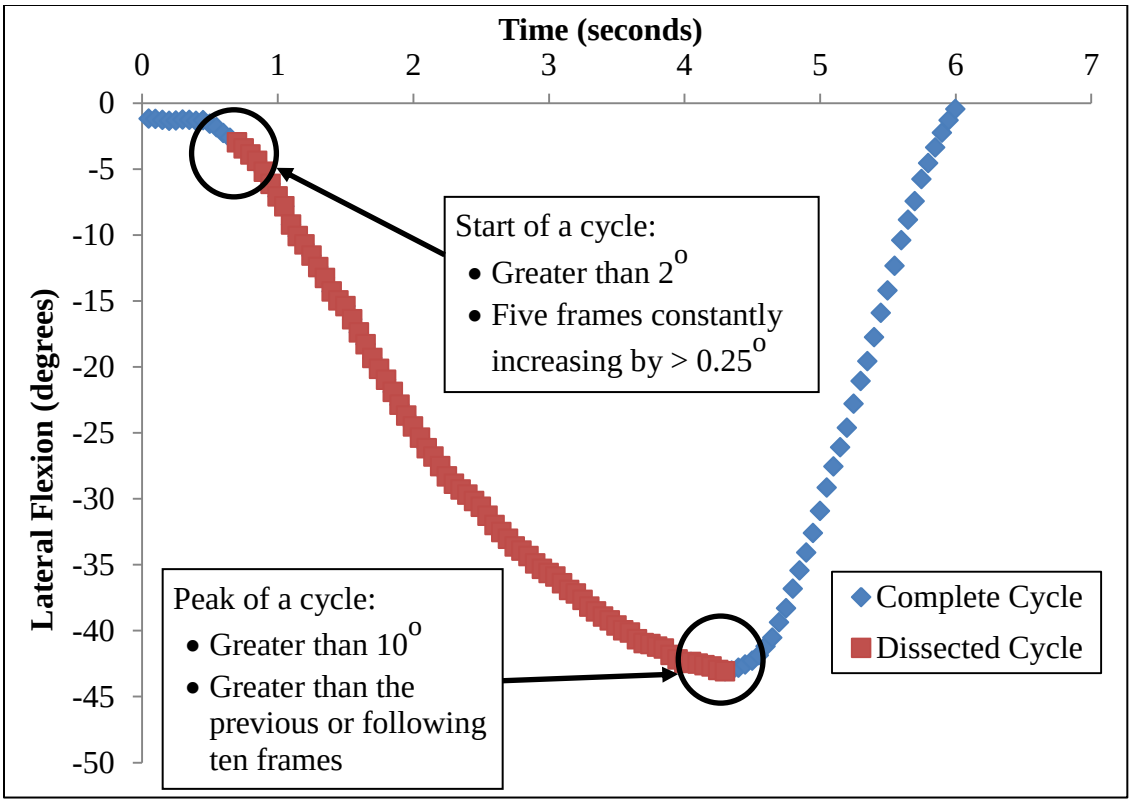

Figure 10. Example of a complete right lateral flexion cycle dissected from the start to peak of the cycle

The calculation of the RMSE between the two trials was conducted for each lateral flexion cycle, all right cycles, all left cycles, and all cycles. For a RMSE calculation to be conducted between trials, each cycle must be sampled for lateral flexion values at time values that correspond between trials. Each cycle had 50 lateral flexion values sampled at 2% intervals of the normalized time series. The difference between the lateral flexion values of trial one (θ_1) and trial two (θ_2) at each sampled time frame *i*, was used in the RMSE calculation as follows, where *n* was the number of sampled data points.

$$RMSE(\theta_1, \theta_2) = \sqrt{\frac{\sum_{i=1}^{n}(\theta_{1,i} - \theta_{2,i})^2}{n}}$$

The RMSE between the complete time series of the two trials was computed in a similar method. Excessive data was truncated from the beginning and end of the prescribed diagnostic motion, each trial's time series was normalized and 200 data points were sampled at 0.5% intervals.

The average rate of motion, or angular velocity (degrees/second), of each lateral flexion cycle was determined from the slope of calculated linear regressions for the frames identified from the start to the peak of a cycle as shown in Figure 11.

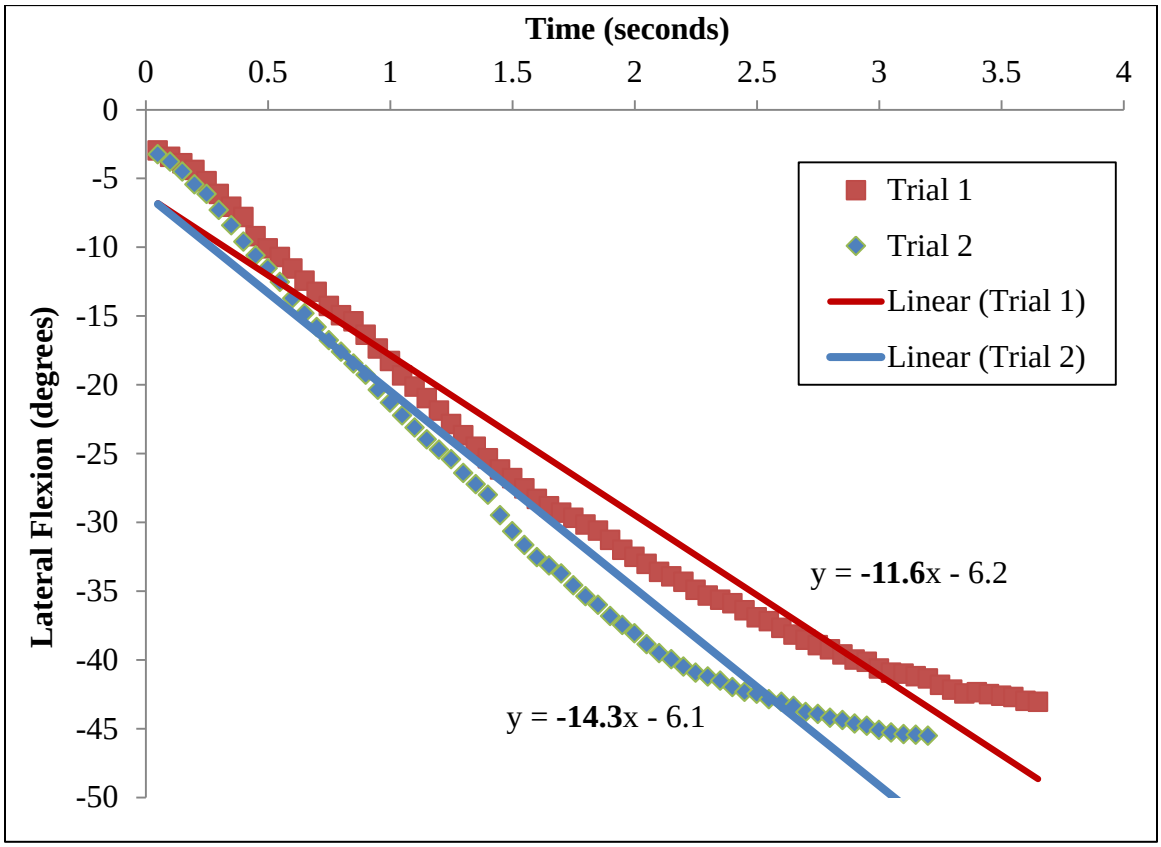

Figure 11. Example of the average rate of motion calculated from the slope of linear regressions applied to the dissected right lateral flexion cycles of two trials

Statistical analyses

Several statistical analyses were conducted to evaluate differences between examiners, consistency within an examiner, differences between active and passive motions, and differences within and between groups (Control, Experimental pre-treatment, Experimental post-treatment, and Longitudinal). Statistical tests included independent samples t-tests, paired samples t-tests, and one-way ANOVAs conducted on the following values:

- Left lateral flexion ROMs (left end-range), right lateral flexion ROMs (right end-range), and the complete ROM from maximum left to maximum right (full ROM)
- Rate of left lateral flexions (left-slope), rate of right lateral flexions (right-slope), and the rate of all lateral flexions (total-slope)
- Root mean square error calculated between trial one and two of the dissected cycles for all left lateral flexions (left RMSE), all right lateral flexions (right RMSE), and all lateral flexions (total RMSE) as well as the RMSE calculated between trial one and trial two of the complete time series
- Left axial rotation ROMs (left end-range), right axial rotation ROMs (right end-range), and the complete ROM from left to right axial rotations (full ROM)

All statistical tests performed are explained in further detail when presented in the *Results* chapter.

RESULTS

All kinematic data were assessed through statistical and descriptive analyses. This *Results* section outlines data obtained on the *Participant Demographics*, *Intra-Examiner Comparisons*, *Inter-Examiner Comparisons*, *Active versus Passive Motion*, *Group Comparisons*, and *Longitudinal Study Comparisons*. Data presented in this *Results* section include values for angular range of motion, rate of cervical lateral flexion, and calculated root mean square error.

Participant Demographics

Prior to all testing procedures, age, height, weight, gender, and handedness were obtained for each participant (Tables 1-3). Additionally, pain scores were collected via a VAS and functionality was assessed through a Neck Pain and Disability Scale (NPDS) (Table 4 and Appendix A4).

As noted previously in the *Methods* section, based on the screening process conducted on a total of 131 volunteers, only 41 subjects, 19 Experimental (14 male and 5 female) and 22 Control (14 male, 6 female, and 2 'not reported'), were selected for kinematic testing with an average age of 27.5 years (±13.1 years) and 19.9 years (±1.9 years) respectively. A total of 90 subjects were not qualified (or not needed due to full groups) for testing following the screening process.

Table 1. Subject age, height, and weight as divided by subject group

	Ages (years)		Height (cm)		Weight (kg)	
	Control	Experimental	Control	Experimental	Control	Experimental
Min	18.0	18.0	154.9	152.4	49.9	44.0
Max	23.0	63.0	193.0	195.6	108.4	120.7
Average	**19.9**	**27.5**	**174.9**	**175.9**	**74.0**	**79.9**
SD	*1.9*	*13.1*	*10.2*	*12.3*	*13.7*	*20.9*

Table 2. Gender comparisons as divided by subject group

	Gender	
	Control	Experimental
Male	14	14
Female	6	5
Not Reported	2	0

Table 3. Subject handedness as divided by subject group

	Handedness	
	Control	Experimental
Right	17	18
Left	4	1
Not Reported	1	0

The data in Tables 1-3 express similar subject pool characteristics between the Control and Experimental group for average height and weight, as well as the distribution of gender and handedness. The average height and weight for the Control and Experimental group were 174.9 cm and 74.0 kg, and 175.9 cm and 79.9 kg respectively.

Table 4. Pre-test VAS, post-test VAS, and NPDS scores as divided by subject group

	Pre-Test VAS		Post-Test VAS		NPDS	
	Control	**Experimental**	**Control**	**Experimental**	**Control**	**Experimental**
Min	0.0	3.0	0.0	1.0	0.0	12.5
Max	0.0	8.0	0.0	7.0	13.0	77.0
Average	**0.0**	**4.6**	**0.0**	**3.8**	**2.5**	**46.9**
SD	*0.0*	*1.7*	*0.0*	*2.0*	*4.1*	*21.0*

As mandated in the screening protocol, to be included in the Control group it was required that the participant select "0" on the VAS. To be included in the Experimental group, the participant had to select a score of "3" or higher on the VAS. As shown in Table 4, the Control subjects reported a zero VAS pain score pre- and post-test; and the Experimental group saw a slight decrease in the average VAS score from pre-treatment to post-treatment. The NPDS scores expressed a strong difference in disability levels between the Control and Experimental group prior to testing with reported average scores of 2.5 (±4.1) and 46.9 (±21.0) respectively.

For each of the following sections, data will be presented for the kinematic results first in the form of ranges of motion (ROM), the rate of change of motion (slope) and the results of the root mean square error (RMSE) analysis. Subject specific data can be found in the *Appendix* for ranges of lateral flexion's (Appendix A6), ranges of axial rotations (Appendix A7), rates of lateral flexion's (Appendix A8), the RMSE of dissected cycles (Appendix A9) and the RMSE of complete time series (Appendix A10). Tables documenting statistical analyses conducted present significant findings as shaded values.

Intra-Examiner Comparisons

Range of Motion

The cervical lateral flexion angular range of motion data for Examiner 2 are presented in Tables 5, 6, and 7 as average left end-range of motion (left end-range), average right end-range of motion (right end-range) and the average full range of motion (full ROM) [total from left end-range to right end-range] in degrees. Table 5 presents data for trials one and two of the Control group, Table 6 provides data for the Experimental group pre-treatment, and Table 7 provides the average kinematic data for trials one and two of the Experimental group post-treatment. The average full range of motion (ROM) for trial one and two of Examiner 2 in the Control group was 71.0 (±11.6) and 71.7 (±11.5) degrees, respectively. The average full ROM for trial one and two of Examiner 2 in the Experimental group was 67.7 (±12.3) and 64.9 (±11.8) degrees for pre-treatment, and 67.0 (±11.4) and 66.5 (±12.00) degrees for post-treatment.

Table 5. Examiner 2 intra-examiner comparisons in the Control group for left end-range, right end-range, and full range of motion values

	Left End-Range (Deg)		Right End-Range (Deg)		Full ROM (Deg)	
	Trial 1	**Trial 2**	**Trial 1**	**Trial 2**	**Trial 1**	**Trial 2**
Min	22.6	24.3	15.9	23.0	39.6	51.5
Max	45.4	46.9	50.5	50.9	89.0	94.8
Average	**35.5**	**35.5**	**35.6**	**36.2**	**71.0**	**71.7**
SD	*5.6*	*5.7*	*7.2*	*6.7*	*11.6*	*11.4*

Table 6. Examiner 2 intra-examiner comparisons in the Experimental group pre-treatment for left end-range, right end-range, and full range of motion values

	Left End-Range (Deg)		Right End-Range (Deg)		Full ROM (Deg)	
	Trial 1	**Trial 2**	**Trial 1**	**Trial 2**	**Trial 1**	**Trial 2**
Min	23.4	23.2	18.9	19.6	44.4	43.1
Max	49.6	47.7	47.9	48.7	92.7	93.7
Average	**34.6**	**33.0**	**33.0**	**31.8**	**67.7**	**64.9**
SD	*7.0*	*6.3*	*7.1*	*6.2*	*12.2*	*11.8*

Table 7. Examiner 2 intra-examiner comparisons in the Experimental group post-treatment for left end-range, right end-range, and full range of motion values

	Left End-Range (Deg)		Right End-Range (Deg)		Full ROM (Deg)	
	Trial 1	**Trial 2**	**Trial 1**	**Trial 2**	**Trial 1**	**Trial 2**
Min	23.5	19.6	21.5	16.8	49.0	48.6
Max	50.4	46.4	45.2	45.4	90.2	89.5
Average	**34.1**	**33.3**	**33.0**	**33.3**	**67.0**	**66.5**
SD	*6.6*	*6.3*	*6.1*	*6.7*	*11.4*	*12.0*

Similarly, the average cervical lateral flexion ROM data for Examiner 3 is presented in Tables 8, 9, and 10 for left end-range, right end-range, and full ROM values in degrees. Range of motion data for trial one and two of Examiner 3 are documented for the Control group in Table 8, the Experimental group pre-treatment in Table 9 and the Experimental group post-treatment in Table 10. The average full ROM for trial one and two of Examiner 3 in the Control group was 65.9 (±11.7) and 66.3 (±11.3) degrees respectively. The average full ROM for trial one and two

of Examiner 3 in the Experimental group was 58.3 (±11.4) and 57.7 (±12.0) degrees for pre-treatment, and 59.8 (±11.4) and 62.3 (±12.7) degrees for post-treatment.

Table 8. Examiner 3 intra-examiner comparisons in the Control group for left end-range, right end-range, and full range of motion values

	Left End-Range (Deg)		Right End-Range (Deg)		Full ROM (Deg)	
	Trial 1	**Trial 2**	**Trial 1**	**Trial 2**	**Trial 1**	**Trial 2**
Min	21.5	21.4	13.8	15.4	35.7	37.9
Max	44.6	44.3	45.4	47.0	87.6	87.1
Average	**33.1**	**33.6**	**32.6**	**32.7**	**65.8**	**66.3**
SD	*6.3*	*5.9*	*7.1*	*7.1*	*11.7*	*11.3*

Table 9. Examiner 3 intra-examiner comparisons in the Experimental group pre-treatment for left end-range, right end-range, and full range of motion values

	Left End-Range (Deg)		Right End-Range (Deg)		Full ROM (Deg)	
	Trial 1	**Trial 2**	**Trial 1**	**Trial 2**	**Trial 1**	**Trial 2**
Min	13.8	18.5	16.0	13.5	35.8	34.4
Max	41.2	40.3	42.8	42.4	83.8	80.6
Average	**29.7**	**29.4**	**28.5**	**28.3**	**58.2**	**57.7**
SD	*6.7*	*6.5*	*5.8*	*6.9*	*11.4*	*12.0*

Table 10. Examiner 3 intra-examiner comparisons in the Experimental group post-treatment for left end-range, right end-range, and full range of motion values

	Left End-Range (Deg)		Right End-Range (Deg)		Full ROM (Deg)	
	Trial 1	**Trial 2**	**Trial 1**	**Trial 2**	**Trial 1**	**Trial 2**
Min	16.0	15.5	17.1	18.3	35.9	33.8
Max	42.0	44.8	46.9	47.4	87.7	92.2
Average	**29.6**	**31.6**	**30.2**	**30.6**	**59.8**	**62.3**
SD	*6.4*	*6.8*	*6.6*	*6.6*	*11.4*	*12.6*

The lateral flexion ROM data were statistically analyzed for intra-examiner consistency of motion using one-way ANOVAs conducted on each examiners' data (Examiner 2 and Examiner 3) within each test group (Control, Experimental pre-treatment, and Experimental

post-treatment). Each of the six ANOVAs tested for significant differences between cycles one through six (three cycles per trial over two trials) for right end-range, left end-range, and full ROM values and included the following cases:

- Examiner 2
    - Control
    - Experimental pre-treatment
    - Experimental post-treatment
- Examiner 3
    - Control
    - Experimental pre-treatment
    - Experimental post-treatment

No significant differences between each of the six cycles were reported for right end-range, left end-range, or full ROM data for Examiner 2 or Examiner 3 within the Control or either Experimental groups.

Rate of motion

As previously indicated in the *Methods* section, the rate of change, or average angular velocity, of cervical lateral flexion was determined through the slope of the values from the start of a cycle to the maximum lateral flexion value of a cycle such that an average rate was calculated for cervical lateral flexion to the left (left-slope), cervical lateral flexion to the right (right-slope) and all cervical lateral flexion's (total-slope). The data for average rate of left, right, and total cervical lateral flexion for cycles one through three (trial one) and cycles four through six (trial two) of Examiner 2 are presented in Tables 11-13. The average slope data for trial one and two of Examiner 2 are presented in Table 11 for the Control group, Table 12 for the Experimental group pre-treatment and Table 13 for the Experimental group post-treatment. The average rate of all cervical lateral flexion's performed (total-slope) for trial one and two of

Examiner 2 within the Control group was 10.6 (±2.9) and 11.5 (±3.3) degrees/second, respectively. The average total-slope for trial one and two of Examiner 2 in the Experimental group was 9.5 (±3.1) and 9.0 (±3.3) degrees/second for pre-treatment testing, and 9.2 (±2.6) and 8.9 (±2.5) degrees/second for post-treatment testing.

Table 11. Examiner 2 intra-examiner comparisons in the Control group for left-slope, right-slope, and total-slope values

	Right-slope (Deg/sec)		Left-slope (Deg/sec)		Total-slope (Deg/sec)	
	Trial 1	**Trial 2**	**Trial 1**	**Trial 2**	**Trial 1**	**Trial 2**
Min	4.2	5.7	4.9	4.9	4.2	4.9
Max	19.9	21.8	17.8	19.8	19.9	21.8
Average	**10.5**	**11.8**	**10.7**	**11.3**	**10.6**	**11.5**
SD	*2.9*	*3.4*	*2.9*	*3.3*	*2.9*	*3.3*

Table 12. Examiner 2 intra-examiner comparisons in the Experimental group pre-treatment for left-slope, right-slope, and total-slope values

	Right-slope (Deg/sec)		Left-slope (Deg/sec)		Total-slope (Deg/sec)	
	Trial 1	**Trial 2**	**Trial 1**	**Trial 2**	**Trial 1**	**Trial 2**
Min	4.3	4.2	4.2	4.2	4.2	4.2
Max	18.7	18.1	18.7	18.1	18.7	18.1
Average	**9.7**	**9.1**	**9.4**	**9.0**	**9.5**	**9.0**
SD	*3.1*	*3.1*	*3.0*	*3.4*	*3.0*	*3.3*

Table 13. Examiner 2 intra-examiner comparisons in the Experimental group post-treatment for left-slope, right-slope, and total-slope values

	Right-slope (Deg/sec)		Left-slope (Deg/sec)		Total-slope (Deg/sec)	
	Trial 1	**Trial 2**	**Trial 1**	**Trial 2**	**Trial 1**	**Trial 2**
Min	5.9	4.8	4.5	4.0	4.5	4.0
Max	20.0	16.6	15.4	13.7	20.0	16.6
Average	**9.8**	**9.4**	**8.7**	**8.5**	**9.2**	**8.9**
SD	*2.7*	*2.6*	*2.5*	*2.4*	*2.6*	*2.5*

The data for average rate of left, right, and total cervical lateral flexion of trial one and trial two for Examiner 3 are documented in Tables 14-16. The average slope data for trial one and two of Examiner 3 are presented in Table 14 for the Control group, Table 15 for the Experimental group pre-treatment and Table 16 for the Experimental group post-treatment. The average total-slope for trial one and two of Examiner 3 within the Control group was 11.5 (±3.6) and 12.0 (±3.5) degrees/second, respectively. For the Experimental group, the average total-slope for trial one and two of Examiner 3 was 9.5 (±3.1) and 10.1 (±3.3) degrees/second for pre-treatment testing, and 9.4 (±2.5) and 10.5 (±3.5) degrees/second for post-treatment testing.

Table 14. Examiner 3 intra-examiner comparisons in the Control group for left-slope, right-slope, and total-slope values

	Right-slope (Deg/sec)		**Left-slope (Deg/sec)**		**Total-slope (Deg/sec)**	
	Trial 1	**Trial 2**	**Trial 1**	**Trial 2**	**Trial 1**	**Trial 2**
Min	3.5	5.6	2.3	2.8	3.5	2.3
Max	23.0	20.8	20.2	19.8	23.0	20.8
Average	**11.1**	**11.6**	**11.8**	**12.3**	**11.5**	**12.0**
SD	*3.7*	*3.5*	*3.4*	*3.5*	*3.6*	*3.5*

Table 15. Examiner 3 intra-examiner comparisons in the Experimental group pre-treatment for left-slope, right-slope, and total-slope values

	Right-slope (Deg/sec)		**Left-slope (Deg/sec)**		**Total-slope (Deg/sec)**	
	Trial 1	**Trial 2**	**Trial 1**	**Trial 2**	**Trial 1**	**Trial 2**
Min	3.8	3.9	3.9	4.0	3.8	3.9
Max	18.1	17.4	14.6	17.8	18.1	17.8
Average	**9.7**	**10.0**	**9.4**	**10.1**	**9.5**	**10.1**
SD	*3.2*	*3.3*	*2.9*	*3.4*	*3.1*	*3.3*

Table 16. Examiner 3 intra-examiner comparisons in the Experimental group post-treatment for left-slope, right-slope, and total-slope values

	Right-slope (Deg/sec)		Left-slope (Deg/sec)		Total-slope (Deg/sec)	
	Trial 1	**Trial 2**	**Trial 1**	**Trial 2**	**Trial 1**	**Trial 2**
Min	5.6	4.8	5.2	4.8	5.2	4.8
Max	15.9	18.7	16.3	21.3	16.3	21.3
Average	**9.5**	**10.3**	**9.2**	**10.7**	**9.4**	**10.5**
SD	*2.4*	*3.3*	*2.7*	*3.6*	*2.5*	*3.5*

Statistical analyses conducted on the intra-examiner consistency for the rate of cervical lateral flexion of Examiner 2 and Examiner 3 included one-way repeated measures ANOVAs performed within each group (Control, Experimental pre-treatment, and Experimental post-treatment) for both right-slope and left-slope. Each of the twelve ANOVAs tested for significant differences between the slope of cycle six and the slopes of each remaining cycles (one through five), and included the following cases:

- Examiner 2
  - Left-slope
    - Control
    - Experimental pre-treatment
    - Experimental post-treatment
  - Right-slope
    - Control
    - Experimental pre-treatment
    - Experimental post-treatment
- Examiner 3
  - Left-slope
    - Control
    - Experimental pre-treatment
    - Experimental post-treatment
  - Right-slope
    - Control
    - Experimental pre-treatment
    - Experimental post-treatment

Statistical results from Examiner 2 are presented in Table 17-a, demonstrating a significant difference between cycle one and cycle six for the right-slope of the Experimental group pre- and post-treatment ($p<0.05$) and the left-slope of the Experimental group post-treatment ($p<0.10$). Significant differences between cycle four and cycle six were reported in all three groups for right-slope ($p<0.10$) as well as the left-slope of the Experimental group post-treatment ($p<0.05$). Table 17 (b-g) contains the descriptive statistics for each ANOVA, documenting the mean, standard error, and confidence interval for each cycle.

Similarly, statistical results from Examiner 3 are presented in Table 18-a, demonstrating a significant difference between cycle one and cycle six for the right-slope of the Control group ($p<0.05$) and the left-slope of the Control and Experimental group post-treatment ($p<0.05$). Significant differences between cycle four and cycle six were found for the left-slope of the Control and Experimental group post-treatment ($p<0.10$). Table 18 (b-g) contain the descriptive statistics for each ANOVA, documenting the mean, standard error, and confidence interval for each cycle.

Table 17-a. Examiner 2 intra-examiner cycle-by-cycle statistical analyses for rate of right and left cervical lateral flexion within the Control and Experimental groups

Group	Test	Type III Sum of Squares	df	Mean Square	F	Sig.
Control	Left-slope (Cycle 1 v. 6)	13.2	1	13.2	0.9	**0.351**
	Error	259.9	18	14.4		
Control	Right-slope (Cycle 1 v. 6)	0.9	1	0.9	0.1	**0.820**
	Error	366.1	21	17.4		
Control	Left-slope (Cycle 4 v. 6)	5.8	1	5.8	1.7	**0.213**
	Error	63.2	18	3.5		
Control	Right-slope (Cycle 4 v. 6)	28.4	1	28.4	4.6	**0.045**
	Error	131.1	21	6.2		
Pre-	Left-slope (Cycle 1 v. 6)	3.0	1	3.0	0.5	**0.505**
	Error	103.4	16	6.5		
Pre-	Right-slope (Cycle 1 v. 6)	34.5	1	34.5	5.6	**0.030**
	Error	104.5	17	6.1		
Pre-	Left-slope (Cycle 4 v. 6)	2.5	1	2.5	0.5	**0.508**
	Error	85.7	16	5.4		
Pre-	Right-slope (Cycle 4 v. 6)	18.8	1	18.8	4.7	**0.044**
	Error	67.5	17	4.0		
Post-	Left-slope (Cycle 1 v. 6)	9.4	1	9.4	3.6	**0.075**
	Error	47.3	18	2.6		
Post-	Right-slope (Cycle 1 v. 6)	63.3	1	63.3	9.8	**0.006**
	Error	116.1	18	6.4		
Post-	Left-slope (Cycle 4 v. 6)	17.7	1	17.7	6.0	**0.025**
	Error	53.4	18	3.0		
Post-	Right-slope (Cycle 4 v. 6)	14.6	1	14.6	3.6	**0.075**
	Error	73.6	18	4.1		

Table 17-b. Cycle-by-cycle descriptive statistics of right-slope for Examiner 2 within the Control group

* All values in deg/sec			95% Confidence Interval	
Cycle	Mean	Std. Error	Lower Bound	Upper Bound
1	11.3	0.6	10.0	12.5
2	10.2	0.6	9.0	11.4
3	10.1	0.7	8.7	11.5
4	12.2	0.7	10.7	13.6
5	12.0	0.8	10.5	13.6
6	11.1	0.7	9.6	12.5

Table 17-c. Cycle-by-cycle descriptive statistics of left-slope for Examiner 2 within the Control group

* All values in deg/sec			95% Confidence Interval	
Cycle	Mean	Std. Error	Lower Bound	Upper Bound
1	10.6	0.8	9.0	12.2
2	10.1	0.5	9.0	11.2
3	10.8	0.7	9.4	12.3
4	12.0	0.8	10.4	13.7
5	10.7	0.7	9.3	12.1
6	11.5	0.8	9.8	13.2

Table 17-d. Cycle-by-cycle descriptive statistics of right-slope for Examiner 2 within the Experimental group pre-treatment

* All values in deg/sec			95% Confidence Interval	
Cycle	Mean	Std. Error	Lower Bound	Upper Bound
1	10.2	0.6	9.0	11.4
2	9.7	0.7	8.2	11.2
3	9.8	0.9	7.9	11.6
4	9.8	0.6	8.5	11.1
5	9.4	0.8	7.8	11.0
6	8.8	0.8	7.2	10.4

Table 17-e. Cycle-by-cycle descriptive statistics of left-slope for Examiner 2 within the Experimental group pre-treatment

* All values in deg/sec			95% Confidence Interval	
Cycle	Mean	Std. Error	Lower Bound	Upper Bound
1	9.9	0.6	8.7	11.0
2	9.6	0.7	8.2	11.0
3	9.7	0.8	8.0	11.3
4	9.8	0.7	8.4	11.3
5	8.9	0.9	7.0	10.7
6	9.4	0.9	7.5	11.4

Table 17-f. Cycle-by-cycle descriptive statistics of right-slope for Examiner 2 within the Experimental group post-treatment

* All values in deg/sec			95% Confidence Interval	
Cycle	Mean	Std. Error	Lower Bound	Upper Bound
1	10.6	0.7	9.1	12.0
2	9.8	0.7	8.4	11.2
3	8.9	0.5	7.8	10.1
4	9.6	0.6	8.4	10.9
5	9.7	0.7	8.3	11.1
6	8.8	0.5	7.6	9.9

Table 17-g. Cycle-by-cycle descriptive statistics of left-slope for Examiner 2 within the Experimental group post-treatment

* All values in deg/sec			95% Confidence Interval	
Cycle	Mean	Std. Error	Lower Bound	Upper Bound
1	9.0	0.6	7.7	10.2
2	8.4	0.5	7.2	9.5
3	8.7	0.6	7.5	9.9
4	9.2	0.6	8.0	10.4
5	8.1	0.6	6.9	9.2
6	8.3	0.5	7.2	9.3

Table 18-a. Examiner 3 intra-examiner cycle-by-cycle statistical analyses for rate of right and left cervical lateral flexion within the Control and Experimental groups

Group	Test	Type III Sum of Squares	df	Mean Square	F	Sig.
Control	Left-slope (Cycle 1 v. 6)	25.6	1	25.6	5.1	**0.035**
	Error	106.0	21	5.0		
Control	Right-slope (Cycle 1 v. 6)	48.9	1	48.9	9.5	**0.006**
	Error	107.8	21	5.1		
Control	Left-slope (Cycle 4 v. 6)	18.6	1	18.6	3.9	**0.061**
	Error	99.2	21	4.7		
Control	Right-slope (Cycle 4 v. 6)	26.8	1	26.8	2.9	**0.102**
	Error	191.9	21	9.1		
Pre-	Left-slope (Cycle 1 v. 6)	5.8	1	5.8	1.1	**0.310**
	Error	95.6	18	5.3		
Pre-	Right-slope (Cycle 1 v. 6)	16.6	1	16.6	2.7	**0.121**
	Error	112.7	18	6.3		
Pre-	Left-slope (Cycle 4 v. 6)	0.9	1	0.9	0.2	**0.700**
	Error	107.9	18	6.0		
Pre-	Right-slope (Cycle 4 v. 6)	12.5	1	12.5	2.9	**0.106**
	Error	77.9	18	4.3		
Post-	Left-slope (Cycle 1 v. 6)	81.1	1	81.1	6.7	**0.020**
	Error	207.2	17	12.2		
Post-	Right-slope (Cycle 1 v. 6)	13.9	1	13.9	1.5	**0.230**
	Error	152.5	17	9.0		
Post-	Left-slope (Cycle 4 v. 6)	24.6	1	24.6	3.5	**0.078**
	Error	118.8	17	7.0		
Post-	Right-slope (Cycle 4 v. 6)	3.7	1	3.7	0.4	**0.524**
	Error	147.0	17	8.6		

Table 18-b. Cycle-by-cycle descriptive statistics of right-slope for Examiner 3 within the Control group

* All values in deg/sec			95% Confidence Interval	
Cycle	Mean	Std. Error	Lower Bound	Upper Bound
1	10.4	0.7	9.1	11.8
2	11.2	0.9	9.4	13.0
3	11.8	0.8	10.1	13.5
4	10.8	0.7	9.3	12.4
5	11.9	0.7	10.4	13.5
6	11.9	0.7	10.4	13.5

Table 18-c. Cycle-by-cycle descriptive statistics of left-slope for Examiner 3 within the Control group

* All values in deg/sec			95% Confidence Interval	
Cycle	Mean	Std. Error	Lower Bound	Upper Bound
1	11.7	0.6	10.4	13.1
2	11.4	0.7	9.9	12.9
3	12.3	0.8	10.6	14.0
4	11.9	0.7	10.5	13.3
5	12.3	0.8	10.6	14.1
6	12.8	0.7	11.3	14.3

Table 18-d. Cycle-by-cycle descriptive statistics of right-slope for Examiner 3 within the Experimental group pre-treatment

* All values in deg/sec			95% Confidence Interval	
Cycle	Mean	Std. Error	Lower Bound	Upper Bound
1	9.3	0.8	7.6	11.0
2	10.1	0.7	8.5	11.6
3	9.7	0.7	8.3	11.1
4	9.4	0.6	8.0	10.7
5	10.4	0.9	8.5	12.2
6	10.2	0.7	8.7	11.7

Table 18-e. Cycle-by-cycle descriptive statistics of left-slope for Examiner 3 within the Experimental group pre-treatment

* All values in deg/sec			95% Confidence Interval	
Cycle	Mean	Std. Error	Lower Bound	Upper Bound
1	9.2	0.7	7.7	10.7
2	9.4	0.6	8.1	10.6
3	9.6	0.7	8.1	11.1
4	10.0	0.7	8.5	11.4
5	10.7	0.8	9.0	12.4
6	9.7	0.8	8.0	11.5

Table 18-f. Cycle-by-cycle descriptive statistics of right-slope for Examiner 3 within the Experimental group post-treatment

* All values in deg/sec			95% Confidence Interval	
Cycle	Mean	Std. Error	Lower Bound	Upper Bound
1	9.2	0.5	8.1	10.4
2	9.3	0.5	8.2	10.4
3	10.1	0.6	8.9	11.3
4	9.6	0.7	8.2	11.1
5	10.1	0.7	8.6	11.6
6	10.1	0.8	8.4	11.8

Table 18-g. Cycle-by-cycle descriptive statistics of left-slope for Examiner 3 within the Experimental group post-treatment

* All values in deg/sec			95% Confidence Interval	
Cycle	Mean	Std. Error	Lower Bound	Upper Bound
1	8.8	0.6	7.6	10.1
2	8.7	0.6	7.4	10.0
3	10.2	0.7	8.7	11.7
4	9.8	0.6	8.4	11.1
5	10.7	1.0	8.5	12.9
6	10.9	0.8	9.1	12.7

Root mean square error

The root mean square error (RMSE) between the cervical lateral flexion of trial one and trial two for an examiner's passive motion within a subject was calculated according to the protocol outlined in the *Methods* section. Investigation of intra-examiner consistency of motion was conducted through the RMSE calculations of the individually dissected lateral flexion cycles from the start of the cycle to the maximum lateral flexion value of that cycle. Tables 19-21 present the average RMSE data of each of the three cycles performed for right lateral flexion (right RMSE), left lateral flexion (left RMSE), and both right and left lateral flexion combined (total RMSE) of Examiner 2. The average RMSE values for each cycle of Examiner 2's passive motions are reported in Table 19 for the Control group, Table 20 for the Experimental group pre-treatment and Table 21 for the Experimental group post-treatment. The average total RMSE between trial one and two for each of the three cycles of Examiner 2 within the Control, Experimental pre-treatment and Experimental post-treatment groups are summarized in Table 22, with a range of 2.5 to 3.3 degrees.

Table 19. Examiner 2 intra-examiner comparisons in the Control group of right, left, and total RMSE values for all three cycles

	Right RMSE (Deg)			Left RMSE (Deg)			Total RMSE (Deg)		
	Cycle 1	Cycle 2	Cycle 3	Cycle 1	Cycle 2	Cycle 3	Cycle 1	Cycle 2	Cycle 3
Min	0.7	0.8	0.8	0.6	0.6	0.8	1.3	1.2	0.8
Max	10.4	9.7	8.0	10.7	8.3	12.0	10.5	9.0	10.2
Average	**3.0**	**2.7**	**3.1**	**2.4**	**3.1**	**3.1**	**2.8**	**3.0**	**3.2**
SD	*2.0*	*2.1*	*1.7*	*2.2*	*1.8*	*2.5*	*1.9*	*1.7*	*1.9*

Table 20. Examiner 2 intra-examiner comparisons in the Experimental group pre-treatment of right, left, and total RMSE values for all three cycles

	Right RMSE (Deg)			Left RMSE (Deg)			Total RMSE (Deg)		
	Cycle 1	Cycle 2	Cycle 3	Cycle 1	Cycle 2	Cycle 3	Cycle 1	Cycle 2	Cycle 3
Min	0.7	0.5	0.8	0.5	0.5	0.9	0.9	0.9	0.9
Max	5.8	11.2	5.9	7.1	6.4	7.5	5.1	7.9	5.5
Average	**2.2**	**2.7**	**3.0**	**2.4**	**2.1**	**3.1**	**2.5**	**2.7**	**3.2**
SD	*1.2*	*2.5*	*1.6*	*1.7*	*1.6*	*1.8*	*1.2*	*1.7*	*1.3*

Table 21. Examiner 2 intra-examiner comparisons in the Experimental group post-treatment of right, left, and total RMSE values for all three cycles

	Right RMSE (Deg)			Left RMSE (Deg)			Total RMSE (Deg)		
	Cycle 1	Cycle 2	Cycle 3	Cycle 1	Cycle 2	Cycle 3	Cycle 1	Cycle 2	Cycle 3
Min	0.7	0.5	0.8	0.6	0.7	0.7	1.6	0.8	0.8
Max	7.2	10.7	7.3	5.7	6.1	4.0	6.4	8.4	5.9
Average	**2.9**	**2.9**	**3.0**	**2.8**	**2.3**	**2.2**	**3.0**	**2.8**	**2.7**
SD	*1.6*	*2.6*	*1.7*	*1.7*	*1.6*	*1.1*	*1.3*	*1.9*	*1.3*

Table 22. Examiner 2 intra-examiner comparisons of total RMSE values (degrees) for all three cycles within the Control, Experimental pre-treatment and Experimental post-treatment groups

	Control			Exp. Pre-Treatment			Exp. Post-Treatment		
	Cycle 1	Cycle 2	Cycle 3	Cycle 1	Cycle 2	Cycle 3	Cycle 1	Cycle 2	Cycle 3
Min	1.3	1.2	0.8	0.9	0.9	0.9	1.6	0.8	0.8
Max	10.5	9.0	10.2	5.1	7.9	5.5	6.4	8.4	5.9
Average	**2.8**	**3.0**	**3.2**	**2.5**	**2.7**	**3.2**	**3.0**	**2.8**	**2.7**
SD	*1.9*	*1.7*	*1.9*	*1.2*	*1.7*	*1.3*	*1.3*	*1.9*	*1.3*

Similarly, Tables 23-25 present the average RMSE data of each of the three cycles performed for right lateral flexion (right RMSE), left lateral flexion (left RMSE), and both right and left lateral flexion combined (total RMSE) of Examiner 3. The average RMSE values for each cycle of Examiner 3's passive motions are reported in Table 23 for the Control group, Table

24 for the Experimental group pre-treatment and Table 25 for the Experimental group post-treatment. The average total RMSE between trial one and two for each of the three cycles of Examiner 3 within the Control, Experimental pre-treatment and Experimental post-treatment groups are summarized in Table 26, with a range of 2.3 to 3.1 degrees.

Table 23. Examiner 3 intra-examiner comparisons in the Control group of right, left, and total RMSE values for all three cycles

	Right RMSE (Deg)			Left RMSE (Deg)			Total RMSE (Deg)		
	Cycle 1	Cycle 2	Cycle 3	Cycle 1	Cycle 2	Cycle 3	Cycle 1	Cycle 2	Cycle 3
Min	0.5	0.5	0.8	0.4	1.1	0.8	0.7	0.9	0.9
Max	6.8	6.2	5.9	7.3	7.4	4.7	6.1	6.4	5.1
Average	**2.6**	**3.3**	**2.2**	**2.9**	**2.6**	**2.1**	**2.9**	**3.1**	**2.3**
SD	*1.9*	*1.8*	*1.4*	*1.8*	*1.5*	*1.2*	*1.5*	*1.4*	*1.1*

Table 24. Examiner 3 intra-examiner comparisons in the Experimental group pre-treatment of right, left, and total RMSE values for all three cycles

	Right RMSE (Deg)			Left RMSE (Deg)			Total RMSE (Deg)		
	Cycle 1	Cycle 2	Cycle 3	Cycle 1	Cycle 2	Cycle 3	Cycle 1	Cycle 2	Cycle 3
Min	0.6	0.9	0.7	0.8	0.6	0.5	1.0	1.1	0.6
Max	4.4	7.2	5.6	7.7	5.3	5.4	5.5	6.1	4.3
Average	**2.4**	**3.4**	**2.8**	**2.9**	**2.5**	**2.6**	**2.8**	**3.1**	**2.8**
SD	*1.3*	*1.8*	*1.5*	*2.0*	*1.5*	*1.3*	*1.4*	*1.3*	*1.0*

Table 25. Examiner 3 intra-examiner comparisons in the Experimental group post-treatment of right, left, and total RMSE values for all three cycles

	Right RMSE (Deg)			Left RMSE (Deg)			Total RMSE (Deg)		
	Cycle 1	Cycle 2	Cycle 3	Cycle 1	Cycle 2	Cycle 3	Cycle 1	Cycle 2	Cycle 3
Min	0.8	1.0	0.7	0.7	0.5	1.1	1.4	0.8	1.2
Max	6.5	5.8	6.2	15.6	11.3	9.5	11.1	8.1	7.1
Average	**2.5**	**2.5**	**2.7**	**3.0**	**2.9**	**2.8**	**3.0**	**2.9**	**2.9**
SD	*1.7*	*1.4*	*1.6*	*3.3*	*2.7*	*2.2*	*2.3*	*1.8*	*1.7*

Table 26. Examiner 3 intra-examiner comparisons of total RMSE values (degrees) for all three cycles within the Control, Experimental pre-treatment and Experimental post-treatment groups

	Control			Exp. Pre-Treatment			Exp. Post-Treatment		
	Cycle 1	Cycle 2	Cycle 3	Cycle 1	Cycle 2	Cycle 3	Cycle 1	Cycle 2	Cycle 3
Min	0.7	0.9	0.9	1.0	1.1	0.6	1.4	0.8	1.2
Max	6.1	6.4	5.1	5.5	6.1	4.3	11.1	8.1	7.1
Average	**2.9**	**3.1**	**2.3**	**2.8**	**3.1**	**2.8**	**3.0**	**2.9**	**2.9**
SD	*1.5*	*1.4*	*1.1*	*1.4*	*1.3*	*1.0*	*2.3*	*1.8*	*1.7*

The RMSE data was statistically analyzed for intra-examiner consistency of motion through one-way ANOVAs conducted on each examiner (Examiner 2 and Examiner 3) within each test group (Control, Experimental pre-treatment, and Experimental post-treatment). Each of the six ANOVAs tested for significant differences between cycles one through three of right, left, and total RMSE for the following cases:

- Examiner 2
    - Control
    - Experimental pre-treatment
    - Experimental post-treatment
- Examiner 3
    - Control
    - Experimental pre-treatment
    - Experimental post-treatment

No significant differences between cycles one through three were reported for the right, left, or total RMSE data of Examiner 2 or Examiner 3 within the Control or Experimental group.

Inter-Examiner Comparisons

Range of motion

The data for Examiner 2 and Examiner 3's passive lateral flexion ranges of motion were averaged over all six cycles within trial one and two and presented in Tables 27-29 as average left end-range, right-end range, and full ROM values. A comparison of Examiner 2 and Examiner 3's average left end-range, right end-range, and full ROM is presented in Table 27 for the Control group, Table 28 for the Experimental group pre-treatment and Table 29 for the Experimental group post-treatment. The average full ROM for Examiner 2 was consistently greater than Examiner 3 for the Control, Experimental pre-treatment, and Experimental post-treatment. The average full ROM for Examiner 2 and Examiner 3 respectively were 71.4 (±11.5) and 66.1 (±11.5) degrees for the Control group, 66.3 (±12.0) and 58.0 (±11.7) degrees for the Experimental group pre-treatment, and 66.8 (±11.7) and 61.04 (±12.0) degrees for the Experimental group post-treatment.

Table 27. Inter-examiner comparisons between Examiner 2 and Examiner 3's average passive motions in the Control group for left end-range, right end-range, and full range of motion values

	Left End-Range (Deg)		Right End-Range (Deg)		Full ROM (Deg)	
	Ex. 2	**Ex. 3**	**Ex. 2**	**Ex. 3**	**Ex. 2**	**Ex. 3**
Min	23.5	21.4	19.5	14.6	45.5	36.8
Max	46.1	44.4	50.7	46.2	91.9	87.4
Average	**35.5**	**33.4**	**35.9**	**32.7**	**71.4**	**66.1**
SD	*5.7*	*6.1*	*6.9*	*7.1*	*11.5*	*11.5*

Table 28. Inter-examiner comparisons between Examiner 2 and Examiner 3's average passive motions in the Experimental group pre-treatment for left end-range, right end-range, and full range of motion values

	Left End-Range (Deg)		Right End-Range (Deg)		Full ROM (Deg)	
	Ex. 2	**Ex. 3**	**Ex. 2**	**Ex. 3**	**Ex. 2**	**Ex. 3**
Min	23.3	16.1	19.2	14.8	43.7	35.1
Max	48.6	40.8	48.3	42.6	93.2	82.2
Average	**33.8**	**29.6**	**32.4**	**28.4**	**66.3**	**58.0**
SD	*6.7*	*6.6*	*6.7*	*6.4*	*12.0*	*11.7*

Table 29. Inter-examiner comparisons between Examiner 2 and Examiner 3's average passive motions in the Experimental group post-treatment for the left end-range, right end-range, and full range of motion values

	Left End-Range (Deg)		Right End-Range (Deg)		Full ROM (Deg)	
	Ex. 2	**Ex. 3**	**Ex. 2**	**Ex. 3**	**Ex. 2**	**Ex. 3**
Min	21.5	15.8	19.2	17.7	48.8	34.8
Max	48.4	43.4	45.3	47.1	89.9	89.9
Average	**33.7**	**30.6**	**33.1**	**30.4**	**66.8**	**61.0**
SD	*6.4*	*6.6*	*6.4*	*6.6*	*11.7*	*12.0*

Statistical analyses for inter-examiner ROM comparisons were conducted as independent samples t-tests of Examiner 2 versus Examiner 3's average passive ranges of motion. Independent samples t-tests were used to compare Examiner 2 and Examiner 3's data for left end-range, right end-range, and full ROM values within the Control, Experimental pre-treatment and Experimental post-treatment groups. As shown in Table 30, a significant difference between Examiner 2 and Examiner 3's ROM (left, right, and full) was found for the Experimental group pre-treatment ($p<0.10$). No significant differences were reported between the passive motions of Examiner 2 and Examiner 3 for the Control group or Experimental group post-treatment.

Table 30. Inter-examiner statistical analyses between Examiner 2 and Examiner 3 for right end-range, left end-range, and full range of motion for the Control, Experimental pre-treatment, and Experimental post-treatment groups

* Values in degrees		Levene's Test for Equality of Variances		t-test for Equality of Means			
Group	**Test**	**F**	**Sig.**	**t**	**df**	**Mean Difference***	**Sig. (2-tailed)**
Control	Right	0.029	0.866	1.6	42	3.2	**0.111**
Control	Left	0.558	0.459	1.2	42	2.0	**0.223**
Control	Full ROM	0.003	0.956	1.6	42	5.3	**0.118**
Pre-	Right	0.012	0.912	2.3	35	4.4	**0.029**
Pre-	Left	0.128	0.723	2.0	36	4.1	**0.053**
Pre-	Full ROM	0.064	0.802	2.1	36	8.0	**0.040**
Post-	Right	0.001	0.970	1.3	36	2.6	**0.200**
Post-	Left	0.082	0.776	1.5	36	2.9	**0.145**
Post-	Full ROM	0.009	0.927	1.5	36	5.5	**0.146**

Rate of motion

The data for Examiner 2 and Examiner 3's rate of passive lateral flexion were averaged over all six cycles within trial one and two and presented in Tables 31-33. Inter-examiner comparisons are presented for right-slope (average of all six right lateral flexions), left-slope (average of all six left lateral flexions), and total-slope (average of all twelve lateral flexions) in Table 31 for the Control group, Table 32 for the Experimental group pre-treatment, and Table 33 for the Experimental group post-treatment. The average total-slope of Examiner 2 and Examiner 3 within the Control group was 11.1 (±2.4) and 11.7 (±3.0) degrees/second, respectively. Within the Experimental group the average total-slope of Examiner 2 and Examiner 3 respectively was 9.2 (±2.9) and 9.8 (±2.8) degrees/second for pre-treatment, and 9.1 (±2.3) and 10.1 (±2.6) degrees/second for post-treatment testing.

Table 31. Inter-examiner comparisons between Examiner 2 and Examiner 3's average rate of passive motions in the Control group for right-slope, left-slope, and total-slope values

	Right-slope (Deg/sec)		Left-slope (Deg/sec)		Total-slope (Deg/sec)	
	Ex. 2	**Ex. 3**	**Ex. 2**	**Ex. 3**	**Ex. 2**	**Ex. 3**
Min	7.3	5.9	6.4	6.9	6.9	6.9
Max	15.8	18.7	15.0	18.2	15.2	18.5
Average	**11.1**	**11.4**	**11.0**	**12.1**	**11.1**	**11.7**
SD	*2.5*	*3.2*	*2.5*	*3.1*	*2.4*	*3.0*

Table 32. Inter-examiner comparisons between Examiner 2 and Examiner 3's average rate of passive motions in the Experimental group pre-treatment for right-slope, left-slope, and total-slope values

	Right-slope (Deg/sec)		Left-slope (Deg/sec)		Total-slope (Deg/sec)	
	Ex. 2	**Ex. 3**	**Ex. 2**	**Ex. 3**	**Ex. 2**	**Ex. 3**
Min	5.0	4.8	4.5	4.8	4.8	5.4
Max	15.8	15.2	15.5	15.0	15.0	14.8
Average	**9.4**	**9.8**	**9.1**	**9.8**	**9.2**	**9.8**
SD	*2.9*	*2.9*	*3.0*	*2.8*	*2.9*	*2.8*

Table 33. Inter-examiner comparisons between Examiner 2 and Examiner 3's average rate of passive motions in the Experimental group post-treatment for right-slope, left-slope, and total-slope values

	Right-slope (Deg/sec)		Left-slope (Deg/sec)		Total-slope (Deg/sec)	
	Ex. 2	**Ex. 3**	**Ex. 2**	**Ex. 3**	**Ex. 2**	**Ex. 3**
Min	6.3	5.9	5.5	5.7	6.0	5.8
Max	15.4	16.0	13.6	14.4	14.5	15.1
Average	**9.6**	**10.1**	**8.6**	**10.1**	**9.1**	**10.1**
SD	*2.4*	*2.6*	*2.2*	*2.7*	*2.3*	*2.6*

Statistical analyses for inter-examiner comparisons of average rates of passive lateral flexions were conducted as independent samples t-tests of Examiner 2 versus Examiner 3. Independent samples t-tests were used to compare the left-slope, right-slope, and total-slope values of Examiner 2 versus Examiner 3 for the Control, Experimental pre-treatment, and

Experimental post-treatment groups. As shown in Table 34, a significant difference between Examiner 2 and Examiner 3's the left-slope values was found for all groups ($p<0.10$) and total-slope values for the Experimental group post-treatment ($p<0.05$).

Table 34. Inter-examiner statistical analyses between Examiner 2 and Examiner 3 for average left-slope, right-slope, and total-slope values within the Control and Experimental groups

Group	Test	df	t-value	Pr > |t|
Control	Left-slope	21	-2.1	**0.050**
Control	Right-slope	21	-0.4	**0.716**
Control	Total-slope	21	-1.2	**0.241**
Pre-	Left-slope	18	-1.9	**0.077**
Pre-	Right-slope	18	-1.0	**0.324**
Pre-	Total-slope	18	-1.6	**0.125**
Post-	Left-slope	18	-3.9	**0.001**
Post-	Right-slope	18	-1.1	**0.277**
Post-	Total-slope	18	-2.5	**0.022**

Root mean square error

The root mean square error (RMSE) values calculated between trial one and trial two of all dissected cycles combined for Examiner 2 and Examiner 3's passive motions are presented in Tables 35-37. Inter-examiner comparisons of the calculated right (all three right lateral flexions), left (all three left lateral flexions), and total (all right and left lateral flexions) RMSE of the dissected cycles combined are presented in Table 35 for the Control group, Table 36 for the Experimental group pre-treatment, and Table 37 for the Experimental group post-treatment. The average total RMSE of all dissected cycles for Examiner 2 and Examiner 3 respectively were 3.1 (±1.6) and 2.9 (±1.0) degrees within the Control group, 2.9 (±1.1) and 3.0 (±0.9) degrees within

the Experimental group pre-treatment, and 2.9 (±1.3) and 3.1 (±1.7) degrees within the Experimental group post-treatment.

Table 35. Inter-examiner comparisons between Examiner 2 and Examiner 3's average right, left, and total RMSE in the Control group

	Right RMSE (Deg)		Left RMSE (Deg)		Total RMSE (Deg)	
	Ex. 2	Ex. 3	Ex. 2	Ex. 3	Ex. 2	Ex. 3
Min	1.6	1.0	0.9	0.9	1.7	1.0
Max	10.5	5.4	9.4	4.8	9.9	4.7
Average	**3.0**	**2.7**	**3.1**	**2.9**	**3.1**	**2.9**
SD	*1.8*	*1.1*	*1.7*	*1.3*	*1.6*	*1.0*

Table 36. Inter-examiner comparisons between Examiner 2 and Examiner 3's average right, left, and total RMSE in the Experimental group pre-treatment

	Right RMSE (Deg)		Left RMSE (Deg)		Total RMSE (Deg)	
	Ex. 2	Ex. 3	Ex. 2	Ex. 3	Ex. 2	Ex. 3
Min	0.9	0.6	0.9	1.4	0.9	1.4
Max	4.8	5.3	7.6	5.0	5.5	4.2
Average	**2.7**	**2.8**	**2.7**	**3.1**	**2.9**	**3.0**
SD	*1.3*	*1.3*	*1.6*	*1.0*	*1.1*	*0.9*

Table 37. Inter-examiner comparisons between Examiner 2 and Examiner 3's average right, left, and total RMSE in the Experimental group post-treatment

	Right RMSE (Deg)		Left RMSE (Deg)		Total RMSE (Deg)	
	Ex. 2	Ex. 3	Ex. 2	Ex. 3	Ex. 2	Ex. 3
Min	1.0	1.3	1.8	1.2	1.6	1.6
Max	4.7	12.4	7.7	5.6	6.2	8.9
Average	**2.6**	**3.1**	**3.1**	**2.7**	**2.9**	**3.1**
SD	*1.3*	*2.5*	*1.7*	*1.2*	*1.3*	*1.7*

The average RMSE values calculated between trial one and trial two for the complete time series of Examiner 2 and Examiner 3's passive motions are presented in Table 38 for the Control, Experimental pre-treatment, and the Experimental post-treatment groups. The average

RSME of the complete time series' for Examiner 2 and Examiner 3 respectively are 8.1 (±2.5) and 8.1 (±3.4) degrees for the Control group, 8.3 (±3.2) and 7.6 (±3.5) degrees for the Experimental group pre-treatment, and 8.5 (±3.8) and 9.0 (±3.1) degrees for the Experimental group post-treatment.

Table 38. Inter-examiner comparisons between Examiner 2 and Examiner 3's average RMSE (degrees) of the complete time-series in the Control and Experimental groups

	Control		Exp. Pre-Treatment		Exp. Post-Treatment	
	Ex. 2	**Ex. 3**	**Ex. 2**	**Ex. 3**	**Ex. 2**	**Ex. 3**
Min	3.6	3.4	3.0	3.0	5.3	4.1
Max	12.9	18.5	16.6	17.9	18.5	14.7
Average	**8.0**	**8.1**	**8.3**	**7.6**	**8.5**	**9.0**
SD	*2.5*	*3.4*	*3.2*	*3.5*	*3.8*	*3.1*

Statistical analyses for inter-examiner comparisons of calculated RMSE values included one-way ANOVAs for the Control and Experimental groups. Each ANOVA tested for differences between Examiner 2 and Examiner 3's average right, left, and total RMSE of the dissected cycles combined as well as the RMSE of the complete time series. No statistically significant differences were found for inter-examiner comparisons of calculated root mean square errors.

Active versus Passive Motion

Range of motion

The cervical lateral flexion range of motion data for Examiner 2 and Examiner 3's passive motion testing as well as active motion testing performed independently by the subjects were averaged over all six cycles within trial one and two and presented in Tables 39-41.

Comparisons of passive (Examiner 2 and Examiner 3) and active motions for average left end-range, right end-range, and full ROM values are presented in Table 39 for the Control group, Table 40 for the Experimental group pre-treatment, and Table 41 for the Experimental group post-treatment. These data demonstrate a consistent trend in which the average ROM for active motion tests were greater than the average ROM during passive motions tests performed by both Examiner 2 and Examiner 3. Comparisons of the average full ROM values for Examiner 2, Examiner 3, and active motion are summarized in Table 42 for the Control, Experimental pre-treatment and Experimental post-treatment groups, with differences between active and passive ROMs ranging from 10.3 to 21.3 degrees.

Table 39. Active and passive motion comparisons in the Control group for average left end-range, right end-range, and full ROM values

	Left End-Range (Deg)			Right End-Range (Deg)			Full ROM (Deg)		
	Ex. 2	**Ex. 3**	**Active**	**Ex. 2**	**Ex. 3**	**Active**	**Ex. 2**	**Ex. 3**	**Active**
Min	23.5	21.4	29.4	19.5	14.6	26.5	45.5	36.8	56.0
Max	46.1	44.4	58.0	50.7	46.2	56.8	91.9	87.4	113.6
Average	**35.5**	**33.4**	**44.3**	**35.9**	**32.7**	**43.1**	**71.4**	**66.1**	**87.4**
SD	*5.7*	*6.1*	*6.3*	*6.9*	*7.1*	*7.4*	*11.5*	*11.5*	*12.5*

Table 40. Active and passive motion comparisons in the Experimental group pre-treatment for average left end-range, right end-range, and full ROM values

	Left End-Range (Deg)			Right End-Range (Deg)			Full ROM (Deg)		
	Ex. 2	**Ex. 3**	**Active**	**Ex. 2**	**Ex. 3**	**Active**	**Ex. 2**	**Ex. 3**	**Active**
Min	23.3	16.1	27.7	19.2	14.8	23.9	43.7	35.1	54.0
Max	48.6	40.8	59.4	48.3	42.6	50.2	93.2	82.2	106.0
Average	**33.8**	**29.6**	**39.6**	**32.4**	**28.4**	**37.3**	**66.3**	**58.0**	**77.0**
SD	*6.7*	*6.6*	*8.2*	*6.7*	*6.4*	*6.7*	*12.0*	*11.7*	*13.5*

Table 41. Active and passive motion comparisons in the Experimental group post-treatment for average left end-range, right end-range, and full ROM values

	Left End-Range (Deg)			Right End-Range (Deg)			Full ROM(Deg)		
	Ex. 2	**Ex. 3**	**Active**	**Ex. 2**	**Ex. 3**	**Active**	**Ex. 2**	**Ex. 3**	**Active**
Min	21.5	15.8	18.8	19.2	17.7	22.0	48.8	34.8	46.8
Max	48.4	43.4	52.2	45.3	47.1	52.0	89.9	89.9	101.1
Average	**33.7**	**30.6**	**40.6**	**33.1**	**30.4**	**38.3**	**66.8**	**61.0**	**78.9**
SD	*6.4*	*6.6*	*6.8*	*6.4*	*6.6*	*6.7*	*11.7*	*12.0*	*11.6*

Table 42. Active and passive motion comparisons of full ROM values (degrees) for the Control, Experimental pre-treatment and Experimental post-treatment groups

	Control			Exp. Pre-Treatment			Exp. Post-Treatment		
	Ex. 2	**Ex. 3**	**Active**	**Ex. 2**	**Ex. 3**	**Active**	**Ex. 2**	**Ex. 3**	**Active**
Min	45.5	36.8	56.0	43.7	35.1	54.0	48.8	34.8	46.8
Max	91.9	87.4	113.6	93.2	82.2	106.0	89.9	89.9	101.1
Average	**71.4**	**66.1**	**87.4**	**66.3**	**58.0**	**77.0**	**66.8**	**61.0**	**78.9**
SD	*11.5*	*11.5*	*12.5*	*12.0*	*11.7*	*13.5*	*11.7*	*12.0*	*11.6*

Statistical analyses included one-way ANOVAs with a Bonferroni comparing the averaged full ROM data of Examiner 2, Examiner 3, and active motion within the Control group and Experimental group pre- and post-treatment. As presented in Table 43, the average active full ROM data was significantly greater than the passive motions of Examiner 2 and Examiner 3 for all comparisons.

Table 43. Statistical analyses of passive versus active motion testing for average full range of motion values within the Control and Experimental groups

*Values in degrees				95% Confidence Interval		
Group	**Test**	**Mean Difference***	**Std. Error***	**Lower Bound***	**Upper Bound***	**Sig.**
Control	Act v. Ex 2	16.0	3.5	7.5	24.5	**0.000**
Control	Act v. Ex 3	21.3	3.5	12.8	29.8	**0.000**
Pre-	Act v. Ex 2	10.4	3.9	0.7	20.1	**0.031**
Pre-	Act v. Ex 3	18.4	3.9	8.7	28.1	**0.000**
Post-	Act v. Ex 2	12.1	3.6	3.1	21.1	**0.005**
Post-	Act v. Ex 3	17.6	3.6	8.7	26.6	**0.000**

Rate of motion

The data for rate of cervical lateral flexion of Examiner 2 and Examiner 3's passive motion testing as well as active motion testing performed independently by the subjects were averaged over all six cycles within trial one and two and presented in Tables 44-46. Comparisons of passive (Examiner 2 and Examiner 3) and active motions for average left-slope (rate of left lateral flexions), right-slope (rate of right lateral flexions), and total-slope (rate of all lateral flexions) values are presented in Table 44 for the Control group, Table 45 for the Experimental group pre-treatment, and Table 45 for the Experimental group post-treatment. These data present a noticeable trend in which the average rate of lateral flexion during active motion tests was greater than the rate of passive motions performed by both Examiner 2 and Examiner 3. Comparisons of the average total-slope values for Examiner 2, Examiner 3, and active motion are summarized in Table 47 for the Control, Experimental pre-treatment and Experimental post-treatment groups, with differences between active and passive rates of motions ranging from 4.6 to 6.8 degrees per second.

Table 44. Active and passive motion comparisons in the Control group for average right-slope, left-slope, and total-slope values

	Right-Slope (Deg/sec)			Left-Slope (Deg/sec)			Total-Slope (Deg/sec)		
	Ex. 2	**Ex. 3**	**Active**	**Ex. 2**	**Ex. 3**	**Active**	**Ex. 2**	**Ex. 3**	**Active**
Min	7.3	5.9	9.1	6.4	6.9	10.0	6.9	6.9	9.6
Max	15.8	18.7	26.1	15.0	18.2	32.7	15.2	18.5	29.4
Average	**11.1**	**11.4**	**16.4**	**11.0**	**12.1**	**18.2**	**11.1**	**11.7**	**17.3**
SD	*2.5*	*3.2*	*4.4*	*2.5*	*3.1*	*4.9*	*2.4*	*3.0*	*4.6*

Table 45. Active and passive motion comparisons in the Experimental group pre-treatment for average right-slope, left-slope, and total-slope values

	Right-Slope (Deg/sec)			Left-Slope (Deg/sec)			Total-Slope (Deg/sec)		
	Ex. 2	**Ex. 3**	**Active**	**Ex. 2**	**Ex. 3**	**Active**	**Ex. 2**	**Ex. 3**	**Active**
Min	5.0	4.8	5.2	4.5	4.8	6.4	4.8	5.4	5.8
Max	15.8	15.2	22.9	15.5	15.0	24.3	15.0	14.8	22.1
Average	**9.4**	**9.8**	**14.2**	**9.1**	**9.8**	**16.0**	**9.2**	**9.8**	**15.1**
SD	*2.9*	*2.9*	*4.8*	*3.0*	*2.8*	*5.7*	*2.9*	*2.8*	*5.1*

Table 46. Active and passive motion comparisons in the Experimental group post-treatment for average right-slope, left-slope, and total-slope values

	Right-Slope (Deg/sec)			Left-Slope (Deg/sec)			Total-Slope (Deg/sec)		
	Ex. 2	**Ex. 3**	**Active**	**Ex. 2**	**Ex. 3**	**Active**	**Ex. 2**	**Ex. 3**	**Active**
Min	6.3	5.9	8.1	5.5	5.7	8.5	6.0	5.8	8.9
Max	15.4	16.0	27.0	13.6	14.4	25.4	14.5	15.1	26.2
Average	**9.6**	**10.1**	**14.6**	**8.6**	**10.1**	**15.3**	**9.1**	**10.1**	**15.0**
SD	*2.4*	*2.6*	*4.7*	*2.2*	*2.7*	*4.9*	*2.3*	*2.6*	*4.7*

Table 47. Active and passive motion comparisons of total-slope values (deg/sec) for the Control, Experimental pre-treatment, and Experimental post-treatment groups

	Control			Exp. Pre-Treatment			Exp. Post-Treatment		
	Ex. 2	**Ex. 3**	**Active**	**Ex. 2**	**Ex. 3**	**Active**	**Ex. 2**	**Ex. 3**	**Active**
Min	6.9	6.9	9.6	4.8	5.4	5.8	6.0	5.8	8.9
Max	15.2	18.5	29.4	15.0	14.8	22.1	14.5	15.1	26.2
Average	**11.1**	**11.7**	**17.3**	**9.2**	**9.8**	**15.1**	**9.1**	**10.1**	**15.0**
SD	*2.4*	*3.0*	*4.6*	*2.9*	*2.8*	*5.1*	*2.3*	*2.6*	*4.7*

Statistical analyses used to investigate the rate of right and left cervical lateral flexion during active motion testing included one-way repeated measures ANOVAs for each group (Control, Experimental pre-treatment, and Experimental post-treatment). Each of the six ANOVAs tested for significant differences between the slope of cycle six and the slopes of the remaining cycles (one through five) for the following cases:

- Left-slope
    - Control
    - Experimental pre-treatment
    - Experimental post-treatment
- Right-slope
    - Control
    - Experimental pre-treatment
    - Experimental post-treatment

Statistical findings are presented in Table 48-a for the Control and Experimental groups, demonstrating that the first cycle in a trial (cycle one and cycle four) was significantly slower than the last cycle (cycle six) for right lateral flexion (right-slope) and left lateral flexion (left-slope) ($p<0.05$). Table 48 (b-g) contains the descriptive statistics for each analysis, documenting the mean, standard error, and confidence interval of each cycle.

Table 48-a. Statistical analyses for consistency of active motion testing for rate of right and left cervical lateral flexion within the Control, Experimental pre-treatment, and Experimental post-treatment groups

Group	Test	Type III Sum of Squares	df	Mean Square	F	Sig.
Control	Left-slope (Cycle 1 v. 6)	394.4	1	394.4	51.0	**0.000**
	Error	162.4	21	7.7		
Control	Right-slope (Cycle 1 v. 6)	517.2	1	517.2	31.6	**0.000**
	Error	343.6	21	16.4		
Control	Left-slope (Cycle 4 v. 6)	275.5	1	275.5	28.4	**0.000**
	Error	204.0	21	9.7		
Control	Right-slope (Cycle 4 v. 6)	431.4	1	431.4	35.4	**0.000**
	Error	255.6	21	12.2		
Pre-	Left-slope (Cycle 1 v. 6)	227.0	1	227.0	14.8	**0.002**
	Error	230.5	15	15.4		
Pre-	Right-slope (Cycle 1 v. 6)	322.5	1	322.5	17.6	**0.001**
	Error	293.9	16	18.4		
Pre-	Left-slope (Cycle 4 v. 6)	70.2	1	70.2	7.9	**0.013**
	Error	133.7	15	8.9		
Pre-	Right-slope (Cycle 4 v. 6)	106.1	1	106.1	11.4	**0.004**
	Error	148.9	16	9.3		
Post-	Left-slope (Cycle 1 v. 6)	113.6	1	113.6	8.0	**0.011**
	Error	255.1	18	14.2		
Post-	Right-slope (Cycle 1 v. 6)	464.5	1	464.5	32.2	**0.000**
	Error	260.0	18	14.4		
Post-	Left-slope (Cycle 4 v. 6)	90.3	1	90.3	5.2	**0.035**
	Error	314.0	18	17.4		
Post-	Right-slope (Cycle 4 v. 6)	341.8	1	341.8	28.6	**0.000**
	Error	215.1	18	11.9		

Table 48-b. Cycle-by-cycle descriptive statistics of right-slope for active motion within the Control group

* All values in deg/sec			95% Confidence Interval	
Cycle	Mean	Std. Error	Lower Bound	Upper Bound
1	13.3	1.0	11.3	15.3
2	17.1	1.1	14.8	19.4
3	19.1	1.1	16.7	21.4
4	13.7	1.1	11.4	16.0
5	16.8	1.1	14.6	19.0
6	18.1	1.0	16.0	20.3

Table 48-c. Cycle-by-cycle descriptive statistics of left-slope for active motion within the Control group

* All values in deg/sec			95% Confidence Interval	
Cycle	Mean	Std. Error	Lower Bound	Upper Bound
1	15.6	1.0	13.6	17.6
2	18.6	1.1	16.4	20.8
3	20.7	1.4	17.8	23.5
4	16.3	1.0	14.2	18.3
5	18.3	1.1	16.0	20.7
6	19.8	1.3	17.1	22.5

Table 48-d. Cycle-by-cycle descriptive statistics of right-slope for active motion within the Experimental group pre-treatment

* All values in deg/sec			95% Confidence Interval	
Cycle	Mean	Std. Error	Lower Bound	Upper Bound
1	11.4	1.1	9.0	13.9
2	14.7	1.6	11.2	18.1
3	15.0	1.2	12.3	17.6
4	13.3	1.2	10.7	15.9
5	15.5	1.5	12.3	18.7
6	15.8	1.2	13.2	18.4

Table 48-e. Cycle-by-cycle descriptive statistics of left-slope for active motion within the Experimental group pre-treatment

* All values in deg/sec			95% Confidence Interval	
Cycle	Mean	Std. Error	Lower Bound	Upper Bound
1	14.1	1.2	11.4	16.7
2	16.2	1.4	13.3	19.0
3	18.2	1.7	14.6	21.8
4	15.8	1.3	12.9	18.6
5	16.9	1.3	14.1	19.6
6	17.8	1.4	14.9	20.8

Table 48-f. Cycle-by-cycle descriptive statistics of right-slope for active motion within the Experimental group post-treatment

* All values in deg/sec			95% Confidence Interval	
Cycle	Mean	Std. Error	Lower Bound	Upper Bound
1	11.9	0.8	10.2	13.6
2	15.6	1.5	12.5	18.7
3	16.6	1.4	13.6	19.6
4	12.6	1.0	10.5	14.7
5	14.2	0.8	12.4	16.0
6	16.8	1.4	13.8	19.8

Table 48-g. Cycle-by-cycle descriptive statistics of left-slope for active motion within the Experimental group post-treatment

* All values in deg/sec			95% Confidence Interval	
Cycle	Mean	Std. Error	Lower Bound	Upper Bound
1	14.2	1.2	11.7	16.8
2	15.5	1.6	12.1	18.8
3	16.4	1.4	13.5	19.2
4	14.5	1.1	12.1	16.9
5	14.8	1.5	11.8	17.9
6	16.7	1.2	14.2	19.2

Statistical analyses conducted on rate of active versus passive motions included independent samples t-tests of average right-slope, left-slope, and total-slope values for the Control and both Experimental groups. The following were evaluated:

- Control
  - Ex. 2 v. Active
    - Right-slope
    - Left-slope
    - Total-slope
  - Ex. 3 v. Active
    - Right-slope
    - Left-slope
    - Total-slope
- Exp. pre-treatment
  - Ex. 2 v. Active
    - Right-slope
    - Left-slope
    - Total-slope
  - Ex. 3 v. Active
    - Right-slope
    - Left-slope
    - Total-slope
- Exp. post-treatment
  - Ex. 2 v. Active
    - Right-slope
    - Left-slope
    - Total-slope
  - Ex. 3 v. Active
    - Right-slope
    - Left-slope
    - Total-slope

Significantly reduced average rates of cervical lateral flexion for the passive motions as compared to active motions were found for all comparisons ($p \leq 0.0001$). The full set of statistical results are presented in Table 49.

Table 49. Statistical analyses for passive versus active motion testing for rate of right, left, and total cervical lateral flexion within the Control and Experimental groups

Group	Test	df	t-value	Pr > |t|
Control	Right-slope (Ex. 2 v. Act)	21	-6.6	**< 0.0001**
Control	Left-slope (Ex. 2 v. Act)	21	-7.9	**< 0.0001**
Control	Total-slope (Ex. 2 v. Act)	21	-7.5	**< 0.0001**
Control	Right-slope (Ex. 3 v. Act)	21	-6.0	**< 0.0001**
Control	Left-slope (Ex. 3 v. Act)	21	-6.0	**< 0.0001**
Control	Total-slope (Ex. 3 v. Act)	21	-6.2	**< 0.0001**
Pre-	Right-slope (Ex. 2 v. Act)	18	-5.6	**< 0.0001**
Pre-	Left-slope (Ex. 2 v. Act)	18	-5.9	**< 0.0001**
Pre-	Total-slope (Ex. 2 v. Act)	18	-6.0	**< 0.0001**
Pre-	Right-slope (Ex. 3 v. Act)	18	-5.2	**< 0.0001**
Pre-	Left-slope (Ex. 3 v. Act)	18	-5.5	**< 0.0001**
Pre-	Total-slope (Ex. 3 v. Act)	18	-5.5	**< 0.0001**
Post-	Right-slope (Ex. 2 v. Act)	18	-5.9	**< 0.0001**
Post-	Left-slope (Ex. 2 v. Act)	18	-7.5	**< 0.0001**
Post-	Total-slope (Ex. 2 v. Act)	18	-6.9	**< 0.0001**
Post-	Right-slope (Ex. 3 v. Act)	18	-4.8	**0.0001**
Post-	Left-slope (Ex. 3 v. Act)	18	-5.8	**< 0.0001**
Post-	Total-slope (Ex. 3 v. Act)	18	-5.4	**< 0.0001**

Root mean square error

The root mean square error (RMSE) values calculated between trial one and trial two of all dissected cycles combined for passive and active motions are documented in Tables 50-52. Active versus passive motion comparisons of the calculated right (all three right lateral flexions), left (all three left lateral flexions), and total (all right and left lateral flexions) RMSE of the dissected cycles combined are presented in Table 50 for the Control group, Table 51 for the Experimental group pre-treatment, and Table 52 for the Experimental group post-treatment.

Table 50. Active and passive motion comparisons in the Control group for average right, left, and total RMSE values

	Right RMSE (Deg)			Left RMSE (Deg)			Total RMSE (Deg)		
	Ex. 2	**Ex. 3**	**Active**	**Ex. 2**	**Ex. 3**	**Active**	**Ex. 2**	**Ex. 3**	**Active**
Min	1.6	1.0	1.9	0.9	0.9	1.3	1.7	1.0	1.7
Max	10.5	5.4	7.8	9.4	4.8	5.5	9.9	4.7	5.8
Average	**3.0**	**2.7**	**3.0**	**3.1**	**2.9**	**2.8**	**3.1**	**2.9**	**3.0**
SD	*1.8*	*1.1*	*1.4*	*1.7*	*1.3*	*1.1*	*1.6*	*1.0*	*1.0*

Table 51. Active and passive motion comparisons in the Experimental group pre-treatment for average right, left, and total RMSE values

	Right RMSE (Deg)			Left RMSE (Deg)			Total RMSE (Deg)		
	Ex. 2	**Ex. 3**	**Active**	**Ex. 2**	**Ex. 3**	**Active**	**Ex. 2**	**Ex. 3**	**Active**
Min	0.9	0.6	1.6	0.9	1.4	1.5	0.9	1.4	1.7
Max	4.8	5.3	7.5	7.6	5.0	7.3	5.5	4.2	6.4
Average	**2.7**	**2.8**	**3.5**	**2.7**	**3.1**	**3.3**	**2.9**	**3.0**	**3.5**
SD	*1.3*	*1.3*	*1.8*	*1.6*	*1.0*	*1.7*	*1.1*	*0.9*	*1.5*

Table 52. Active and passive motion comparisons in the Experimental group post-treatment for average right, left, and total RMSE values

	Right RMSE (Deg)			Left RMSE (Deg)			Total RMSE (Deg)		
	Ex. 2	**Ex. 3**	**Active**	**Ex. 2**	**Ex. 3**	**Active**	**Ex. 2**	**Ex. 3**	**Active**
Min	1.0	1.3	1.2	1.8	1.2	1.3	1.6	1.6	1.8
Max	4.7	12.4	17.5	7.7	5.6	5.2	6.2	8.9	12.9
Average	**2.6**	**3.1**	**4.0**	**3.1**	**2.7**	**3.1**	**2.9**	**3.1**	**3.7**
SD	*1.3*	*2.5*	*3.6*	*1.7*	*1.2*	*1.1*	*1.3*	*1.7*	*2.5*

Comparisons of passive and active average total RMSE values calculated from the dissected cycles are summarized in Table 53 for the Control, Experimental pre-treatment, and Experimental post-treatment groups. The average RMSE values calculated between trial one and trial two for the complete time series of passive and active motions are presented in Table 54 for the Control, Experimental pre-treatment, and Experimental post-treatment groups. While no

observable trends can be documented for passive and active motion comparisons of total RMSE values for the dissected cycles, it can be noted that the average RMSE values for the complete time series of active motion tests was consistently greater than passive motion tests for all groups.

Table 53. Active and passive motion comparisons for total RMSE values (degrees) of the dissected cycles in the Control, Experimental pre-treatment, and Experimental post-treatment groups

	Control			Exp. Pre-Treatment			Exp. Post-Treatment		
	Ex. 2	**Ex. 3**	**Active**	**Ex. 2**	**Ex. 3**	**Active**	**Ex. 2**	**Ex. 3**	**Active**
Min	1.7	1.0	1.7	0.9	1.4	1.7	1.6	1.6	1.8
Max	9.9	4.7	5.8	5.5	4.2	6.4	6.2	8.9	12.9
Average	**3.1**	**2.9**	**3.0**	**2.9**	**3.0**	**3.5**	**2.9**	**3.1**	**3.7**
SD	*1.6*	*1.0*	*1.0*	*1.1*	*0.9*	*1.5*	*1.3*	*1.7*	*2.5*

Table 54. Active and passive motion comparisons for the average RMSE (degrees) of the full time-series in the Control, Experimental pre-treatment and Experimental post-treatment groups

	Control			Experimental Pre-Treatment			Experimental Post-Treatment		
	Ex. 2	**Ex. 3**	**Active**	**Ex. 2**	**Ex. 3**	**Active**	**Ex. 2**	**Ex. 3**	**Active**
Min	3.6	3.4	3.2	3.0	3.0	3.8	5.3	4.1	3.4
Max	12.9	18.5	36.9	16.6	17.9	38.2	18.5	14.7	22.2
Average	**8.0**	**8.1**	**12.3**	**8.3**	**7.6**	**10.4**	**8.5**	**9.0**	**10.2**
SD	*2.5*	*3.4*	*7.6*	*3.2*	*3.5*	*8.3*	*3.8*	*3.1*	*5.7*

One-way ANOVAs with a Bonferroni was conducted on the average RMSE of the complete time series for active versus passive motions within the Control, Experimental pre-treatment and Experimental post-treatment groups, as shown in Table 55. Significantly reduced RMSE values was found for the passive motions of Examiner 2 and Examiner 3 compared to active motion tests for the complete time series within the Control group ($p \leq 0.05$).

Table 55. Statistical analyses of passive versus active motion tests for RMSE values (degrees) of the complete time series within the Control, Experimental pre-treatment and Experimental post-treatment groups

Group	Test	Mean Difference	Std. Error	95% Confidence Interval		Sig.
				Lower Bound	Upper Bound	
Control	Ex. 2 v. Act.	4.3	1.5	0.6	8.0	**0.018**
Control	Ex. 3 v. Act.	4.3	1.5	0.5	8.0	**0.020**
Pre-	Ex. 2 v. Act.	2.1	1.8	-2.3	6.6	**0.726**
Pre-	Ex. 3 v. Act.	2.8	1.8	-1.6	7.3	**0.359**
Post-	Ex. 2 v. Act.	1.7	1.4	-1.8	5.3	**0.666**
Post-	Ex. 3 v. Act.	1.2	1.5	-2.4	4.8	**1.000**

Secondary motion – axial rotation

The secondary motion, or axial rotation, that occurred at the point of maximum lateral flexion was recorded for each subject and averaged for all cycles over trial one and trial two for Examiner 2, Examiner 3, and active motion within each group. Positive axial rotation values are associated with ipsilateral lateral flexion values such that the left lateral flexion end-range was accompanied by axial rotation to the left, and right lateral flexion end-range was associated with axial rotation to the right. A negative axial rotation value indicates contralateral rotation, or axial rotation in the opposite direction as the lateral flexion performed. The secondary motion data of Examiner 2, Examiner 3, and active motion testing for the Control, Experimental pre-treatment, and Experimental post-treatment group are documented in Tables 56, 57, and 58 respectively. From the full ROM values, or the range of left and right axial rotation values that occurred between maximum left and right lateral flexions, a trend can be observed such that active motion rotation was greater than Examiner 2's rotation which was greater than Examiner 3's rotation.

Table 56. Active versus passive motion comparisons of secondary motion (axial rotation) for the Control group ("+" values indicate ipsilateral rotation and "-" values indicate contralateral rotation)

	Left End-Range (Deg)			Right End-Range (Deg)			Full ROM (Deg)		
	Ex. 2	Ex. 3	Active	Ex. 2	Ex. 3	Active	Ex. 2	Ex. 3	Active
Min	-10.7	-3.2	-1.9	-1.9	-5.7	-3.9	-3.4	-3.2	1.9
Max	23.3	22.7	27.0	21.5	21.4	28.1	40.9	37.1	47.5
Average	**10.6**	**6.9**	**10.3**	**9.1**	**8.6**	**11.5**	**19.6**	**15.4**	**21.8**
SD	*5.4*	*5.2*	*6.7*	*4.6*	*4.7*	*6.3*	*8.5*	*8.2*	*11.3*

Table 57. Active versus passive motion comparisons of secondary motion (axial rotation) for the Experimental group pre-treatment ("+" values indicate ipsilateral rotation and "-" values indicate contralateral rotation)

	Left End-Range (Deg)			Right End-Range (Deg)			Full ROM (Deg)		
	Ex. 2	Ex. 3	Active	Ex. 2	Ex. 3	Active	Ex. 2	Ex. 3	Active
Min	-6.1	-13.3	-17.0	-0.2	-4.2	-10.4	-2.3	-9.7	-24.2
Max	35.5	31.6	46.2	27.1	20.5	36.0	56.8	45.2	65.5
Average	**11.1**	**6.8**	**11.5**	**11.5**	**10.2**	**13.4**	**22.6**	**17.0**	**25.0**
SD	*8.5*	*8.4*	*11.5*	*4.8*	*4.6*	*9.6*	*11.5*	*11.5*	*19.5*

Table 58. Active versus passive motion comparisons of secondary motion (axial rotation) for the Experimental group post-treatment ("+" values indicate ipsilateral rotation and "-" values indicate contralateral rotation)

	Left End-Range (Deg)			Right End-Range (Deg)			Full ROM (Deg)		
	Ex. 2	Ex. 3	Active	Ex. 2	Ex. 3	Active	Ex. 2	Ex. 3	Active
Min	-9.0	-14.7	-10.9	-2.4	-8.2	-19.1	-4.8	-19.9	-24.6
Max	27.0	28.7	48.8	25.6	22.9	32.7	51.4	45.2	65.7
Average	**11.3**	**6.3**	**12.5**	**11.7**	**9.2**	**13.5**	**23.0**	**15.5**	**26.0**
SD	*7.5*	*8.3*	*10.8*	*5.0*	*6.0*	*10.2*	*10.9*	*12.4*	*19.0*

Statistical analyses of passive versus active average full range of secondary motions were performed on the Control, Experimental pre-treatment and Experimental post-treatment groups. The statistical tests performed included one-way ANOVAs with a Bonferroni comparing the average full ROM values for axial rotation during Examiner 2, Examiner 3, and active motion

tests. A significant difference was found between the secondary full ROM values of Examiner 3 and active motion tests within the Control group and Experimental group post-treatment as documented in Table 59.

Table 59. Statistical analyses of the average secondary full ROM (axial rotation) for comparisons of Examiner 2, Examiner 3, and active motion within the Control and Experimental groups

Group	Test	Mean Diff.	Std. Error	95% Confidence Interval		Sig.
				Lower	Upper	
Control	Ex. 2 v. Ex. 3	4.2	2.5	-1.8	10.3	**0.278**
Control	Ex. 2 v. Active	-2.4	2.5	-8.6	3.7	**1.000**
Control	Ex. 3 v. Active	-6.6	2.5	-12.6	-0.7	**0.023**
Pre-	Ex. 2 v. Ex. 3	4.2	4.4	-6.8	15.2	**1.000**
Pre-	Ex. 2 v. Active	-3.0	4.6	-14.4	8.5	**1.000**
Pre-	Ex. 3 v. Active	-7.2	4.5	-18.4	4.0	**0.348**
Post-	Ex. 2 v. Ex. 3	7.5	4.5	-3.7	18.7	**0.309**
Post-	Ex. 2 v. Active	-3.0	4.5	-14.0	8.0	**1.000**
Post-	Ex. 3 v. Active	-10.5	4.5	-21.6	0.7	**0.073**

Group Comparisons

Range of motion

The cervical lateral flexion range of motion data of trial one and trial two were averaged for Examiner 2, Examiner 3, and active motions. These data for left end-range, right end-range, and full ROM are presented in Tables 60, 61, and 62. Comparisons of average ROM values between the Control group, Experimental group pre-treatment, and Experimental group post-treatment are presented in Table 60 for Examiner 2, Table 61 for Examiner 3 and Table 62 for active motion tests. From these data, it can be observed that the range of motion of the Control group was greater than that of the Experimental group pre- and post-treatment. The average full

ROM data of the Control group, Experimental group pre-treatment and Experimental group post-treatment are summarized in Table 63.

Table 60. Control, Experimental pre-treatment and Experimental post-treatment comparisons for Examiner 2's average left end-range, right end-range, and full ROM values

	Left End-Range (Deg)			Right End-Range (Deg)			Full ROM (Deg)		
	Cont.	Pre-	Post-	Cont.	Pre-	Post-	Cont.	Pre-	Post-
Min	23.5	23.3	21.5	19.5	19.2	19.2	45.5	43.7	48.8
Max	46.1	48.6	48.4	50.7	48.3	45.3	91.9	93.2	89.9
Average	**35.5**	**33.8**	**33.7**	**35.9**	**32.4**	**33.1**	**71.4**	**66.3**	**66.8**
SD	*5.7*	*6.7*	*6.4*	*6.9*	*6.7*	*6.4*	*11.5*	*12.0*	*11.7*

Table 61. Control, Experimental pre-treatment and Experimental post-treatment comparisons for Examiner 3's average left end-range, right end-range, and full ROM values

	Left End-Range (Deg)			Right End-Range (Deg)			Full ROM (Deg)		
	Cont.	Pre-	Post-	Cont.	Pre-	Post-	Cont.	Pre-	Post-
Min	21.4	16.1	15.8	14.6	14.8	17.7	36.8	35.1	34.8
Max	44.4	40.8	43.4	46.2	42.6	47.1	87.4	82.2	89.9
Average	**33.4**	**29.6**	**30.6**	**32.7**	**28.4**	**30.4**	**66.1**	**58.0**	**61.0**
SD	*6.1*	*6.6*	*6.6*	*7.1*	*6.4*	*6.6*	*11.5*	*11.7*	*12.0*

Table 62. Control, Experimental pre-treatment and Experimental post-treatment comparisons for active motion average left end-range, right end-range, and full ROM values

	Left End-Range (Deg)			Right End-Range (Deg)			Full ROM (Deg)		
	Cont.	Pre-	Post-	Cont.	Pre-	Post-	Cont.	Pre-	Post-
Min	29.4	27.7	18.8	26.5	23.9	22.0	56.0	54.0	46.8
Max	58.0	59.4	52.2	56.8	50.2	52.0	113.6	106.0	101.1
Average	**44.3**	**39.6**	**40.6**	**43.1**	**37.3**	**38.3**	**87.4**	**77.0**	**78.9**
SD	*6.3*	*8.2*	*6.8*	*7.4*	*6.7*	*6.7*	*12.5*	*13.5*	*11.6*

Table 63. Control, Experimental pre-treatment and Experimental post-treatment comparisons for full ROM values (degrees) of Examiner 2, Examiner 3, and active motion

	Examiner 2			Examiner 3			Active motion		
	Cont.	Pre-	Post-	Cont.	Pre-	Post-	Cont.	Pre-	Post-
Min	45.5	43.7	48.8	36.8	35.1	34.8	56.0	54.0	46.8
Max	91.9	93.2	89.9	87.4	82.2	89.9	113.6	106.0	101.1
Average	**71.4**	**66.3**	**66.8**	**66.1**	**58.0**	**61.0**	**87.4**	**77.0**	**78.9**
SD	*11.5*	*12.0*	*11.7*	*11.5*	*11.7*	*12.0*	*12.5*	*13.5*	*11.6*

Statistical analyses were conducted on the average left end-range versus right end-range values within the Control group, Experimental group pre-treatment and Experimental group post-treatment. Paired samples t-tests were performed for Examiner 2, Examiner 3, and active motion as presented in Table 64. A marginally significant difference between left and right end-range values was found only for active motion testing in the Experimental group post-treatment ($p<0.10$).

Independent samples t-tests were used to evaluate differences between the average full ROM of the Control and Experimental groups for Examiner 2, Examiner 3, and active motion as presented in Table 65. Significant differences between the Control group and Experimental group pre-treatment were documented for Examiner 3 and active motion, and a significant difference between the Control group and Experimental group post-treatment was found only for active motion ($p<0.05$).

Analysis of the Experimental group pre-treatment versus post-treatment included paired samples t-tests conducted on the average full ROM values of Examiner 2, Examiner 3, and active motion as documented in Table 66. Examiner 3's data demonstrated a significant difference between the Experimental group pre-treatment and post-treatment ($p<0.05$).

Table 64. Average left versus right end-range values for Examiner 2, Examiner 3, and active motion within the Control and Experimental groups

Group	Test	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval		t	df	Sig. (2-tailed)
					Lower	Upper			
Control	Ex. 2	0.4	4.6	1.0	-1.6	2.5	0.5	21	**0.657**
Control	Ex. 3	-0.8	5.5	1.2	-3.2	1.7	-0.7	21	**0.522**
Control	Active	-1.2	4.7	1.0	-3.2	0.9	-1.1	21	**0.266**
Pre-	Ex. 2	-1.4	4.4	1.0	-3.6	0.8	-1.3	17	**0.197**
Pre-	Ex. 3	-1.1	4.8	1.1	-3.4	1.2	-1.0	18	**0.313**
Pre-	Active	-2.3	5.6	1.4	-5.2	0.6	-1.7	16	**0.109**
Post-	Ex. 2	-0.5	4.1	0.9	-2.5	1.4	-0.6	18	**0.567**
Post-	Ex. 3	-0.2	4.2	1.0	-2.2	1.8	-0.2	18	**0.832**
Post-	Active	-2.2	5.4	1.2	-4.8	0.4	-1.8	18	**0.086**

Table 65. Statistical analyses for Control versus Experimental groups' average full ROM for Examiner 2, Examiner 3, and active motion

Examiner	Test	Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Mean Diff.	Std. Error Diff.	Sig. (2-tailed)
Ex. 2	Pre- v. Control	0.0	0.855	1.5	39	5.4	3.5	**0.136**
Ex. 2	Post- v. Control	0.2	0.676	1.3	39	4.6	3.5	**0.192**
Ex. 3	Pre- v. Control	0.3	0.608	2.3	39	8.1	3.5	**0.027**
Ex. 3	Post- v. Control	0.1	0.734	1.4	39	4.8	3.6	**0.182**
Active	Pre- v. Control	0.6	0.453	2.8	39	10.9	4.0	**0.009**
Active	Post- v. Control	0.3	0.619	2.3	39	8.5	3.6	**0.025**

Table 66. Statistical analyses for the Experimental group pre-treatment versus post-treatment for the average full ROM values of Examiner 2, Examiner 3, and active motion

Examiner	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval		t	df	Sig. (2-tailed)
				Lower	Upper			
Ex. 2	-0.8	5.1	1.2	-3.2	1.7	-0.7	18	**0.508**
Ex. 3	-3.3	4.0	0.9	-5.2	-1.4	-3.6	18	**0.002**
Active	-2.5	8.3	1.9	-6.5	1.5	-1.3	18	**0.208**

Rate of motion

The rate of cervical lateral flexion data from trial one and trial two were averaged for Examiner 2, Examiner 3, and active motion tests. The average rate of left lateral flexions (left-slope), right lateral flexions (right-slope), and all lateral flexions (total-slope) are presented in Tables 67-69. Comparisons of average rate of motion values between the Control group, Experimental group pre-treatment, and Experimental group post-treatment are presented in Table 67 for Examiner 2, Table 68 for Examiner 3 and Table 69 for active motion. From these data, it can be observed that the rate of motion of the Control group was greater than that of the Experimental group pre-treatment and post-treatment. This was true for Examiner 2, Examiner 3, and active motion as demonstrated in Table 70.

Table 67. Control, Experimental pre-treatment and Experimental post-treatment comparisons for Examiner 2's average left-slope, right-slope, and total-slope values

	Left-slope (Deg/sec)			Right-slope (Deg/sec)			Total-slope (Deg/sec)		
	Cont.	**Pre-**	**Post-**	**Cont.**	**Pre-**	**Post-**	**Cont.**	**Pre-**	**Post-**
Min	6.4	4.5	5.5	7.3	5.0	6.3	6.9	4.8	6.0
Max	15.0	15.5	13.6	15.8	15.8	15.4	15.2	15.0	14.5
Average	**11.0**	**9.1**	**8.6**	**11.1**	**9.4**	**9.6**	**11.1**	**9.2**	**9.1**
SD	*2.5*	*3.0*	*2.2*	*2.5*	*2.9*	*2.4*	*2.4*	*2.9*	*2.3*

Table 68. Control, Experimental pre-treatment and Experimental post-treatment comparisons for Examiner 3's average left-slope, right-slope, and total-slope values

	Left-slope (Deg/sec)			Right-slope (Deg/sec)			Total-slope (Deg/sec)		
	Cont.	**Pre-**	**Post-**	**Cont.**	**Pre-**	**Post-**	**Cont.**	**Pre-**	**Post-**
Min	6.9	4.8	5.7	5.9	4.8	5.9	6.9	5.4	5.8
Max	18.2	15.0	14.4	18.7	15.2	16.0	18.5	14.8	15.1
Average	**12.1**	**9.8**	**10.1**	**11.4**	**9.8**	**10.1**	**11.7**	**9.8**	**10.1**
SD	*3.1*	*2.8*	*2.7*	*3.2*	*2.9*	*2.6*	*3.0*	*2.8*	*2.6*

Table 69. Control, Experimental pre-treatment and Experimental post-treatment comparisons for active motion average left-slope, right-slope, and total-slope values

	Left-slope (Deg/sec)			Right-slope (Deg/sec)			Total-slope (Deg/sec)		
	Cont.	Pre-	Post-	Cont.	Pre-	Post-	Cont.	Pre-	Post-
Min	10.0	6.4	8.9	9.1	5.2	8.1	9.6	5.8	8.9
Max	32.7	24.3	26.2	26.1	22.9	27.0	29.4	22.1	26.2
Average	**18.2**	**16.0**	**15.0**	**16.4**	**14.2**	**14.6**	**17.3**	**15.1**	**15.0**
SD	*4.9*	*5.7*	*4.7*	*4.4*	*4.8*	*4.7*	*4.6*	*5.1*	*4.7*

Table 70. Control, Experimental pre-treatment and Experimental post-treatment comparisons for total-slope values (deg/sec) of Examiner 2, Examiner 3, and active motion

	Examiner 2			Examiner 3			Active motion		
	Cont.	Pre-	Post-	Cont.	Pre-	Post-	Cont.	Pre-	Post-
Min	6.9	4.8	6.0	6.9	5.4	5.8	9.6	5.8	8.9
Max	15.2	15.0	14.5	18.5	14.8	15.1	29.4	22.1	26.2
Average	**11.1**	**9.2**	**9.1**	**11.7**	**9.8**	**10.1**	**17.3**	**15.1**	**15.0**
SD	*2.4*	*2.9*	*2.3*	*3.0*	*2.8*	*2.6*	*4.6*	*5.1*	*4.7*

Statistical analyses were conducted on average left-slope versus right-slope values within the Control group, Experimental group pre-treatment, and Experimental group post-treatment for Examiner 2, Examiner 3, and active motion in the form of paired samples t-tests. A significant difference between left and right rate of lateral flexion values was found within the Control group for Examiner 3 and active motion, within the Experimental group pre-treatment for active motion, and within the Experimental group post-treatment for Examiner 2 (Table 71).

For comparisons of the average total-slope of the Control group and Experimental group pre-treatment, independent samples t-tests were conducted for Examiner 2, Examiner 3, and active motion. Significant differences between the Control group and Experimental group pre-treatment were documented for Examiner 2 and Examiner 3 (Table 72). Analysis of the Experimental group pre-treatment versus post-treatment included paired samples t-tests

conducted on the average total-slope values of Examiner 2, Examiner 3, and active motion. No significant differences between the Experimental group pre-treatment and post-treatment were found for the average rate of cervical lateral flexion of Examiner 2, Examiner 3, or active motion.

Table 71. Statistical analyses for left versus right rate of cervical lateral flexion for Examiner 2, Examiner 3, and active motion within the Control and Experimental groups

Group	Test	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval		t	df	Sig. (2-tailed)
					Lower	Upper			
Control	Ex. 2	0.2	1.4	0.3	-0.4	0.8	0.6	21	**0.575**
Control	Ex. 3	-0.7	1.8	0.4	-1.5	0.1	-1.9	21	**0.076**
Control	Active	-1.8	2.0	0.4	-2.7	-1.0	-4.4	21	**0.000**
Pre-	Ex. 2	0.3	1.5	0.3	-0.4	1.0	0.8	18	**0.430**
Pre-	Ex. 3	0.1	1.1	0.2	-0.4	0.6	0.3	18	**0.738**
Pre-	Active	-1.7	2.6	0.6	-3.0	-0.5	-2.9	18	**0.010**
Post-	Ex. 2	1.0	0.9	0.2	0.5	1.4	4.6	18	**0.000**
Post-	Ex. 3	0.0	1.2	0.3	-0.6	0.6	0.0	18	**0.971**
Post-	Active	-0.7	1.8	0.4	-1.6	0.2	-1.7	18	**0.103**

Table 72. Statistical analyses for the Control versus the Experimental group pre-treatment average rate of total cervical lateral flexion for Examiner 2, Examiner 3, and active motion

Examiner	Test	Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Mean Diff.	Std. Error Diff.	Sig. (2-tailed)
Ex. 2	Pre- v. Control	0.9	0.346	2.2	39	1.8	0.8	**0.033**
Ex. 3	Pre- v. Control	0.3	0.585	2.1	39	1.9	0.9	**0.043**
Active	Pre- v. Control	1.4	0.247	1.4	39	2.2	1.5	**0.156**

Root mean square error

The root mean square error (RMSE) between trial one and trial two was calculated for Examiner 2, Examiner 3, and active motion testing within the Control group, Experimental group pre-treatment and Experimental group post-treatment. The RMSE values of the dissected cycles were calculated for all three cycles of right lateral flexion (right RMSE), all three cycles of left lateral flexion (left RMSE), and all six lateral flexion cycles combined (total RMSE). Comparisons of dissected RMSE values between the Control group, Experimental group pre-treatment, and Experimental group post-treatment are presented in Table 73 for Examiner 2, Table 74 for Examiner 3 and Table 75 for active motion testing. Group comparisons of the RMSE values calculated between trial one and trial two for the complete time-series are documented in Table 76 for Examiner 2, Examiner 3, and active motion.

Statistical analyses conducted included paired and independent samples t-tests comparing right RMSE and left RMSE values, RMSE values of the Control versus Experimental group, and RMSE values of the Experimental group pre-treatment versus post-treatment. No significant differences were found from the aforementioned statistical analyses.

Table 73. Control, Experimental pre-treatment and Experimental post-treatment comparisons for Examiner 2's average right, left, and total RMSE values

	Right RMSE (Deg)			Left RMSE (Deg)			Total RMSE (Deg)		
	Cont.	**Pre-**	**Post-**	**Cont.**	**Pre-**	**Post-**	**Cont.**	**Pre-**	**Post-**
Min	1.6	0.9	1.0	0.9	0.9	1.8	1.7	0.9	1.6
Max	10.5	4.8	4.7	9.4	7.6	7.7	9.9	5.5	6.2
Average	**3.0**	**2.7**	**2.6**	**3.1**	**2.7**	**3.1**	**3.1**	**2.9**	**2.9**
SD	*1.8*	*1.3*	*1.3*	*1.7*	*1.6*	*1.7*	*1.6*	*1.1*	*1.3*

Table 74. Control, Experimental pre-treatment and Experimental post-treatment comparisons for Examiner 3's average right, left, and total RMSE values

	Right RMSE (Deg)			Left RMSE (Deg)			Total RMSE (Deg)		
	Cont.	**Pre-**	**Post-**	**Cont.**	**Pre-**	**Post-**	**Cont.**	**Pre-**	**Post-**
Min	1.0	0.6	1.3	0.9	1.4	1.2	1.0	1.4	1.6
Max	5.4	5.3	12.4	4.8	5.0	5.6	4.7	4.2	8.9
Average	**2.7**	**2.8**	**3.1**	**2.9**	**3.1**	**2.7**	**2.9**	**3.0**	**3.1**
SD	*1.1*	*1.3*	*2.5*	*1.3*	*1.0*	*1.2*	*1.0*	*0.9*	*1.7*

Table 75. Control, Experimental pre-treatment and Experimental post-treatment comparisons for active motion average right, left, and total RMSE values

	Right RMSE (Deg)			Left RMSE (Deg)			Total RMSE (Deg)		
	Cont.	**Pre-**	**Post-**	**Cont.**	**Pre-**	**Post-**	**Cont.**	**Pre-**	**Post-**
Min	1.9	1.6	1.2	1.3	1.5	1.3	1.7	1.7	1.8
Max	7.8	7.5	17.5	5.5	7.3	5.2	5.8	6.4	12.9
Average	**3.0**	**3.5**	**4.0**	**2.8**	**3.3**	**3.1**	**3.0**	**3.5**	**3.7**
SD	*1.4*	*1.8*	*3.6*	*1.1*	*1.7*	*1.1*	*1.0*	*1.5*	*2.5*

Table 76. Control, Experimental pre-treatment and Experimental post-treatment comparisons for Examiner 2, Examiner 3, and active motion average complete time-series RMSE values

	Examiner 2			Examiner 3			Active Motion		
	Cont.	**Pre-**	**Post-**	**Cont.**	**Pre-**	**Post-**	**Cont.**	**Pre-**	**Post-**
Min	3.6	3.0	5.3	3.4	3.0	4.1	3.2	3.8	3.4
Max	12.9	16.6	18.5	18.5	17.9	14.7	36.9	38.2	22.2
Average	**8.0**	**8.3**	**8.5**	**8.1**	**7.6**	**9.0**	**12.3**	**10.4**	**10.2**
SD	*2.5*	*3.2*	*3.8*	*3.4*	*3.5*	*3.1*	*7.6*	*8.3*	*5.7*

Longitudinal Study Comparisons

Range of motion

Five subjects were selected from the Experimental group to participate in a 72-hour follow-up assessment. Data from these five individuals were analyzed and were termed the Longitudinal group. The cervical lateral flexion range of motion data for trial one and trial two of the Longitudinal group were averaged for Examiner 2, Examiner 3, and active motion. These data for left end-range, right end-range, and full ROM are presented in Tables 77, 78, and 79. Comparisons of average ROM values between the Longitudinal group pre-treatment, post-treatment and 72-hours post-treatment are presented in Table 77 for Examiner 2, Table 78 for Examiner 3 and Table 79 for active motion tests. From these data it can be observed that, in general, the average ROM of the subject's pre-treatment and 72-hours post-treatment was less than post-treatment for the initial test session. Differences between the average full ROMs pre-treatment and post-treatment ranged from 0.3 to 2.2 degrees, and differences between post-treatment and 72-hours ranged from 0.1 to 1.6 degrees. The average full ROM data of the Longitudinal group pre-treatment, post-treatment, and 72-hours post-treatment are summarized in Table 80.

Statistical analyses conducted included paired samples t-tests comparing the average full ROM values of the Longitudinal group pre-treatment, post-treatment, and 72-hour post-treatment for Examiner 2, Examiner 3, and active motion. No significant differences were found from the statistical tests performed.

Table 77. Longitudinal group comparisons of pre-treatment, post-treatment, and 72-hours post-treatment for Examiner 2's average left end-range, right end-range, and full ROM values

	Left End-Range (Deg)			Right End-Range (Deg)			Full ROM (Deg)		
	Pre-	**Post-**	**72 Hr**	**Pre-**	**Post-**	**72 Hr**	**Pre-**	**Post-**	**72 Hr**
Min	25.6	29.5	27.3	17.8	22.2	18.8	50.6	53.0	46.3
Max	42.2	40.9	43.5	43.4	43.2	41.0	80.7	82.1	83.8
Average	**35.1**	**35.3**	**35.4**	**32.4**	**34.4**	**32.7**	**67.5**	**69.7**	**68.1**
SD	*4.9*	*3.5*	*5.4*	*8.1*	*6.8*	*7.4*	*11.4*	*9.0*	*12.4*

Table 78. Longitudinal group comparisons of pre-treatment, post-treatment, and 72-hours post-treatment for Examiner 3's average left end-range, right end-range, and full ROM values

	Left End-Range (Deg)			Right End-Range (Deg)			Full ROM (Deg)		
	Pre-	**Post-**	**72 Hr**	**Pre-**	**Post-**	**72 Hr**	**Pre-**	**Post-**	**72 Hr**
Min	22.2	27.7	24.0	16.1	17.4	17.9	46.7	45.2	41.8
Max	42.3	40.5	39.2	43.5	43.0	42.2	79.2	82.7	78.7
Average	**32.5**	**34.0**	**31.5**	**30.9**	**30.8**	**33.2**	**63.4**	**64.8**	**64.7**
SD	*5.6*	*4.5*	*5.0*	*8.9*	*8.2*	*8.2*	*12.0*	*12.0*	*12.4*

Table 79. Longitudinal group comparisons of pre-treatment, post-treatment, and 72-hours post-treatment for active motion average left end-range, right end-range, and full ROM values

	Left End-Range (Deg)			Right End-Range (Deg)			Full ROM (Deg)		
	Pre-	**Post-**	**72 Hr**	**Pre-**	**Post-**	**72 Hr**	**Pre-**	**Post-**	**72 Hr**
Min	34.1	38.6	31.1	28.6	27.6	28.0	63.6	69.2	60.5
Max	46.6	47.7	48.2	47.9	51.4	49.4	92.5	98.0	97.1
Average	**41.9**	**42.2**	**40.0**	**39.2**	**39.3**	**41.0**	**81.1**	**81.5**	**81.0**
SD	*3.8*	*2.9*	*5.5*	*6.4*	*7.5*	*7.2*	*8.9*	*9.3*	*12.0*

Table 80. Longitudinal group comparisons of pre-treatment, post-treatment, and 72-hours post-treatment for the full ROM (degrees) of Examiner 2, Examiner 3, and active motion

	Examiner 2			Examiner 3			Active motion		
	Pre-	**Post-**	**72 Hr**	**Pre-**	**Post-**	**72 Hr**	**Pre-**	**Post-**	**72 Hr**
Min	50.6	53.0	46.3	46.7	45.2	41.8	63.6	69.2	60.5
Max	80.7	82.1	83.8	79.2	82.7	78.7	92.5	98.0	97.1
Average	**67.5**	**69.7**	**68.1**	**63.4**	**64.8**	**64.7**	**81.1**	**81.5**	**81.0**
SD	*11.4*	*9.0*	*12.4*	*12.0*	*12.0*	*12.4*	*8.9*	*9.3*	*12.0*

DISCUSSION

This section has been formatted to parallel to the *Results* section and discusses descriptive trends, statistical findings, and clinical relevancies related to *Intra-Examiner Comparisons*, *Inter-Examiner Comparisons*, *Active versus Passive Motions*, *Group Comparisons*, and *Longitudinal Study Comparisons* as well as the *Limitations & Future Work* of this study.

Intra-Examiner Comparisons

The primary objective of the intra-examiner comparisons was to investigate the consistency in the passive diagnostic motions performed by each examiner within a given subject. The consistency of passive diagnostic motions performed by Examiner 2 and Examiner 3 were assessed through data obtained on cervical lateral flexion range of motion, rate of motion, and the calculated root mean square error.

Range of motion

The data obtained for the cervical lateral flexion ROM from Examiner 2 demonstrated no statistical differences between the six cycles performed during the two trials for a given subject. The same held true for Examiner 3's data. Furthermore, the difference between the average full ROM values did not exceed three degrees across trial one and two for either examiner. This was true for all groups.

Thus, these data demonstrate that the motions produced by an examiner during a clinical assessment were consistent not only across cycles, but across trials. This intra-examiner consistency of cervical palpatory diagnostic testing has been well documented through findings from previous studies exhibiting agreement (Deboer et al., 1985, Mior et al., 1985, Stochkendahl et al., 2006, Seffinger et al., 2004). However, most studies have used Kappa scores to determine intra-examiner consistency based on the final diagnosis as opposed to objective values such as range of motion (Deboer et al., 1985, Mior et al., 1985, Stochkendahl et al., 2006, Seffinger et al., 2004).

There are potential limitations to this conclusion. For example, all of the examiners who participated in this research had over 10 years of experience and were teaching colleagues. If an array of examiners were sampled with different experience levels and different types of training this conclusion may not hold true.

Rate of motion

To recall from the *Methods* section, the rate of motion was defined as the average angular velocity from the start to the peak of a cervical lateral flexion cycle. While the difference between the average rate of cervical lateral flexion for trial one and trial two did not exceed 1.1 degrees per second for Examiner 2 or Examiner 3, statistical analyses conducted on the average rate of each cycle resulted in significant differences within a trial. Specifically, the average rate of the first cycle in a trial was significantly different than successive cycles.

For Examiner 2, the average rate of lateral flexion during cycle one of trial one and cycle one of trial two was *greater* than subsequent cycles in the trial. This indicated that on the first

cycle of each trial, Examiner 2 moved slightly faster than in following cycles. Of the six possible evaluations for trial one (right and left slopes for the Control, Experimental pre-treatment, and Experimental post-treatment groups) three demonstrated the first cycle to be faster than subsequent cycles. Additionally for trial two, four of the six evaluations showed the first cycle to be faster.

In contrast, the average rate of lateral flexion during the first cycle of a trial was *less* than subsequent cycles within a given trial for Examiner 3. The average rate of cycle one was significantly less for three of six evaluations for trial one, and two of six evaluations for trial two.

These findings suggested that the first cycle within a cervical palpatory diagnosis was conducted at a slightly different rate than the successive cycles. This was most likely because the examiners focused on acclimating themselves to an individual subject as opposed to the diagnostic cues associated with cervical dysfunction. Subjects, specifically those in pain, can often be guarded to passive motions performed by an examiner, artificially inducing tissue tensions not related to dysfunction (Seffinger and Hruby, 2007). Guarding often makes diagnoses difficult, and can result in false identification of dysfunction (Seffinger and Hruby, 2007). Also, this different rate during the first cycle allowed the examiner to become acclimated with a subject and allowed the subject a time period to become comfortable with the motion and relax during subsequent movements. This finding was also supported by Bush et al. (2010), who found trial one differed significantly from other trials; however this was based on standard error differences and not speed.

Although guarding may be a possibility, it would seem as though this effect would be reduced after the first trial within an examiner and would not be present in the following cycles.

No previous research was found during the review of literature in which the rate of passive motions was investigated for intra-examiner consistency of cervical palpatory diagnostic motions.

Root mean square error

For the calculated left, right, and total RMSE between trial one and trial two of the three dissected cycles, no statistically significant differences were found for either Examiner 2 or Examiner 3. This finding was supported across all three test groups. Since this measure documented the differences between two trials, and no statistically significant differences were found in the RMSE comparisons, it also supported the conclusion that examiners were consistent within themselves for a given subject.

Inter-Examiner Comparisons

The primary objective of the inter-examiner comparisons was to investigate the consistency in passive diagnostic motions across examiners.

Range of motion

The data obtained for the cervical lateral flexion ROM produced by Examiner 2 and Examiners 3's diagnostic assessments demonstrated a consistent trend within the Control, Experimental pre-treatment and Experimental post-treatment groups in which Examiner 2's

average ROM was greater than Examiner 3's average ROM. The differences between the average full ROM values for Examiner 2 and Examiner 3 were 5.3, 8.3, and 5.8 degrees for the Control, Experimental group pre-treatment, and Experimental group post-treatment respectively. Statistical analyses demonstrated that the average right end-range, left end-range, and full ROM values of Examiner 2 were significantly greater than Examiner 3 within the Experimental group pre-treatment only, as documented in Table 30.

These findings demonstrated that the examiners moved individuals through different ranges of motion. Specifically, this indicated that the examiners were makings their diagnostic assessment at different end-points. These data demonstrated that the variability between examiners was more predominant in people with pain and/or cervical dysfunction prior to treatment. While differences between the passive ROM values for each examiner were observed in healthy individuals (Control group) and subjects who had just received treatment (Experimental post-treatment), these differences lacked statistical significances and were not as substantial as the Experimental group pre-treatment.

Rate of motion

Differences between passive cervical diagnostic motions for Examiner 2 and Examiner 3 were also documented for the rate of motion values; Examiner 3 moved at a slightly greater average angular velocity than Examiner 2. The differences between the average rates of lateral flexion during all cycles (total-slope) of Examiner 3 and Examiner 2 were 0.7, 0.6, and 1.0 degrees per second for the Control, Experimental pre-treatment, and Experimental post-treatment groups respectively. Statistical analyses demonstrated significant differences between the

average rate of left lateral flexions for all groups and the average rate of all lateral flexions for the Experimental group post-treatment, as presented in Table 34.

The difference between the rates of passive motions performed by each examiner again demonstrated that there was variability in the standard cervical palpatory diagnostic procedures performed by highly practiced physicians. The average rate of left lateral flexions was significantly greater for Examiner 3 in comparison to Examiner 2 for all groups, but not during right lateral flexions.

The significantly different rates of lateral flexions performed between examiners in the Experimental group post-treatment suggested different diagnostic approaches to subjects that were previously diagnosed and treated. Examiner 3 moved subjects to a greater range of motion at a quicker rate in both directions during the post-treatment diagnoses. In contrast, Examiner 2 remained consistent in the ranges of motion performed pre-treatment and post-treatment but at a slower overall rate post-treatment. This could be attributed to the fact that Examiner 2 treated the subjects and therefore investigated the diagnostic cues near the end-range values with more care post-treatment to determine if the treatment applied to the region was successful.

Inconsistency between the cervical mobility assessments performed by different examiners has been well documented throughout previous studies (Deboer et al., 1985, Mior et al., 1985, Pool et al., 2004, Seffinger et al., 2004, Stochkendahl et al., 2006). However, as with intra-examiner comparisons, most of the previous investigations of inter-examiner consistency were analyzed through Kappa scores of subjective diagnostic measures instead of objective data (Deboer et al., 1985, Mior et al., 1985, Seffinger et al., 2004, Stochkendahl et al., 2006). Studies by Stochkendahl et al. (2006), Mior et al.(1985), DeBoer et al. (1985), and Pool et al. (2004)

found poor levels of inter-examiner agreement through Kappa scores. These inter-examiner differences in diagnoses could have been found because assessments were being made by each examiner at different end-points. To recall, cervical palpatory diagnoses were based upon magnitude and symmetry of motion as well as the tissue texture and resistance at end-range. An eight degree difference between examiners ROMs, as seen in the Experimental group pre-treatment, could result in examiners making diagnoses based upon motion symmetry, tissue texture and resistances at different points in a subject's motion. This different assessment point may produce increased resistance, yielding a difference in symmetry and texture, thus resulting in different diagnoses.

Active versus Passive Motion

Investigations of the differences between the passive diagnostic motions performed by Examiner 2 and Examiner 3 to active motions were assessed through lateral flexion range and rate of motion, the calculated root mean square errors, and secondary (axial rotation) range of motion.

Range of motion

From the data obtained on cervical lateral flexion range of motion, it was shown that the average ranges of motion achieved during active motions were statistically greater than passive motions (Table 43). This was observed within the Control, Experimental pre-treatment, and Experimental post-treatment groups, with average active full ROM over ten degrees greater than

Examiner 2's average full ROM and over seventeen degrees greater than Examiner 3's average full ROM. The data obtained on secondary (axial rotation) range of motion demonstrated a similar trend with the average axial rotation full ROM for active motions over two degrees greater than Examiner 2's average secondary full ROM and over six degrees greater than Examiner 3's average secondary full ROM. Statistical analyses found that the average secondary full ROM of active motions were significantly greater than the passive motions performed by Examiner 3 for the Control and Experimental group post-treatment, as exemplified in Table 59.

The finding that active motions produced greater cervical ROMs was contradictive to most previously published results (Dvorak et al., 1992, Wong and Nansel, 1992, Christensen and Nilsson, 1998, Lantz et al., 1999, Chen et al., 1999, Jordan, 2000, Castro et al., 2000). Wong and Nansel (1992) reported average passive cervical ROM values greater than active motion values. Castro et al. (2000) and Dvorak et al. (1992) both documented similar findings with passive motion tests that resulted in larger ROM values and smaller standard deviations than active motions. In comparison, this study produced findings that passive motion tests resulted in smaller ranges of motion and smaller standard deviations than active motions. However, when evaluating the lateral flexion and axial rotation angles coupled together, Malmström et al. (2006) and Jordan et al. (2003) cited that larger coupled axial rotation was accompanied by larger primary lateral flexion. For this study, the active motion instructions presented to the subjects did not include specific instructions requiring the subjects to conduct all motions within the primary motion plane (frontal plane). This resulted in subjects performing larger secondary motions (axial rotation) than achieved during passive tests. This allowed subjects to alter the anatomical orientation of their vertebrae through axial rotation, artificially increasing their performance range and thus the primary ROMs achievable due to anatomical geometric restrictions.

This could furthermore be used to explain differences between the average lateral flexion ROMs of Examiner 2 and Examiner 3, following the trend of increased lateral flexion with increased axial rotation.

Rate of motion

A cycle-by-cycle statistical analysis demonstrated that the first cycle within an active motion trial was significantly different than the following cycles in terms of the average speed of movement. As shown in Table 48 for the active motion tests, the average rate of left and right lateral flexion during the first cycle of a trial was significantly *slower* than the following two cycles in a trial for the Control, Experimental pre-treatment, and Experimental post-treatment ($p<0.05$). This demonstrated that the participants may have been more focused at the start of the trial, and as it progressed they became less focused and more comfortable, therefore speeding up the movement.

Comparing the data obtained on the rate of cervical lateral flexion for *active and passive* motions, it was shown that average rate of active motions were approximately five degrees per second greater than passive motions performed by Examiner 2 or Examiner 3 (Table 47). Statistical analyses presented in Table 49 demonstrated that the average rate of left lateral flexion (left-slope), right lateral flexion (right-slope) and all lateral flexions (total-slope) were significantly greater during active motions for the Control and Experimental groups. While published literature was not available for comparison, some inferences were made. Since the subjects were comfortable with their limitations of cervical movement and did not assess their own dysfunction during the movement, their lateral flexions during active motions were less

inhibited and therefore could be performed more quickly. In addition, the examiners were blinded to whether the participants were in pain, and proceeded at a slower rate as they conducted the diagnosis so they did not move any subject too quickly and cause pain.

Root mean square error

While there were no discernible differences between active and passive motions for the calculated RMSE values of the dissected cycles, differences were documented for the calculated RMSE values of the complete time series within all groups. Statistical analyses found the average calculated RMSE of the complete time series to be greater for active motions in comparison to the passive motions performed by Examiner 2 or Examiner 3 within the Control group only.

The reason this significant difference was only observed for the RMSE of the complete time series, and more specifically within the Control group, was because of the fast rate in which active motions were performed by subjects. Since the calculation of RMSE values for the complete time series was based upon the differences of lateral flexion values sampled at specific times within the normalized time series of each trial, if the overall rate in which the trials were performed differed by a large amount then the possibility of comparing lateral flexions at substantially different portions of a lateral flexion cycle caused the RMSE values to be higher. For example, if the second trial of an active motion evaluation within a subject was performed at a much faster rate than the first, then sampled lateral flexion values at the same time point in the normalized time series of each trial may have resulted in a comparison of a lateral flexion value associated with the start of a cycle to a value near the peak of a cycle. This circumstance was not

as evident within the RMSE values of the dissected cycles because the time series for each cycle was normalized such that the start and peak of each cycle was the same time value for each trial. While this finding did not suggest any significant clinical relevancies, it demonstrated the limitations and potential concerns for the use of calculated RMSE values in the evaluation of clinical diagnostic motions.

Group Comparisons

The groups contained within this study included the Control group, Experimental group pre-treatment and Experimental group post-treatment. These groups were evaluated for symmetry of motion (left versus right) within each group, as well as for differences across groups.

Within groups: Range of motion

Recall from the *Methods* section, based upon the subject screening inclusion criteria, it was required that participants in the Control group exhibited left and right range of motion symmetry as determined by Examiner 1, while inclusion in the Experimental group required a VAS of three or greater.

From the data obtained on lateral flexion ranges of motion, it was shown that the average difference between left and right end-range values was greater for active motions in comparison to passive motions. In addition, the Experimental group pre-treatment had larger difference values of average left and right end-range values than the Control group or Experimental group

post-treatment. Statistical analyses of left versus right lateral flexion end-range values found a marginally significant difference for active motions within the Experimental group post-treatment, ($p<0.10$). The average motion asymmetry for active motions was slightly larger for the Experimental group pre-treatment in contrast to the Experimental group post-treatment; however the higher variability in the pre-treatment group resulted in a lack of statistical significance. For passive motion tests, the largest difference between average left and right lateral flexion end-range values was observed within the Experimental group pre-treatment with a reduction in the average difference following treatment.

For passive motions, the Control group exhibited the lowest standard deviations and for active motions the Control group exhibited a lower standard deviation than the Experimental group pre-treatment but not post-treatment. Findings on range of motion symmetry within the Control group supported the results of the subject screening process, in that the Control group did not demonstrate significant differences between left and right motions, producing the lowest difference values between left and right lateral flexions for both active and passive motions.

Furthermore, these data demonstrated that groups of individuals in pain had a larger range of motion asymmetry which could be reduced through manual medicine treatment. This reduction in asymmetry post-treatment was likely due to the muscle energy technique used to reduce tissue tension in portions of the cervical region that inhibited motion, thus extending the ranges of motion on the affected side. One potential reason for a lack of significant differences in motion asymmetry in the Experimental group was that some of the participants showed reduced ranges of motions to the right while other exhibited reduced ranges of motion to the left, ultimately reducing the mean difference of left and right end-range values. Previous studies have

not investigated variability in kinematic range of motion asymmetries between healthy and affected groups.

Within groups: Rate of motion

From the data obtained on rate of left and right lateral flexions, mixed results on motion asymmetry within groups were observed. While no consistent trends were found between the the average rates of left and right lateral flexions, significant differences were documented for Examiner 3 and active motion within the Control group, active motion within the Experimental group pre-treatment, and Examiner 2 within the Experimental group post-treatment.

Within groups: Root mean square error

There were no asymmetries noted between left and right RMSE values for the dissected cycle for Examiner 2, Examiner 3, and active motion for any group.

Across groups: Range of motion

From the data obtained for the lateral flexion ranges of motion during Examiner 2, Examiner 3, and active motion evaluations it was shown that the ROM of the Control group was greater than the Experimental group post-treatment which was greater than the Experimental group pre-treatment (Table 63). The statistical analyses (Table 65) documented significant differences between the average full ROM values of the Control and Experimental pre-treatment

groups for Examiner 3 and active motions, and the Control and Experimental post-treatment groups for active motions only.

These findings demonstrated that the average lateral flexion ROM of the Control group was substantially greater than the Experimental group. This was strongly supported through previous studies that documented reduced cervical ROMs in groups of individuals that exhibited cervical dysfunction in comparison to healthy individuals (Dall'Alba et al., 2001, Prushansky et al., 2006, Grip et al., 2007, Bush et al., 2010, Johnston et al., 1985). Although the effects of manual treatment on cervical dysfunction have been documented by several studies as an increase in cervical ROM post-treatment (Cleland et al., 2005, Cleland et al., 2007, Burns and Wells, 2006, Fernandez-de-las-Penas et al., 2007), a positive effect of treatment was only observed in this study for Examiner 3's diagnostic movements. It was likely that a significant increase in lateral flexion ROM post-treatment was only observed in Examiner 3 due to a decrease in axial rotation ROM. In contrast, Examiner 2 and active motions demonstrated an insignificant increase in lateral flexion but showed an increase in axial rotation ROM post-treatment. This increase in secondary motion could have masked the effects of treatment observed in the primary motions performed by Examiner 2 and active motions.

Across groups: Rate of motion

The data obtained on the rate of lateral flexion demonstrated that the Control group moved at a faster rate than the Experimental group pre-treatment and post-treatment, but there were no differences in rate of motion between the Experimental group pre-treatment and post-treatment. Active and passive motions were performed at a rate of approximately two degrees

per second faster within the Control group compared to the Experimental group pre-treatment and post-treatment. Statistical analyses found a significant difference between the Control and Experimental group pre-treatment for the average rate of all lateral flexions. While the differences between the average rates of the Control and Experimental group post-treatment were just as large for Examiner 2, Examiner 3, and active motions, the variability of values obtained for the Experimental group post-treatment were greater than those obtained pre-treatment.

Findings on rate of motion suggested that healthy individuals were able to perform cervical motions at a greater rate than individuals in pain. Furthermore, passive motions were performed at a significantly greater rate on healthy individuals in contrast to those in pain who had not received treatment, most likely because the affected subjects were slightly guarded and the soft tissues associated with cervical mobility had greater tension on the affected side(s). These findings also demonstrated that manual treatment did not affect the rate at which an evaluation was performed.

It should be noted that the examiners were blinded to the group assignment of the participant, so the fact that the data showed differences in the passive movement rates of healthy subjects versus those in pain further enhanced the efficacy of those palpatory assessments. Examiners were detecting differences in the affected groups of individuals, which were expressed by movements at different rates.

Longitudinal Study Comparisons

To recall, the Longitudinal group consisted of five subjects selected from the Experimental group who participated in a 72-hour follow-up assessment. These five individuals

were investigated for immediate and long-term (72-hours) effects of treatment. While statistical analyses of these data produced no significant findings, a trend was observed in which the Longitudinal group post-treatment had a slightly larger average full ROM than pre-treatment or 72-hours post-treatment.

For passive motion tests performed by Examiner 2 and Examiner 3, the average full ROM data followed the trend that post-treatment was greater than 72-hours post-treatment which was greater than the pre-treatment assessment. This suggested that the effects of a single manual treatment were immediate, but diminished over time. Average differences between post-treatment and pre-treatment average full ROM values were 1.4 and 2.2 degrees for Examiner 3 and Examiner 2 respectively. For active motions, the trend was followed in which the average full ROM values were greater post-treatment than pre-treatment or 72-hour post-treatment. However, differences in average active full ROM values between test sessions never exceeded 0.5 degrees, suggesting that the effects of treatment were less apparent during active motion evaluations, or may have been a result of the additional rotation permitted during active motions.

Although these trends observed were not supported through statistical analyses, likely due to a small sample size and small magnitudes of change, similar findings have been documented by other researchers. Fernandez-de-las-Penas et al. (2007) found a trend towards an increase in active cervical ROM immediately and 48 hours post HVLA treatment in a group of 70 patients with neck pain that was not supported through statistical findings. The Fernandez-de-las-Penas et al. (2007) study suggested that the effects of a single manual treatment had a positive effect on the achievable cervical ROMs that was immediate but reduced with time.

Limitations & Future Work

The technique of cervical palpatory diagnosis included evaluations of ranges and symmetry of cervical motions, tissue texture characteristics, and tissue resistances at the end-ranges of motion. While the investigations of cervical range and symmetry of motion were possible through the kinematic data obtained in this study, the tissue resistances and associated forces applied by the examiner were not analyzed in this study. The addition of force data may further strengthen trends observed in the kinematic data, but not confirmed through statistical analyses. For example, an examiner may have moved a subject in symmetric motions and based the diagnosis on asymmetries in tissue resistances at left and right end-ranges. In the current study, the kinematics would have signified healthy cervical motion (based upon symmetry) although the examiner diagnosis would have indicated that the individual demonstrated signs of cervical dysfunction. Quantification of the forces applied during the palpatory assessment may help evaluate changes in tissue resistance, and allow for further objectification of parameters essential to diagnosis of cervical dysfunction. Future studies aimed at quantifying the passive diagnostic motions conducted on the cervical spine should include kinetic measures, so that evaluations can be based upon both the kinematic cervical motions and the tissue resistance at end-ranges.

This study was also limited by the prescribed protocol for active motions. Cervical ranges of active motion in this study produced results that contradicted results from previously published literature. Specifically, other research found active lateral flexion ranges of motion to be significantly less than passive motions, while for this work the opposite was true. Future studies of active motion should require participants to maintain lateral flexion motion in the frontal plane. The lack of instruction regarding out of plane motion could have resulted in

uncontrolled coupled axial rotations that were larger than the axial rotations produced during passive motion tests. Similarly, in future studies coupling of the motions should be highly controlled.

An obstacle encountered during this study was the organization and implementation of a longitudinal study. Organization of a study that required practicing osteopathic physicians to attend five separate testing dates each requiring two to five hours of their time, posed a challenge. Furthermore, recruiting five subjects who were all experiencing neck pain and scheduling them for two separate testing dates over a 72-hour time period that coincided with the physicians' availability required significant effort. To facilitate future longitudinal studies, testing should be conducted in conjunction with the examiners' and patients' clinical schedules. Ultimately, this would allow for multiple longitudinal testing dates involving a larger subject pool, with decreased scheduling conflicts.

CONCLUSIONS, FUTURE IMPLICATIONS, & SUMMARY OF FINDINGS

The purpose of this study was to quantify motions of a standard manual medicine cervical diagnostic procedure, as well as the effects of manual treatment, through kinematic measures. Previous literature has demonstrated a lack of objective data obtained to investigate osteopathic palpatory diagnosis and treatment techniques. Much of the previous research conducted on intra- and inter-examiner reliability of diagnosis, as well as the effects of treatment, has been based upon subjective measures and analyzed through Kappa scores. Furthermore, no previous research has evaluated intra- and inter-examiner reliability, active versus passive motions, within and across group comparisons, and the effects of treatment all through a single data set, as done in this research study. This chapter will discuss *Conclusions*, *Future Implications*, and a *Summary of Findings* based upon the objective data obtained through this study.

Conclusions

Based upon the findings presented in the *Discussions* chapter, several conclusions could be derived. Specifically, the objective kinematic data obtained through this study produced significant findings associated with the palpatory cervical diagnosis technique and active motion evaluations, with support through literature.

This study demonstrated that objective measures in the form of 3D kinematic data were successful in characterizing passive and active motion evaluations. Furthermore, these data were effective in identifying differences between patient groups, differences between examiners' motions, and consistency in the diagnostic motions within an examiner. In contrast, these kinematic measures alone were not able to demonstrate significant differences between pre- and

post-treatment in most of the evaluations. While Examiner 3 demonstrated a significant effect of manual treatment, this trend did not produce statistically significant results for Examiner 2 or active motion evaluations. Kinematics alone were not sufficient in capturing significant effects of treatment, both immediately and 72-hours post-treatment. In addition, active motion evaluations were successfully quantified through 3D kinematic measures, and demonstrated the capability to identify differences between groups, as well as differences between subject induced movements and passive motions performed by examiners.

Many of these findings, derived from kinematic data, were also paralleled through conclusions made in other studies that primarily collected only subjective information. Specifically, conclusions associated with intra- and inter-examiner reliability of diagnosis, healthy versus pain groups, and the effects of manual treatment were supported through previous studies. The inclusion of objective data coupled with subjective information in future studies will produce a more robust data set, improve the repeatability of data, and allow for detailed comparisons of manual techniques within and across examiners. The objective results and findings of this study are essential to advance the understanding and ability to conduct comparative research related to manual diagnosis and treatment techniques.

Future Implications

Biomechanical measures, such as motions and forces, have the potential to be used as a means to establish a reference and associated procedures for teaching a cervical palpatory diagnostic technique. This technique could be implemented as a ‘gold standard’ for osteopathic cervical diagnosis, which could be used by instructors as the basis for teaching and evaluating

medical students. For example, in the teaching process, an instructor could move a patient to a position, that position and the force applied to the subject could be objectified, and the cues felt to determine a dysfunction identified. The students could then move the same patient to the identical position using the same force and feel the cues described by the instructor. In other words, objective measures could be used as a biofeedback mechanism to evaluate the performance of a student during an osteopathic diagnosis technique. Ultimately, these objective biomechanical measures could be used to normalize the standards associated with the manual diagnosis technique, increasing the effectiveness and consistency of teaching and implementing the techniques.

Summary of Findings

The data obtained during this study were used in six primary evaluations, resulting in the several findings. These findings were thoroughly discussed in the *Results* and *Discussion* chapters. Below, a summary in the form of a list is provided for the convenience of the reader.

1. Consistency of motion patterns during the manual diagnostic motion within an examiner.
    a. Examiners were highly consistent within themselves for cervical ranges of motion achieved during passive lateral flexions for a given subject.
    b. The rate, or angular velocity, in which an examiner performed passive lateral flexions was different for the first cycle of a trial compared to the following two cycles.
        i. Examiner 2 had a *faster* rate in the first cycle of a trial.

ii. Examiner 3 had a *slower* rate in the first cycle of a trial.

2. Consistency of motion patterns during the manual diagnostic motion across examiners.
    a. Examiners *did not* perform passive cervical lateral flexions through the same ranges of motion. Greater inter-examiner differences occurred during diagnosis of individuals in pain prior to treatment.
        i. Examiner 2 had larger average lateral flexion ranges of motion than Examiner 3.
    b. Examiners *did not* perform passive cervical lateral flexions at the same rate of motion. Greater inter-examiner differences occurred during diagnosis of individuals in pain post-treatment.
        i. Examiner 3 had an average faster rate of lateral flexion than Examiner 2.
3. Differences between cervical lateral flexion conducted passively by an examiner and actively by the subject.
    a. The ranges of motion achieved during active motions were greater than passive motion tests performed by Examiners 2 or 3.
        i. The average primary (lateral flexion) ROM of active motions were greater than the average lateral flexion ROM of Examiner 2 or Examiner 3.
        ii. The average secondary (axial rotation) ROM of active motions were greater than the average axial rotation ROM of Examiner 2 or Examiner 3.
            1. Due to the geometric orientation of the vertebral column, the uncontrolled, larger axial rotations performed during active motions allowed for less restriction of lateral flexion and therefore greater ROMs.

b. Similar to passive motion tests, the first cycle in an active motion trial was performed at a different rate than the following cycles.
    i. During active motions, the first cycle was *faster* than the following two cycles in a trial.
c. The rate in which lateral flexions were performed was greater during active motions in comparison to the passive motions performed by Examiner 2 or Examiner 3.
d. The calculated RMSE of the dissected cycles did not express differences between active and passive motion evaluations, but did for the RMSE of the complete time series.
    i. The calculated RMSE of the complete time series was greater for active motion in comparison to passive motion tests.

4. Differences in kinematic patterns between individuals free of neck pain and individuals experiencing neck pain.
    a. Symmetry of left and right lateral flexion ranges of motion was different in healthy and pain groups.
        i. The Control group demonstrated no differences between left and right end-range values.
        ii. The Experimental group demonstrated a larger difference between left and right end-range values.
    b. Individuals free of neck pain had a larger cervical ROM than individuals experiencing neck pain.

        i. The Control group had a greater average lateral flexion ROM in comparison to the Experimental group.
    c. Individuals free of neck pain moved at a faster rate during active and passive motion evaluations in comparison to those experiencing neck pain.
        i. The Control group moved at a faster rate during passive and active lateral flexions than the Experimental group.
5. Differences in kinematic patterns between subjects pre- and post- manual treatment.
    a. The effects of manual treatment were minimal when evaluated through active and passive motion tests.
        i. Only Examiner 3 demonstrated a significant increase in lateral flexion ROM following treatment.
6. Differences in kinematic patterns between pre-treatment, post-treatment, and a 72-hour post-treatment for a subset of subjects.
    a. Trends in the data of manual treatment demonstrated an immediate increase in lateral flexion ROM that was not sustained during the 72-hour follow-up.

APPENDICES

A1. Visual-Analog Scale (VAS) for Neck Pain

A visual analogue scale (VAS) will be used to assess our subject's estimate of pain at the time of the experiment.
VAS scales have been proven to be effective for measuring pain, especially when they are anchored by word descriptors.
In our experiment, subjects will be requested to mark the point on the line they feel represents their perception of their current pain status.

Visual Analogue Pain Scale

Date_____

Time: _____

How severe is your pain today? Please circle a number on the line to indicate your current level of pain specifically in your head, neck and shoulder region.

No pain |0-----1-----2-----3-----4-----5-----6-----7-----8-----9-----10|Very severe pain

A2. Neck Pain and Disability Scale (NPDS)

1. How bad is your pain today? Score

0|____:____|____:____|____:____|____:____|____:____|5 _____
NO PAIN MOST SEVERE PAIN

2. How bad is your pain on the average?

0|____:____|____:____|____:____|____:____|____:____|5 _____
NO PAIN MOST SEVERE PAIN

3. How bad is your pain at its worst?

0|____:____|____:____|____:____|____:____|____:____|5 _____
NO PAIN CANNOT TOLERATE

4. Does your pain interfere with your sleep?

0|____:____|____:____|____:____|____:____|____:____|5 _____
NOT AT ALL CAN'T SLEEP

5. How bad is your pain with standing?

0|____:____|____:____|____:____|____:____|____:____|5 _____
NO PAIN MOST SEVERE PAIN

6. How bad is your pain with walking?

0|____:____|____:____|____:____|____:____|____:____|5 _____
NO PAIN MOST SEVERE PAIN

7. Does your pain interfere with driving or riding a car?

0|____:____|____:____|____:____|____:____|____:____|5 _____
NOT AT ALL CAN'T DRIVE OR RIDE

8. Does your pain interfere with social activities?

0|____:____|____:____|____:____|____:____|____:____|5 _____
NOT AT ALL ALWAYS

9. Does your pain interfere with recreational activities?

0|____:____|____:____|____:____|____:____|____:____|5 _____
NOT AT ALL ALWAYS

A2. (cont'd)

10. Does your pain interfere with work activities?

0|____:____|____:____|____:____|____:____|____:____|5 _____
NOT AT ALL CAN'T WORK

11. Does your pain interfere with your personal care (eating, dressing, bathing, etc.)?

0|____:____|____:____|____:____|____:____|____:____|5 _____
NOT AT ALL ALWAYS

12. Does your pain interfere with your personal relationships (family, friends, sex, etc.)?

0|____:____|____:____|____:____|____:____|____:____|5 _____
NOT AT ALL ALWAYS

13. How has your pain changed your outlook on life and the future (depression, hopelessness)?

0|____:____|____:____|____:____|____:____|____:____|5 _____
NO CHANGE COMPLETELY CHANGED

14. Does pain affect your emotions?

0|____:____|____:____|____:____|____:____|____:____|5 _____
NOT AT ALL COMPLETELY

15. Does your pain affect your ability to think or concentrate?

0|____:____|____:____|____:____|____:____|____:____|5 _____
NOT AT ALL COMPLETELY

16. How stiff is your neck?

0|____:____|____:____|____:____|____:____|____:____|5 _____
NOT STIFF CAN'T MOVE NECK

17. How much trouble do you have turning your neck?

0|____:____|____:____|____:____|____:____|____:____|5 _____
NO TROUBLE CAN'T MOVE NECK

18. How much trouble do you have looking up or down?

0|____:____|____:____|____:____|____:____|____:____|5 _____
NO TROUBLE CAN'T LOOK UP OR DOWN

A2. (cont'd)

19. How much trouble do you have working overhead?

0|____:____|____:____|____:____|____:____|____:____|5 _____
NO TROUBLE CAN'T WORK OVERHEAD

20. How much do pain pills help?

0|____:____|____:____|____:____|____:____|____:____|5 _____
COMPLETE RELIEF NO RELIEF

TOTAL _____

A3. Lifestyles Questionnaire

CONFIDENTIAL

Lifestyle Questionnaire

Please be as thorough and accurate as possible when answering the following questions. If anything is unclear, please ask the test administrator for clarification on the day of testing.

1. What is your current age? _____yrs, measurement of height___ft.___in,
measurement of weight _____ lbs. Male Female (circle one)

2. Are you currently under medical care? Yes ____, No _____

Explain:_____

3. Have you been injured recently in the head/ neck region?

Yes____ No _____

How long ago? _____

Is it a reoccurring pain/injury?_____If so, how often?_____

Are you under current treatment for this condition? Yes___ No___

Who is your current treating physician?_____

Has this condition impaired your daily activities? Yes___ No___

Explain: _____

4. Have you experienced any back or neck pain today? Yes___,No ____

Do you know the cause?_____

5. Are you currently taking any pain medications?

Yes _____, No_____

If so, which medication(s)_____

_____

What are the medications for?_____

A3. (cont'd)

6. Are you right_____ or left _____ handed?

7. Are you pregnant? Yes ___No ___
(If the subject is pregnant, she may be excused from the testing.)

A4. Subject Questionnaire Responses

Subject	Group	Age	Sex	Height (m)	Weight (kg)	Pre-Test VAS/10	Post-Test VAS/10	NDPS/100
4	Cont.	22	M	NR	NR	0	0	12
5	Cont.	22	F	1.68	56.7	0	0	1
27	Cont.	23	M	1.73	69.9	0	0	7
41	Cont.	22	F	1.70	72.6	0	0	0
46	Cont.	18	M	1.70	68.0	0	0	0
51	Cont.	20	NR	1.83	NR	0	0	13
56	Cont.	18	M	1.88	75.8	0	0	0
59	Cont.	18	F	1.57	54.4	0	0	0
63	Cont.	18	M	1.78	74.8	0	0	6
67	Cont.	19	M	1.93	90.7	0	0	8
68	Cont.	18	M	1.73	72.6	0	0	4
69	Cont.	18	M	1.88	80.3	0	0	0
77	Cont.	18	M	1.78	72.6	0	0	0
79	Cont.	23	F	1.57	49.9	0	0	0
83	Cont.	22	F	1.55	56.7	0	0	1
85	Cont.	21	M	1.73	90.7	0	0	0
88	Cont.	18	M	1.85	77.1	0	0	0
90	Cont.	22	M	1.80	108.4	0	0	1
96	Cont.	20	F	1.70	77.1	0	0	0
106	Cont.	21	M	1.80	70.3	0	0	3
111	Cont.	19	M	1.75	86.2	0	0	0
117	Cont.	18	NR	1.78	74.8	0	0	0
6	Exp.	21	M	1.91	94.4	8	7	74
9	Exp.	18	M	1.80	74.8	5	3	56
12	Exp.	21	M	1.88	79.4	4	2	15/50
14	Exp.	18	M	1.78	70.3	5	4	31
23	Exp.	20	F	1.55	47.6	4	2	35
25	Exp.	37	F	1.73	94.4	3	2	77
54	Exp.	27	M	1.85	99.8	6	6	73
55	Exp.	43	M	1.80	86.2	4	4	66
57	Exp.	22	M	1.83	90.7	3	4	25
70	Exp.	21	M	1.83	63.5	3	2	29
72	Exp.	53	M	1.68	59.9	7	6	58
80	Exp.	22	M	1.80	68.0	3	1	21.5
84	Exp.	20	M	1.68	108.9	3	2	12.5
91	Exp.	21	F	1.63	61.2	6	4	54.5
95	Exp.	38	F	1.52	120.7	3	1	24
98	Exp.	18	M	1.83	65.8	3	4	53.5
112	Exp.	18	F	1.57	44.0	7	7	56
115	Exp.	21	M	1.80	83.9	7	7	28
125	Exp.	63	M	1.96	104.3	4	5	70

NR = Not Reported

A5. Measurements of Qualysis Accuracy

The Qualysis six-camera motion capture system was assessed for measurement accuracy through the use of three rigid linear "wands" with a passive marker attached to each end and a right triangle with a passive marker attached to each vertex. Accuracy of the Qualysis motion capture system was determined through a comparison of the manually measured data to the mean and standard deviation of values obtained from the motion capture system.

	Manual Measures	Qualysis Measures	
		Average Mean	Average SD
Wand 1 (mm)	173	173.6	0.7
Wand 2 (mm)	176	176.2	1.0
Wand 3 (mm)	156	156.9	1.3
Angle AB (deg)	90	90.3	0.8
Angle AC (deg)	45	44.9	0.4
Angle CB (deg)	45	44.9	0.6

A6. Ranges of Lateral Flexions (Primary Motions)

			Right End Range Values (degrees)						Left End Range Values (degrees)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
4	Ex. 2	Cont.	30.2	32.8	29.4	29.3	29.8	29.1	27.7	32.6	28.3	24.6	27.7	29.3
4	Ex. 3	Cont.	24.2	28.8	28.3	24.4	26.3	26.4	22.9	23.2	24.3	23.0	26.1	31.0
4	Active	Cont.	46.8	46.6	48.7	41.1	46.6	47.6	43.6	43.9	44.6	41.6	42.8	44.3
5	Ex. 2	Cont.	48.5	45.2	44.3	46.0	47.9	44.2	40.5	42.0	44.4	44.2	46.9	46.4
5	Ex. 3	Cont.	39.0	33.5	37.8	36.7	40.1	41.0	35.5	35.7	39.0	43.3	44.3	41.3
5	Active	Cont.	52.1	53.4	54.8	53.8	57.2	56.4	56.0	56.0	56.1	55.8	58.5	59.9
27	Ex. 2	Cont.	32.8	37.2	36.7	37.4	42.4	42.4	40.6	39.2	42.6	41.6	42.0	42.1
27	Ex. 3	Cont.	36.5	38.1	39.0	33.9	31.8	34.5	43.5	42.6	41.5	37.1	40.0	41.6
27	Active	Cont.	44.0	47.6	47.5	47.9	49.0	52.5	49.9	49.5	50.3	53.5	52.6	52.1
41	Ex. 2	Cont.	42.5	37.4	39.3	39.9	36.6	37.0	42.9	44.0	44.1	42.3	40.7	39.5
41	Ex. 3	Cont.	29.3	28.9	23.4	28.9	25.0	24.6	35.6	34.8	36.8	39.5	36.4	36.2
41	Active	Cont.	47.5	43.7	41.3	44.5	43.9	40.8	53.1	45.9	51.6	46.2	47.4	49.5
46	Ex. 2	Cont.	48.5	44.5	43.1	50.9	50.5	45.3	39.0	35.8	33.4	37.6	32.1	31.0
46	Ex. 3	Cont.	41.9	44.9	45.4	47.0	44.8	46.4	34.9	34.9	31.6	38.5	34.3	35.7
46	Active	Cont.	54.2	56.0	55.5	53.0	54.8	54.4	45.5	48.4	45.4	43.6	44.5	47.1
51	Ex. 2	Cont.	40.4	37.9	33.7	36.9	34.6	38.9	35.3			33.2	31.6	
51	Ex. 3	Cont.	34.2	32.8	34.5	35.8	35.5	35.1	36.8	36.4	35.5	34.0	34.1	34.5
51	Active	Cont.	41.4	37.5	42.5	32.4	36.4	37.9	45.3	45.2	40.9	41.6	45.0	39.2
56	Ex. 2	Cont.	39.0	40.3	42.9	44.4	39.1	44.3	41.0	42.8	41.3	43.0	46.7	46.4
56	Ex. 3	Cont.	44.6	38.0	44.0	44.6	42.6	44.1	40.1	40.6	38.7	42.6	43.9	42.7
56	Active	Cont.	54.9	51.4	54.3	54.4	50.3	55.7	52.4	48.7	49.4	49.9	47.9	50.7
59	Ex. 2	Cont.	35.9	35.2	38.8	36.0	31.1	33.3	32.3	31.6	31.4	34.7	38.4	
59	Ex. 3	Cont.	37.8	34.7	34.0	30.2	39.6	34.7	34.0	32.4	31.7	31.4	28.7	29.1
59	Active	Cont.	42.9	41.9	40.1	36.4	40.1	40.9	45.9	43.7	40.9	39.9	41.1	45.3
63	Ex. 2	Cont.	26.5	23.7	26.3	23.0	24.2	28.3	29.5	32.7	36.9	28.7	27.5	30.0
63	Ex. 3	Cont.	15.8	13.8	16.2	15.4	16.9	16.6	22.2	22.0	21.5	22.5	22.5	21.4
63	Active	Cont.	31.9	29.8	30.7	23.9	31.5	29.4	29.5	32.0	35.5	32.2	37.0	35.2

A6. (cont'd)

			Right End Range Values (degrees)						Left End Range Values (degrees)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
67	Ex. 2	Cont.	46.5	50.3	50.5	43.2	44.5	42.5	37.2	37.0	37.3	36.3	34.1	35.7
67	Ex. 3	Cont.	40.3	44.6	40.9	39.7	40.1	34.6	34.0	33.2	30.7	30.6	32.1	32.4
67	Active	Cont.	53.9	53.5	56.5	48.8	49.2	51.5	43.3	42.2	40.5	43.1	41.2	43.5
68	Ex. 2	Cont.	25.7	28.4	24.6	30.0	31.0	31.6	25.1	23.0	24.3	29.0	28.7	33.1
68	Ex. 3	Cont.	19.6	26.4	29.6	27.2	30.3	30.9	24.8	22.0	23.4	25.9	24.0	26.3
68	Active	Cont.	34.9	35.8	34.1	34.3	37.7	38.2	33.8	38.1	36.9	33.2	38.6	39.1
69	Ex. 2	Cont.	43.7	41.8	44.9	47.3	45.1	46.4	45.4	38.9	35.6	43.6	34.8	46.2
69	Ex. 3	Cont.	32.1	32.4	28.4	35.6	26.4	26.8	32.5	34.6	33.3	34.0	30.1	35.6
69	Active	Cont.	51.3	52.7	50.4	49.9	47.4	45.1	55.0	49.9	49.7	47.8	46.1	52.1
77	Ex. 2	Cont.	35.0	35.1	34.1	32.7	37.9	36.9	30.1	30.8	30.8	34.3	35.6	33.2
77	Ex. 3	Cont.	37.4	34.5	35.1	28.0	34.2	32.5	35.4	32.6	32.3	30.7	29.2	31.5
77	Active	Cont.	40.8	42.0	39.4	37.8	43.7	44.2	37.9	34.9	35.0	40.4	40.7	40.1
79	Ex. 2	Cont.	35.3	30.7	31.2	31.2	38.2	36.8	36.7	34.7	35.5	36.3	36.9	38.1
79	Ex. 3	Cont.	33.6	38.1	36.3	27.9	29.1	34.7	40.2	38.6	39.1	39.4	41.0	40.6
79	Active	Cont.	41.8	44.0	42.3	42.7	45.4	44.3	43.6	42.3	44.2	39.7	42.6	42.7
83	Ex. 2	Cont.	39.1	40.2	40.5	38.5	38.9	37.9	31.1	33.8	35.7	35.7	34.7	36.3
83	Ex. 3	Cont.	35.0	33.6	34.1	33.5	33.0	32.8	26.0	29.5	32.4	31.8	29.3	33.6
83	Active	Cont.	43.8	42.7	42.8	42.2	43.1	43.9	45.4	44.0	42.3	41.7	41.3	41.6
85	Ex. 2	Cont.	30.1	33.3	34.9	31.3	31.4	31.8	37.7	39.2	41.3	35.6	33.8	37.5
85	Ex. 3	Cont.	30.2	31.2	30.5	30.0	33.3	30.0	36.5	33.9	33.1	36.1	36.3	34.7
85	Active	Cont.	30.3	29.7	32.3	30.1	30.2	33.2	38.9	36.3	37.7	39.2	38.5	40.2
88	Ex. 2	Cont.	27.9	29.6	25.3	27.8	28.6	30.9	31.0	27.4	30.9	32.7	25.3	26.5
88	Ex. 3	Cont.	24.5	31.0	28.8	25.7	30.6	30.2	25.7	23.9	28.3	26.2	25.1	26.5
88	Active	Cont.	29.2	32.7	35.0	28.4	33.9	36.1	26.7	29.8	33.4	39.8	37.4	38.5
90	Ex. 2	Cont.	37.1	33.4	29.6	35.3	34.9	33.3	36.4	35.7	33.9	35.3	36.1	38.3
90	Ex. 3	Cont.	34.0	29.9	32.7	38.8	37.1	35.3	44.6	37.7	37.2	35.2	36.0	34.5
90	Active	Cont.	41.0	43.8	43.1	41.4	37.5	40.6	48.5	53.0	52.7	46.9	45.1	46.9

A6. (cont'd)

			Right End Range Values (degrees)						Left End Range Values (degrees)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
96	Ex. 2	Cont.	38.2	32.2	24.7	39.0	35.0	29.1	38.4	37.0	37.0	38.7	36.2	35.0
96	Ex. 3	Cont.	29.1	18.3	27.4	25.1	26.0	24.1	38.9	35.4	38.4	39.4	36.8	38.8
96	Active	Cont.	40.9	41.5	39.4	38.9	39.6	41.7	44.5	43.3	46.3	45.9	45.7	45.2
106	Ex. 2	Cont.	27.2	30.3	32.4	34.3	33.3	32.3	35.7	36.6	38.8	33.6	30.9	33.9
106	Ex. 3	Cont.	26.9	28.7	27.3	30.3	26.8	27.9	30.5	27.4	34.4	31.9	31.8	31.9
106	Active	Cont.	42.3	40.2	42.2	41.1	42.2	43.0	53.9	49.5	50.9	45.9	46.9	45.8
111	Ex. 2	Cont.	38.2	36.7	41.4	36.3	39.7	37.9	39.8	41.5	41.7	35.8		39.3
111	Ex. 3	Cont.	44.0	35.6	39.4	42.2	42.1	44.7	43.7	40.4	40.9	36.4	40.1	41.2
111	Active	Cont.	47.0	46.5	48.6	44.5	44.9	43.8	49.0	46.4	46.6	50.5	48.1	49.9
117	Ex. 2	Cont.	30.5	29.0	15.9	26.5	27.2	23.1	29.4	22.6	23.7	28.1	24.3	31.1
117	Ex. 3	Cont.	29.8	31.5	32.3	33.0	32.4	32.0	24.0	25.1	28.9	29.0	29.6	30.4
117	Active	Cont.	41.9	42.9	41.1	42.6	40.3	40.9	43.0	43.1	41.8	43.3	40.1	39.5

Pre-Treatment

			Right End Range Values (degrees)						Left End Range Values (degrees)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
6	Ex. 2	Exp.	39.0	47.9	34.9	32.8	27.7	24.9	28.0	26.1	24.7	30.2	27.0	28.2
6	Ex. 3	Exp.	30.5	33.6	25.1	25.4	25.4	29.7	13.8	21.7	19.7	20.0	19.1	20.8
6	Active	Exp.	35.0			38.3	37.2	40.9	31.5			37.1	38.7	40.1
9	Ex. 2	Exp.	28.2	24.9	29.4	25.1	31.0	25.2	34.2	34.7	34.0	28.3	26.0	28.7
9	Ex. 3	Exp.	19.6	19.4	17.0	19.9	13.5	22.9	26.3	26.9	28.7	25.4	24.8	24.4
9	Active	Exp.	34.2	31.9	33.2	25.0	27.5	22.5	33.6	31.1	34.3	32.8	31.1	35.8
12	Ex. 2	Exp.	40.2	34.5	33.5	31.2	27.0	25.7	30.2	28.2	25.5	28.6	27.8	31.0
12	Ex. 3	Exp.	16.2	20.4	16.0	13.6	16.5	16.8	19.6	21.1	19.8	20.8	20.4	19.9
12	Active	Exp.	41.9	39.1	36.5	34.7	31.1	29.4	34.2	36.6	35.5	34.3	31.3	30.5

A6. (cont'd)

Pre-Treatment

			Right End Range Values (degrees)						Left End Range Values (degrees)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
14	Ex. 2	Exp.	41.1	40.2	37.0	39.0	39.1	39.1	45.5	44.8	48.3	43.8	42.1	42.5
14	Ex. 3	Exp.	42.8	33.5	32.8	42.4	34.4	34.7	41.0	30.4	35.7	35.0	35.1	31.1
14	Active	Exp.	43.6	48.2	42.0	45.8	40.0	44.0	43.9	37.7	48.0	49.6	47.2	53.3
23	Ex. 2	Exp.	43.1	42.5	43.6	45.5	47.6	48.7	49.6	49.0	47.6	43.0	43.6	45.0
23	Ex. 3	Exp.	37.7	31.6	35.0	38.1	33.7	31.9	40.1	38.6	37.7	40.3	39.1	39.7
23	Active	Exp.	44.9	41.4	43.9	46.4	44.4	47.3	51.5	48.9	54.8	46.3	44.3	46.5
25	Ex. 2	Exp.	31.6	32.8	28.5	31.9	32.8	26.0	27.6	30.8	30.2	28.6	25.4	26.5
25	Ex. 3	Exp.	26.5	24.2	26.5	30.8	33.1	32.5	25.1	24.8	22.8	22.5	20.1	18.5
25	Active	Exp.	35.4	36.8	38.6	35.7	40.0	38.8	28.6	29.5	31.1	29.5	31.1	31.9
54	Ex. 2	Exp.	26.4	28.1	32.2	28.0	34.5	32.0	32.6	42.9	42.2	36.9	36.5	33.3
54	Ex. 3	Exp.	33.3	29.1	29.6	26.4	28.0	30.5	35.6	34.2	34.0	28.5	30.2	29.3
54	Active	Exp.	37.1	39.5	38.8	35.0	35.7	38.5	46.7	54.0	54.2	45.5	47.5	50.3
55	Ex. 2	Exp.	23.1	22.1		23.7	23.3	19.6	23.5	24.2		24.1	23.5	23.5
55	Ex. 3	Exp.	28.2	32.2	22.2	22.7	21.5	21.1	21.3	30.8	21.7	23.5	23.6	19.3
55	Active	Exp.	25.9	31.3	26.8	26.9	26.2	26.8	30.8	32.4		30.0	31.7	33.8
57	Ex. 2	Exp.	39.8	40.5	42.6	40.1	39.2	39.3	37.9	45.2	45.8	47.7	47.3	44.5
57	Ex. 3	Exp.	31.7	27.9	32.0	34.8	35.0	39.3	38.0	36.7	41.0	35.2	33.0	34.0
57	Active	Exp.	41.4	40.1	43.8	37.7	38.3	43.2	44.4	44.2	45.5	42.2	44.3	47.0
70	Ex. 2	Exp.	38.9	34.6	36.3	32.7	32.0	28.9	34.7	35.3	37.6	35.1	35.7	32.8
70	Ex. 3	Exp.	29.1	28.0	28.8	27.7	30.5	30.3	25.8	25.3	29.0	25.3	27.9	25.2
70	Active	Exp.	38.2	38.5	38.6	38.2	38.5	40.4	40.2	38.1	40.3	37.1	37.7	39.1
72	Ex. 2	Exp.	30.9	28.1	31.8	28.0	28.5	29.7	29.9	33.1	31.8	32.8	35.4	38.5
72	Ex. 3	Exp.	27.3	31.4	30.7	27.5	25.3	22.8	23.5	29.0	28.1	36.0	27.7	31.4
72	Active	Exp.	41.6	41.0	42.8	42.4	43.7	44.7	38.7	43.7	47.0	43.7	42.3	41.9
80	Ex. 2	Exp.	39.2	36.8	35.6	34.3	34.3	34.3	35.8	33.8	33.5	30.9	33.8	33.3
80	Ex. 3	Exp.	30.3	33.6	34.1	34.0	35.7	31.3	35.0	31.8	35.0	36.8	37.4	37.6
80	Active	Exp.	40.7	41.4	40.3	33.1	44.6	38.4	44.0	44.5	43.6	44.2	45.4	43.8

A6. (cont'd)

Pre-Treatment

			Right End Range Values (degrees)						Left End Range Values (degrees)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
84	Ex. 2	Exp.	21.4	18.9	20.8	25.1	26.3	27.2	28.3	25.6	28.8	28.1	25.5	26.3
84	Ex. 3	Exp.	22.8	23.0	21.3	26.6	28.3	25.7	28.6	28.0	27.6	27.0	25.5	26.0
84	Active	Exp.	30.4	29.0	29.5	30.4	29.8	29.0	35.8	38.1	36.9	30.3	26.8	27.5
91	Ex. 2	Exp.	36.9	40.1	41.2	39.9	39.7	40.6	39.9	39.6	40.2	35.9	35.0	33.0
91	Ex. 3	Exp.	36.2	39.1	37.6	40.3	40.2	40.2	37.9	38.0	38.1	40.3	38.6	40.0
91	Active	Exp.	44.0	47.8	52.1	45.5	46.0	47.0	43.6	43.5	44.2	39.9	44.7	44.8
95	Ex. 2	Exp.	33.9	34.7	31.9	31.4	33.5	31.9	34.0	34.8	33.2	34.8	33.3	33.1
95	Ex. 3	Exp.	32.3	33.0	29.7	29.8	30.6	31.8	34.4	32.2	33.4	32.9	34.9	35.8
95	Active	Exp.	35.0	35.3	36.7	37.2	38.3	37.9	35.0	38.8	38.9	34.0	35.9	35.5
98	Ex. 2	Exp.	28.2	24.9	26.8	29.4	26.4	30.3	39.7	37.2	42.2	36.5	33.8	31.6
98	Ex. 3	Exp.	29.6	28.9	29.7	24.0	22.7	26.0	41.2	39.1	35.4	36.8	34.3	31.0
98	Active	Exp.	53.1	45.4	40.1	35.9	39.3	41.2	61.7	61.3	57.3	57.2	54.5	54.2
112	Ex. 2	Exp.	39.7	35.8	42.9	35.2	34.7	33.9	32.0	33.2	31.2	34.2	31.6	34.0
112	Ex. 3	Exp.	32.7	31.6	29.9	34.2	35.1	32.4	27.5	28.3	29.5	28.2	28.7	29.3
112	Active	Exp.	38.2	39.0	38.0	32.4	40.3	42.4	30.8	31.4	35.9	29.6	34.7	36.4
115	Ex. 2	Exp.	25.2	22.0	26.7	27.5	27.9	29.0	31.7	31.3		33.8	29.9	36.1
115	Ex. 3	Exp.	24.5	21.4	21.9	20.9	19.3	20.0	23.7	26.9	28.7	34.6	30.1	31.4
115	Active	Exp.	25.3	30.1	29.1				38.7	33.4	32.3			
125	Ex. 2	Exp.	25.7	26.1	23.3	27.6	26.7	26.6	26.5	25.8	29.0	27.0	23.2	25.2
125	Ex. 3	Exp.	24.7	23.0	24.7	23.9	24.5	20.0	22.5	22.9	21.9	23.2	23.4	24.3
125	Active	Exp.	26.4	28.2	26.5	24.5	25.9	23.7	30.2	30.4	29.8	27.2	28.9	28.5

A6. (cont'd)

Post-Treatment

			Right End Range Values (degrees)						Left End Range Values (degrees)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
6	Ex. 2	Exp.	34.9	30.9	34.9	28.8	28.4	29.3	34.8	29.6	32.1	32.6	31.9	32.9
6	Ex. 3	Exp.	24.4	27.0	27.9	25.7	25.4	25.9	25.6	21.4	22.8	26.2	23.7	26.5
6	Active	Exp.	39.7	39.4	40.9	35.9	39.7	40.2	38.5	37.9	38.6	34.1	35.7	37.6
9	Ex. 2	Exp.	31.2	31.5	29.8	40.5	42.2	39.9	38.4	33.4	35.2	29.9	33.9	32.3
9	Ex. 3	Exp.	24.2	26.0	27.0	26.9	25.6	18.7	26.3	23.2	28.1	23.7	24.0	26.8
9	Active	Exp.	39.2	37.9	40.6	36.6	43.4	43.9	38.6	39.3	38.8	36.8	36.3	40.4
12	Ex. 2	Exp.	31.0	29.2	31.6	31.0	25.6	26.7	34.4	30.3	29.3	32.9	25.7	31.7
12	Ex. 3	Exp.	17.2	20.6	17.2	18.3	18.9	18.3	18.8	16.0	18.7	15.5	15.9	16.7
12	Active	Exp.	39.5	34.1	34.1	36.3	35.7	33.7	30.7	31.6	30.4	37.3	35.6	37.7
14	Ex. 2	Exp.	39.5	30.7	30.8	40.8	44.7	38.8	36.2	39.7	31.5	41.5	36.9	41.1
14	Ex. 3	Exp.	37.9	40.1	37.0	34.5	36.4	39.3	18.1	24.5	28.7	44.0	41.9	43.8
14	Active	Exp.	45.9	38.6	32.9	45.9	32.8	34.2	48.4	47.0	35.7	41.6	48.1	47.3
23	Ex. 2	Exp.	39.8	41.5	36.7	42.8	45.5	41.5	50.4	48.6	47.9	42.7	41.6	42.3
23	Ex. 3	Exp.	34.5	34.4	33.8	33.4	35.3	28.2	35.5	37.6	37.8	41.2	40.9	37.4
23	Active	Exp.	44.3	42.5	40.6	41.0	42.6	44.0	49.0	44.6	45.3	42.5	41.8	44.0
25	Ex. 2	Exp.	34.8	34.9	35.3	35.7	35.9	35.9	25.5	25.7	26.6	26.4	27.7	31.0
25	Ex. 3	Exp.	29.2	32.1	30.9	28.4	30.5	31.1	22.8	19.5	24.8	26.3	26.2	27.0
25	Active	Exp.	41.1	38.2	42.2	41.3	45.3	42.5	36.6	37.6	36.9	29.4	30.0	31.4
54	Ex. 2	Exp.	40.9	35.6	31.8	37.2	32.2	35.8	41.0	39.4	37.4	36.6	38.7	36.2
54	Ex. 3	Exp.	31.2	34.4	33.6	31.8	28.5	29.5	30.3	34.2	36.8	31.4	34.1	37.1
54	Active	Exp.	41.2	42.7	45.6	41.7	42.2	44.5	46.7	48.7	51.8	47.1	47.3	52.7
55	Ex. 2	Exp.	21.5	23.6	22.7	25.2	24.2	25.6	28.1	26.1	26.3	27.3	26.8	26.7
55	Ex. 3	Exp.	21.8	23.8	25.4	22.8	25.7	19.4	27.8	29.6	34.4	30.7	29.8	24.4
55	Active	Exp.	25.8	28.3	28.2	26.0	27.7	29.5	32.4	34.4	36.7	39.0	39.8	39.5
57	Ex. 2	Exp.	39.0	42.7	44.8	40.7	43.0	43.2	43.8	45.3	43.2	45.3	45.0	46.4
57	Ex. 3	Exp.	32.8	30.2	31.4	32.3	32.5	37.2	40.6	40.3	40.3	37.3	38.3	40.1
57	Active	Exp.	38.1	44.3	44.9	40.5	38.8	41.4	46.0	46.9	48.3	50.4	49.1	52.5

A6. (cont'd)

Post-Treatment

			Right End Range Values (degrees)						Left End Range Values (degrees)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
70	Ex. 2	Exp.	29.0	28.8	30.3	32.3	30.2	32.3	38.0	38.3	43.5	31.6	33.6	36.2
70	Ex. 3	Exp.	32.0	33.6	34.9	30.8	36.4	36.3	30.4	34.7	30.7	30.9	32.8	35.5
70	Active	Exp.	39.4	38.6	45.5	48.2	44.5	45.1	44.5	40.3	46.0	46.1	44.1	47.2
72	Ex. 2	Exp.	34.0	34.1	31.2	31.4	32.5	24.3	31.3	28.7	26.3	25.8	19.6	27.9
72	Ex. 3	Exp.	22.8	31.8	32.5	30.8	27.8	29.5	28.0	30.3	29.2	31.3	30.5	31.1
72	Active	Exp.	41.2	40.6	41.5	38.9	41.4	42.8	43.2	43.1	47.9	45.5	47.6	47.0
80	Ex. 2	Exp.	36.4	37.6	36.2	30.5	33.0	35.4	36.6	39.0	34.9	36.1	36.8	37.0
80	Ex. 3	Exp.	34.8	35.7	35.7	37.8	34.1	36.5	36.0	35.2	35.2	37.9	36.8	35.3
80	Active	Exp.	42.5	40.5	43.6	38.8	39.2	41.7	47.3	46.2	43.5	43.2	43.3	42.8
84	Ex. 2	Exp.	29.1	27.8	23.5	23.3	27.0	23.2	28.1	27.3	28.2	29.9	26.9	26.7
84	Ex. 3	Exp.	25.7	28.1	26.3	24.5	23.2	22.6	28.0	28.6	30.6	28.0	27.0	27.2
84	Active	Exp.	28.1	29.5	26.1	30.6	34.8	37.2	36.4	36.1	36.7	39.0	36.8	37.6
91	Ex. 2	Exp.	44.1	45.2	43.8	42.7	42.6	41.9	39.3	39.3	40.5	40.5	41.9	42.5
91	Ex. 3	Exp.	41.0	46.9	45.7	42.0	47.4	46.3	39.6	37.5	42.0	40.2	44.8	40.9
91	Active	Exp.	47.8	54.7	55.4	47.5	48.4	48.6	46.2	49.0	49.6	45.2	45.5	45.8
95	Ex. 2	Exp.	34.2	33.4	32.7	33.4	32.2	32.4	32.3	30.0	29.6	32.2	30.1	29.7
95	Ex. 3	Exp.				34.2	37.5	35.0				33.3	34.8	31.8
95	Active	Exp.	37.8	40.6	38.0	38.3	37.0	39.0	37.6	37.3	38.6	37.7	39.7	43.1
98	Ex. 2	Exp.	27.0	24.8	24.9	16.8	24.2	28.6	39.6	34.3	31.5	34.1	34.1	31.5
98	Ex. 3	Exp.	32.5	23.0	25.1	27.7	25.1	26.1	37.0	31.4	32.5	33.4	33.8	33.9
98	Active	Exp.	34.6	36.5	32.8	32.8	30.9	32.7	45.2	43.3	46.3	45.7	43.7	44.7
112	Ex. 2	Exp.	40.5	40.0	39.3	38.3	37.8	36.7	34.1	34.0	34.9	36.7	36.6	40.0
112	Ex. 3	Exp.	33.9	38.5	38.0	35.6	35.5	39.3	29.7	27.5	28.9	30.5	28.9	28.6
112	Active	Exp.	43.4	43.0	43.4	41.6	46.3	46.1	35.5	34.9	36.0	37.7	38.3	38.0
115	Ex. 2	Exp.	25.4	27.9	26.0	29.7	31.7	30.6	31.1	28.2	27.3	26.2	28.2	24.7
115	Ex. 3	Exp.	24.4	22.2	23.4	26.1	27.3	26.1	26.5	24.9	26.7	24.2	25.9	25.7
115	Active	Exp.	18.5	26.0	31.6	27.0	28.8	26.5	39.1	44.7	49.5	35.7	7.3	18.4

A6. (cont'd)

Post-Treatment

			Right End Range Values (degrees)						Left End Range Values (degrees)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
125	Ex. 2	Exp.	26.2	26.3	27.3	27.6	27.4	26.2	27.3	25.5	23.5	27.0	25.7	22.4
125	Ex. 3	Exp.	24.8	25.0	25.3	34.3	34.3	34.3	25.4	24.8	24.8	30.9	33.8	33.3
125	Active	Exp.	29.3	32.4	30.2	25.6	29.4	30.0	31.9	33.5	31.4	31.7	31.4	31.9

Pre-Treatment

			Right End Range Values (degrees)						Left End Range Values (degrees)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
126	Ex. 2	Long.	34.9	30.3	29.1	32.8	34.8	33.0	39.6	36.6	36.3	34.6	35.3	34.8
126	Ex. 3	Long.	30.0	30.3	31.1	28.9	31.8	30.6	33.5	31.4	35.2	33.6	33.1	30.1
126	Active	Long.												
127	Ex. 2	Long.	31.6	29.4	30.3	30.5	30.2	30.4	28.8	26.5	23.2	29.6	29.8	28.0
127	Ex. 3	Long.	23.8	24.2	25.9	27.4	28.2	27.4	25.2	24.0	27.8	24.4	20.3	22.8
127	Active	Long.	37.1	40.8	39.7	36.3	38.7	39.9	36.8	38.0	38.0	40.0	40.8	40.2
128	Ex. 2	Long.	36.7	36.9	36.8	39.4	38.5	38.5	41.6	41.6	41.3	35.4	40.8	42.8
128	Ex. 3	Long.	36.8	39.9	36.5	37.9	39.2	40.3	36.5	39.3	39.2	33.1	35.6	37.1
128	Active	Long.	39.8	42.2	40.7	40.0	41.1	40.0	43.5	44.7	45.2	44.1	43.9	45.2
129	Ex. 2	Long.	18.8	18.0	18.2	17.6	21.0	22.2	32.4	33.4	31.6	33.8	33.9	34.1
129	Ex. 3	Long.	22.1	19.8	20.1	17.6	17.2	12.5	32.9	25.2	31.7	31.4	33.0	45.3
129	Active	Long.	29.9	31.6	30.7	31.4	30.9	27.4	41.3	41.3	37.7	47.6	41.4	31.4
131	Ex. 2	Long.	42.0	40.5	43.2	41.0	43.5	42.1	35.3	36.1	36.1	40.7	38.5	39.6
131	Ex. 3	Long.	42.6	46.6	40.7	39.6	39.8	39.1	35.1	34.3	34.1	37.9	36.4	36.4
131	Active	Long.	48.7	49.2	47.1	46.6	46.0	44.4	45.7	45.3	44.0	43.1	41.6	46.0

A6. (cont'd)

Post-Treatment

			Right End Range Values (degrees)						Left End Range Values (degrees)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
126	Ex. 2	Long.	32.1	29.6	28.4	35.9	36.2	35.5	36.6	33.2	35.9	30.9	31.8	32.1
126	Ex. 3	Long.	32.5	32.6	31.4	30.5	27.9	28.2	31.6	36.1	35.7	35.3	35.2	37.2
126	Active	Long.	31.1	36.1	36.4	33.4	41.0	36.2	38.5	38.9	39.3	39.4	41.1	40.8
127	Ex. 2	Long.	33.1	33.5	34.6	34.2	31.9	30.0	32.6	31.9	33.5	31.4	33.8	32.2
127	Ex. 3	Long.	30.2	24.3	28.4	26.8	28.3	27.9	26.9	27.4	26.5	32.7	31.0	29.5
127	Active	Long.	39.5	41.4	41.3	34.7	36.3	38.3	39.1	41.7	40.0	41.9	41.8	44.6
128	Ex. 2	Long.	42.9	41.4	42.7	42.6	43.5	39.6	38.7	41.1	39.0	37.7	38.4	37.0
128	Ex. 3	Long.	36.4	35.3	35.3	40.1	35.9	38.1	37.8	37.6	38.7	32.6	35.3	34.8
128	Active	Long.	41.2	43.5	44.5	44.1	39.1	42.8	40.7	41.5	41.7	39.9	40.5	42.5
129	Ex. 2	Long.	25.2	21.4	21.8	23.0	25.5	27.9	35.7	30.1	28.0	33.3	40.7	39.8
129	Ex. 3	Long.	17.6	14.9	17.3	20.6	19.9	20.3	28.5	26.8	31.7	33.5	28.9	30.6
129	Active	Long.	26.9	29.0	28.6	33.6	30.6	28.2	45.4	40.8	46.3	40.9	38.8	40.6
131	Ex. 2	Long.	42.8	37.7	38.5	38.6	39.8	41.2	38.2	35.8	37.2	38.0	38.3	37.9
131	Ex. 3	Long.	41.1	39.6	42.7	43.3	40.4	37.7	37.6	39.8	39.9	39.6	41.1	39.6
131	Active	Long.	49.0	52.6	51.8	49.7	50.3	47.4	47.2	45.0	45.8	45.9	48.2	46.3

A6. (cont'd)

72-Hours Post-Treatment

			Right End Range Values (degrees)						Left End Range Values (degrees)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
126	Ex. 2	Long.	27.8	29.7	30.9	28.2	28.6	28.6	30.6	31.9	32.2	31.8	31.2	33.1
126	Ex. 3	Long.	29.6	29.1	30.4	26.7	28.0	27.3	27.8	27.6	29.4	27.7	25.4	28.2
126	Active	Long.	34.1	37.3	36.2	37.8	38.3	38.5	35.1	36.8	36.8	35.2	37.5	38.2
127	Ex. 2	Long.	40.2	39.4	39.7	41.9	39.1	36.1	44.2	44.6	39.8	35.6	35.2	36.1
127	Ex. 3	Long.	39.0	39.0	38.1	40.9	43.2	43.1	36.9	37.0	36.3	35.1	33.6	35.1
127	Active	Long.	44.4	47.6	48.7	44.3	44.2	46.8	45.3	47.7	48.6	43.7	45.4	46.0
128	Ex. 2	Long.	23.2	19.0	18.8	22.4	18.8	22.9	28.9	30.2	28.0	31.1	27.0	26.7
128	Ex. 3	Long.	20.3	20.3	16.7	19.1	23.9	22.6	29.8	25.4	23.1	24.8	26.0	27.2
128	Active	Long.	27.0	29.7	29.9	32.4	30.9	29.0	36.3	34.7	31.7	40.7	32.5	30.4
129	Ex. 2	Long.	39.8	38.9	39.8	38.7	36.2	40.9	41.6	43.1	42.6	41.0	42.0	42.4
129	Ex. 3	Long.	37.4	37.4	37.1	36.3	40.3	41.8	38.4	38.8	39.4	36.0	37.2	39.1
129	Active	Long.	45.1	48.5	49.7	47.1	48.5	49.1	43.5	46.1	47.0	44.8	46.5	47.7
131	Ex. 2	Long.	39.8	38.9	39.8	38.7	36.2	40.9	41.6	43.1	42.6	41.0	42.0	42.4
131	Ex. 3	Long.	37.4	37.4	37.1	36.3	40.3	41.8	38.4	38.8	39.4	36.0	37.2	39.1
131	Active	Long.	45.1	48.5	49.7	47.1	48.5	49.1	43.5	46.1	47.0	44.8	46.5	47.7

A6. (cont'd)

			ROM (End Range Left + End Range Right) (degrees)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**
4	Ex. 2	Cont.	58.0	65.4	57.7	53.9	57.5	58.4
4	Ex. 3	Cont.	47.0	52.0	52.6	47.4	52.4	57.4
4	Active	Cont.	90.4	90.5	93.2	82.8	89.4	91.9
5	Ex. 2	Cont.	89.0	87.2	88.7	90.2	94.8	90.6
5	Ex. 3	Cont.	74.6	69.2	76.8	80.0	84.4	82.3
5	Active	Cont.	108.1	109.5	110.9	109.6	115.7	116.3
27	Ex. 2	Cont.	73.4	76.4	79.3	79.0	84.4	84.5
27	Ex. 3	Cont.	80.0	80.6	80.5	71.0	71.8	76.1
27	Active	Cont.	93.8	97.1	97.7	101.4	101.6	104.6
41	Ex. 2	Cont.	85.4	81.4	83.4	82.2	77.3	76.5
41	Ex. 3	Cont.	64.9	63.7	60.3	68.4	61.4	60.7
41	Active	Cont.	100.6	89.6	93.0	90.6	91.3	90.3
46	Ex. 2	Cont.	87.5	80.3	76.5	88.5	82.6	76.3
46	Ex. 3	Cont.	76.8	79.8	77.0	85.5	79.1	82.2
46	Active	Cont.	99.7	104.4	100.9	96.6	99.3	101.4

A6. (cont'd)

			ROM (End Range Left + End Range Right) (degrees)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**
51	Ex. 2	Cont.	75.8			70.1	66.2	
51	Ex. 3	Cont.	71.0	69.2	70.0	69.8	69.5	69.6
51	Active	Cont.	86.6	82.7	83.3	73.9	81.4	77.1
56	Ex. 2	Cont.	80.0	83.1	84.2	87.3	85.9	90.7
56	Ex. 3	Cont.	84.7	78.6	82.7	87.1	86.5	86.7
56	Active	Cont.	107.3	100.1	103.7	104.3	98.1	106.4
59	Ex. 2	Cont.	68.2	66.8	70.2	70.7	69.5	
59	Ex. 3	Cont.	71.8	67.1	65.6	61.6	68.3	63.8
59	Active	Cont.	88.8	85.6	81.0	76.3	81.1	86.2
63	Ex. 2	Cont.	56.0	56.4	63.3	51.7	51.7	58.4
63	Ex. 3	Cont.	38.0	35.7	37.6	37.9	39.4	38.0
63	Active	Cont.	61.4	61.8	66.1	56.1	68.5	64.6
67	Ex. 2	Cont.	83.7	87.2	87.8	79.5	78.6	78.2
67	Ex. 3	Cont.	74.3	77.8	71.6	70.4	72.3	67.0
67	Active	Cont.	97.3	95.7	97.0	91.8	90.5	95.0
68	Ex. 2	Cont.	50.8	51.4	48.9	59.0	59.7	64.7
68	Ex. 3	Cont.	44.5	48.4	53.0	53.0	54.3	57.2
68	Active	Cont.	68.6	74.0	71.0	67.5	76.3	77.3
69	Ex. 2	Cont.	89.0	80.7	80.5	91.0	79.9	92.6
69	Ex. 3	Cont.	64.6	67.0	61.7	69.5	56.5	62.4
69	Active	Cont.	106.2	102.6	100.1	97.8	93.5	97.1
77	Ex. 2	Cont.	65.1	65.9	64.9	66.9	73.5	70.0
77	Ex. 3	Cont.	72.8	67.1	67.4	58.7	63.4	64.1
77	Active	Cont.	78.6	76.8	74.5	78.2	84.4	84.3
79	Ex. 2	Cont.	72.0	65.5	66.7	67.5	75.1	74.8
79	Ex. 3	Cont.	73.7	76.7	75.4	67.3	70.1	75.3
79	Active	Cont.	85.4	86.3	86.5	82.4	88.1	87.0

A6. (cont'd)

			ROM (End Range Left + End Range Right) (degrees)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**
83	Ex. 2	Cont.	70.2	74.0	76.2	74.2	73.7	74.2
83	Ex. 3	Cont.	61.0	63.1	66.4	65.3	62.3	66.4
83	Active	Cont.	89.2	86.7	85.1	83.9	84.4	85.6
85	Ex. 2	Cont.	67.9	72.4	76.3	66.9	65.2	69.3
85	Ex. 3	Cont.	66.8	65.1	63.6	66.2	69.6	64.7
85	Active	Cont.	69.1	65.9	69.9	69.3	68.7	73.4
88	Ex. 2	Cont.	58.8	56.9	56.1	60.5	53.9	57.4
88	Ex. 3	Cont.	50.2	54.9	57.0	51.8	55.6	56.7
88	Active	Cont.	55.9	62.6	68.4	68.1	71.3	74.6
90	Ex. 2	Cont.	73.6	69.1	63.5	70.6	71.0	71.6
90	Ex. 3	Cont.	78.6	67.6	69.9	74.0	73.1	69.9
90	Active	Cont.	89.5	96.8	95.8	88.3	82.5	87.5
96	Ex. 2	Cont.	76.6	69.2	61.7	77.6	71.1	64.1
96	Ex. 3	Cont.	68.0	53.6	65.8	64.5	62.8	62.9
96	Active	Cont.	85.4	84.9	85.7	84.7	85.3	86.9
106	Ex. 2	Cont.	62.9	67.0	71.1	67.9	64.2	66.2
106	Ex. 3	Cont.	57.4	56.1	61.8	62.2	58.6	59.7
106	Active	Cont.	96.2	89.6	93.0	87.0	89.2	88.8
111	Ex. 2	Cont.	77.9	78.2	83.0	72.1		77.2
111	Ex. 3	Cont.	87.7	76.0	80.3	78.6	82.1	85.8
111	Active	Cont.	95.9	92.9	95.2	95.0	93.0	93.8
117	Ex. 2	Cont.	59.9	51.6	39.6	54.7	51.5	54.3
117	Ex. 3	Cont.	53.8	56.7	61.2	61.9	62.0	62.4
117	Active	Cont.	84.9	86.0	82.9	85.9	80.3	80.5

A6. (cont'd)

			Pre-Treatment						Post-Treatment					
			ROM (End Range Left + End Range Right) (degrees)						ROM (End Range Left + End Range Right) (degrees)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
6	Ex. 2	Exp.	67.0	74.0	59.6	63.0	54.7	53.1	69.7	60.5	67.1	61.4	60.3	62.2
6	Ex. 3	Exp.	44.3	55.3	44.8	45.4	44.5	50.5	50.0	48.3	50.7	51.9	49.0	52.3
6	Active	Exp.	66.6			75.4	75.9	81.0	78.2	77.2	79.5	70.0	75.3	77.7
9	Ex. 2	Exp.	62.5	59.6	63.4	53.4	56.9	53.8	69.5	65.0	65.0	70.4	76.1	72.2
9	Ex. 3	Exp.	45.9	46.2	45.7	45.3	38.3	47.3	50.5	49.2	55.2	50.6	49.6	45.5
9	Active	Exp.	67.8	63.0	67.6	57.8	58.7	58.4	77.8	77.2	79.4	73.4	79.7	84.4
12	Ex. 2	Exp.	70.5	62.7	59.0	59.8	54.8	56.6	65.5	59.4	60.9	63.9	51.2	58.4
12	Ex. 3	Exp.	35.8	41.5	35.8	34.4	36.9	36.7	35.9	36.6	35.9	33.8	34.8	35.0
12	Active	Exp.	76.1	75.8	72.0	69.1	62.4	59.9	70.2	65.7	64.5	73.5	71.3	71.4
14	Ex. 2	Exp.	86.6	85.0	85.3	82.8	81.2	81.6	75.7	70.3	62.3	82.3	81.6	79.9
14	Ex. 3	Exp.	83.8	63.9	68.6	77.4	69.5	65.8	56.0	64.6	65.7	78.5	78.3	83.2
14	Active	Exp.	87.5	85.9	90.0	95.4	87.2	97.2	94.2	85.6	68.6	87.5	80.9	81.5
23	Ex. 2	Exp.	92.7	91.5	91.1	88.6	91.2	93.7	90.2	90.1	84.6	85.5	87.0	83.8
23	Ex. 3	Exp.	77.8	70.2	72.7	78.3	72.8	71.6	70.1	72.0	71.6	74.7	76.2	65.6
23	Active	Exp.	96.4	90.3	98.7	92.6	88.7	93.8	93.3	87.2	85.9	83.5	84.5	87.9
25	Ex. 2	Exp.	59.2	63.6	58.7	60.5	58.2	52.5	60.3	60.7	62.0	62.0	63.5	66.9
25	Ex. 3	Exp.	51.5	49.0	49.3	53.3	53.2	51.0	52.0	51.6	55.7	54.7	56.7	58.1
25	Active	Exp.	64.0	66.3	69.7	65.2	71.1	70.6	77.7	75.9	79.0	70.7	75.2	73.8
54	Ex. 2	Exp.	59.0	71.0	74.4	64.8	71.0	65.3	81.9	74.9	69.1	73.7	70.9	72.0
54	Ex. 3	Exp.	68.9	63.3	63.6	54.9	58.2	59.8	61.5	68.6	70.4	63.3	62.6	66.6
54	Active	Exp.	83.8	93.5	93.1	80.5	83.2	88.8	87.9	91.4	97.4	88.7	89.4	97.2
55	Ex. 2	Exp.	46.5	46.2		47.8	46.8	43.1	49.6	49.7	49.0	52.6	51.0	52.3
55	Ex. 3	Exp.	49.5	63.0	43.9	46.2	45.1	40.4	49.7	53.4	59.8	53.5	55.4	43.8
55	Active	Exp.	56.7	63.7		56.9	57.8	60.6	58.1	62.7	64.9	65.0	67.5	69.0
57	Ex. 2	Exp.	77.7	85.7	88.4	87.7	86.5	83.8	82.8	88.1	88.0	86.0	88.0	89.5
57	Ex. 3	Exp.	69.7	64.6	73.0	70.0	68.0	73.3	73.5	70.5	71.6	69.6	70.7	77.3
57	Active	Exp.	85.8	84.3	89.3	79.9	82.6	90.2	84.1	91.1	93.1	90.9	87.8	93.9

A6. (cont'd)

			Pre-Treatment						Post-Treatment					
			ROM (End Range Left + End Range Right) (degrees)						ROM (End Range Left + End Range Right) (degrees)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
70	Ex. 2	Exp.	73.6	69.9	73.8	67.8	67.7	61.7	67.0	67.0	73.8	63.9	63.7	68.5
70	Ex. 3	Exp.	55.0	53.3	57.8	53.0	58.3	55.6	62.3	68.3	65.5	61.6	69.2	71.7
70	Active	Exp.	78.4	76.6	78.9	75.2	76.2	79.4	83.9	78.9	91.5	94.3	88.6	92.3
72	Ex. 2	Exp.	60.9	61.2	63.5	60.8	63.8	68.3	65.3	62.8	57.5	57.1	52.1	52.2
72	Ex. 3	Exp.	50.8	60.4	58.7	63.5	53.0	54.3	50.7	62.2	61.7	62.1	58.3	60.6
72	Active	Exp.	80.3	84.7	89.7	86.2	86.1	86.5	84.4	83.7	89.4	84.4	89.0	89.8
80	Ex. 2	Exp.	74.9	70.6	69.1	65.2	68.1	67.7	73.0	76.7	71.2	66.6	69.8	72.4
80	Ex. 3	Exp.	65.3	65.4	69.1	70.8	73.1	68.9	70.8	71.0	70.9	75.7	71.0	71.8
80	Active	Exp.	84.7	85.9	83.8	77.3	90.0	82.2	89.8	86.7	87.2	82.0	82.4	84.5
84	Ex. 2	Exp.	49.7	44.4	49.6	53.2	51.8	53.6	57.2	55.1	51.8	53.2	53.9	49.9
84	Ex. 3	Exp.	51.4	51.0	48.8	53.6	53.8	51.6	53.7	56.7	56.8	52.6	50.2	49.9
84	Active	Exp.	66.2	67.1	66.4	60.7	56.6	56.4	64.5	65.6	62.8	69.7	71.6	74.8
91	Ex. 2	Exp.	76.8	79.7	81.4	75.8	74.7	73.5	83.4	84.5	84.2	83.2	84.6	84.4
91	Ex. 3	Exp.	74.1	77.0	75.7	80.6	78.8	80.3	80.7	84.3	87.7	82.2	92.2	87.2
91	Active	Exp.	87.6	91.3	96.3	85.4	90.7	91.8	94.0	103.7	105.0	92.7	93.8	94.4
95	Ex. 2	Exp.	67.8	69.5	65.1	66.1	66.8	65.0	66.5	63.4	62.3	65.6	62.3	62.1
95	Ex. 3	Exp.	66.6	65.2	63.1	62.7	65.5	67.6				67.5	72.3	66.8
95	Active	Exp.	70.0	74.2	75.6	71.2	74.3	73.4	75.5	77.9	76.6	76.0	76.7	82.1
98	Ex. 2	Exp.	67.9	62.1	69.0	65.9	60.2	61.9	66.5	59.2	56.4	50.9	58.2	60.1
98	Ex. 3	Exp.	70.9	68.0	65.1	60.8	57.0	57.1	69.6	54.3	57.6	61.1	58.9	60.1
98	Active	Exp.	114.8	106.7	97.4	93.0	93.8	95.4	79.8	79.8	79.1	78.5	74.6	77.4
112	Ex. 2	Exp.	71.7	68.9	74.1	69.3	66.3	67.9	74.6	74.1	74.2	74.9	74.4	76.8
112	Ex. 3	Exp.	60.2	59.9	59.4	62.4	63.8	61.7	63.6	66.0	66.9	66.0	64.4	68.0
112	Active	Exp.	69.0	70.5	73.9	62.0	75.0	78.9	79.0	77.9	79.4	79.3	84.6	84.1

A6. (cont'd)

			Pre-Treatment						Post-Treatment					
			ROM (End Range Left + End Range Right) (degrees)						ROM (End Range Left + End Range Right) (degrees)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
115	Ex. 2	Exp.	56.8	53.3		61.4	57.8	65.1	56.5	56.1	53.3	56.0	59.9	55.3
115	Ex. 3	Exp.	48.1	48.3	50.5	55.5	49.4	51.3	50.8	47.1	50.1	50.3	53.2	51.8
115	Active	Exp.	64.0	63.4	61.3				57.6	70.7	81.1	62.7	36.1	44.9
125	Ex. 2	Exp.	52.2	51.9	52.4	54.5	49.9	51.8	53.5	51.7	50.7	54.6	53.1	48.7
125	Ex. 3	Exp.	47.2	45.9	46.6	47.1	47.9	44.2	50.2	49.8	50.0	65.2	68.1	67.7
125	Active	Exp.	56.6	58.6	56.2	51.7	54.9	52.2	61.2	65.9	61.6	57.3	60.8	61.9

			Pre-Treatment					
			ROM (End Range Left + End Range Right) (degrees)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**
126	Ex. 2	Long.	74.4	67.0	65.4	67.4	70.1	67.8
126	Ex. 3	Long.	63.4	61.7	66.3	62.4	64.9	60.7
126	Active	Long.						
127	Ex. 2	Long.	60.4	56.0	53.5	60.1	60.0	58.4
127	Ex. 3	Long.	48.9	48.2	53.7	51.8	48.5	50.2
127	Active	Long.	74.0	78.8	77.7	76.3	79.5	80.1
128	Ex. 2	Long.	78.3	78.5	78.1	74.8	79.3	81.3
128	Ex. 3	Long.	73.3	79.2	75.8	70.9	74.7	77.4
128	Active	Long.	83.3	87.0	85.9	84.0	85.0	85.2
129	Ex. 2	Long.	51.2	51.4	49.8	51.4	54.9	56.3
129	Ex. 3	Long.	55.0	45.0	51.8	49.0	50.3	57.8
129	Active	Long.	71.2	72.9	68.4	79.0	72.3	58.7

A6. (cont'd)

Pre-Treatment

			ROM (End Range Left + End Range Right) (degrees)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**
131	Ex. 2	Long.	77.3	76.6	79.4	81.7	82.1	81.8
131	Ex. 3	Long.	77.7	80.9	74.8	77.5	76.2	75.5
131	Active	Long.	94.4	94.5	91.1	89.7	87.6	90.5

Post-Treatment

			ROM (End Range Left + End Range Right) (degrees)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**
126	Ex. 2	Long.	68.7	62.9	64.3	66.8	68.0	67.6
126	Ex. 3	Long.	64.0	68.7	67.1	65.8	63.1	65.5
126	Active	Long.	69.6	75.0	75.8	72.8	82.1	77.0
127	Ex. 2	Long.	65.7	65.5	68.1	65.6	65.7	62.2
127	Ex. 3	Long.	57.1	51.7	54.9	59.5	59.4	57.4
127	Active	Long.	78.6	83.1	81.3	76.6	78.0	82.9
128	Ex. 2	Long.	81.6	82.4	81.6	80.2	81.8	76.6
128	Ex. 3	Long.	74.1	73.0	74.0	72.6	71.2	73.0
128	Active	Long.	81.9	85.0	86.2	84.0	79.6	85.3
129	Ex. 2	Long.	61.0	51.4	49.8	56.3	66.2	67.7
129	Ex. 3	Long.	46.1	41.7	49.0	54.0	48.7	50.9
129	Active	Long.	72.4	69.7	74.9	74.5	69.5	68.8
131	Ex. 2	Long.	81.0	73.4	75.7	76.7	78.0	79.1
131	Ex. 3	Long.	78.7	79.3	82.6	82.9	81.5	77.2
131	Active	Long.	96.2	97.7	97.5	95.6	98.5	93.7

A6. (cont'd)

72-Hours Post-Treatment

			ROM (End Range Left + End Range Right) (degrees)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**
126	Ex. 2	Long.	72.6	66.9	70.0	72.4	71.7	68.9
126	Ex. 3	Long.	67.0	70.4	70.5	69.8	62.7	68.4
126	Active	Long.	77.3	83.2	84.7	78.0	80.6	83.0
127	Ex. 2	Long.	58.4	61.6	63.0	60.0	59.8	61.7
127	Ex. 3	Long.	57.3	56.7	59.8	54.4	53.4	55.5
127	Active	Long.	69.1	74.1	72.9	73.1	75.8	76.8
128	Ex. 2	Long.	84.3	84.0	79.5	77.5	74.3	72.2
128	Ex. 3	Long.	75.9	76.0	74.3	76.0	76.9	78.2
128	Active	Long.	89.6	95.3	97.3	88.0	89.6	92.8
129	Ex. 2	Long.	52.1	49.2	46.9	53.5	45.8	49.6
129	Ex. 3	Long.	50.2	45.7	39.8	43.9	50.0	49.8
129	Active	Long.	63.3	64.4	61.6	73.0	63.4	59.4
131	Ex. 2	Long.	81.4	82.0	82.4	79.7	78.2	83.2
131	Ex. 3	Long.	75.8	76.3	76.5	72.4	77.5	80.8
131	Active	Long.	88.6	94.6	96.7	92.0	95.0	96.8

A7. Ranges of Axial Rotation (Secondary Motions)

			Right End Range Values (degrees) ("+" ipsilateral & "-" contralateral)						Left End Range Values (degrees) ("+" ipsilateral & "-" contralateral)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
4	Ex. 2	Cont.	5.8	11.9	8.2	5.7	12.4	11.0	10.9	8.1	6.9	4.1	8.4	11.5
4	Ex. 3	Cont.	7.5	11.0	13.5	9.9	13.2	10.4	1.7	0.5	1.7	0.5	0.8	2.0
4	Active	Cont.	16.7	6.9	10.8	14.4	11.2	11.6	11.2	0.7	5.9	8.7	8.5	15.3
5	Ex. 2	Cont.	5.8	11.9	8.2	7.0	14.2	11.7	10.9	8.1	6.9	6.7	3.8	4.1
5	Ex. 3	Cont.	4.6	12.5	13.4	6.0	10.1	13.3	4.6	2.3	2.6	2.7	1.4	2.0
5	Active	Cont.	16.7	6.9	10.8	6.4	3.1	-0.2	11.2	0.7	5.9	1.2	-0.4	3.2
27	Ex. 2	Cont.	-1.6	-1.9	1.1	0.5	-1.5	0.2	5.9	8.2	7.9	9.8	3.2	3.1
27	Ex. 3	Cont.	-4.6	-5.7	-3.7	2.2	0.6	-5.2	3.2	2.5	5.2	4.9	5.3	4.6
27	Active	Cont.	4.6	3.0	3.8	4.1	2.1	2.9	5.4	0.1	-1.9	7.3	2.4	-0.2
41	Ex. 2	Cont.	0.4	0.5	4.7	3.2	10.0	7.3	4.1	9.9	11.5	1.8	1.2	-10.7
41	Ex. 3	Cont.	5.6	8.1	6.0	4.8	2.0	4.6	-0.9	-1.2	-0.7	-0.1	4.2	3.6
41	Active	Cont.	8.9	15.4	15.7	9.9	19.9	13.5	2.6	-0.2	4.0	4.6	12.6	18.3
46	Ex. 2	Cont.	9.4	3.4	1.9	8.5	11.7	6.4	12.6	8.7	4.8	10.3	7.2	2.8
46	Ex. 3	Cont.	3.8	4.4	5.9	6.8	5.4	8.4	8.5	9.7	6.4	8.6	6.9	6.3
46	Active	Cont.	13.9	14.4	16.4	15.5	14.6	15.2	15.7	14.5	15.6	16.8	13.4	17.7
51	Ex. 2	Cont.	4.6	4.6	7.6	3.3	10.2	9.0	14.0			12.1	18.3	
51	Ex. 3	Cont.	4.5	5.8	6.0	3.1	-1.6	5.1	3.5	4.2	2.5	3.3	0.8	2.2
51	Active	Cont.	1.9	1.3	1.0	-3.9	2.8	4.4	9.4	9.3	8.2	10.8	14.7	6.3
56	Ex. 2	Cont.	9.7	7.7	12.1	12.0	9.0	9.2	9.0	15.7	13.8	9.7	11.6	14.2
56	Ex. 3	Cont.	8.1	8.3	11.9	9.5	10.1	7.7	7.0	10.2	6.2	8.5	6.8	7.4
56	Active	Cont.	10.3	9.3	9.3	13.3	15.8	16.2	3.0	7.6	9.7	11.5	10.3	9.6
59	Ex. 2	Cont.	10.0	9.9	8.8	9.7	8.1	12.6	6.0	5.5	4.7	14.8	8.0	
59	Ex. 3	Cont.	1.3	5.7	8.8	6.3	11.5	10.0	5.3	-1.2	6.0	8.2	2.2	-1.0
59	Active	Cont.	2.9	6.5	4.7	5.4	3.7	6.3	0.8	0.3	2.9	2.1	0.7	2.5
63	Ex. 2	Cont.	11.5	19.9	18.3	11.1	16.0	19.1	18.5	7.8	10.4	20.1	17.1	15.2
63	Ex. 3	Cont.	9.3	6.8	8.3	10.5	9.8	11.1	14.3	10.5	10.6	15.1	12.3	13.5
63	Active	Cont.	17.1	17.2	18.8	14.0	14.8	14.8	21.0	19.3	22.3	25.6	27.0	25.0

A7. (cont'd)

			Right End Range Values (degrees) ("+" ipsilateral & "-" contralateral)						Left End Range Values (degrees) ("+" ipsilateral & "-" contralateral)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
67	Ex. 2	Cont.	8.6	11.1	9.1	6.3	6.3	10.8	7.0	7.4	7.5	15.2	10.0	13.4
67	Ex. 3	Cont.	7.1	8.2	8.0	4.1	5.9	2.5	9.1	8.1	7.4	6.5	7.8	8.8
67	Active	Cont.	13.2	13.5	17.7	18.2	16.2	18.5	12.5	12.9	13.8	15.9	17.1	14.2
68	Ex. 2	Cont.	7.4	8.0	3.6	6.0	8.3	11.1	11.7	17.2	17.7	6.4	3.8	5.8
68	Ex. 3	Cont.	5.5	12.2	14.2	8.8	9.6	14.0	1.1	-3.0	-3.2	4.0	3.6	6.8
68	Active	Cont.	4.7	10.2	6.4	10.1	13.1	17.8	9.1	15.3	16.1	6.6	6.8	0.8
69	Ex. 2	Cont.	18.0	14.0	13.8	19.9	13.1	13.8	17.3	10.2	10.6	20.3	11.0	21.9
69	Ex. 3	Cont.	11.2	12.4	12.6	15.0	13.7	16.8	11.3	11.1	10.7	3.0	4.5	4.4
69	Active	Cont.	10.6	13.3	7.1	18.0	10.7	11.0	7.6	19.6	16.5	8.4	13.0	14.3
77	Ex. 2	Cont.	6.6	11.7	6.5	7.5	5.4	9.7	7.8	5.4	10.9	10.6	11.4	9.3
77	Ex. 3	Cont.	6.6	6.2	8.8	4.6	3.6	-0.2	8.3	11.1	8.9	7.1	6.1	4.9
77	Active	Cont.	6.2	0.2	2.1	5.1	3.1	7.1	12.8	3.5	0.9	4.9	5.3	-0.9
79	Ex. 2	Cont.	7.6	10.3	5.8	10.1	11.5	7.0	16.6	14.6	13.9	16.7	11.5	11.9
79	Ex. 3	Cont.	9.2	6.4	8.6	6.5	6.7	6.8	10.7	11.4	10.1	10.9	7.9	9.6
79	Active	Cont.	13.2	9.1	10.3	14.6	13.7	14.8	13.8	15.8	15.0	17.4	17.8	15.0
83	Ex. 2	Cont.	4.9	6.2	9.7	6.7	7.2	2.5	4.5	2.7	-2.8	2.4	3.4	1.8
83	Ex. 3	Cont.	6.3	9.4	8.5	2.7	5.6	3.6	-1.5	0.0	-1.9	0.0	2.7	-1.1
83	Active	Cont.	16.1	10.1	10.0	19.9	11.3	12.9	1.9	-0.6	1.4	-0.1	-0.9	-0.1
85	Ex. 2	Cont.	9.1	8.8	6.7	7.4	10.4	11.0	8.3	10.4	8.4	10.1	5.3	9.0
85	Ex. 3	Cont.	8.2	8.5	9.3	7.2	8.3	8.6	5.1	8.8	1.2	3.9	4.0	7.2
85	Active	Cont.	2.8	6.8	5.6	2.2	6.9	6.3	6.1	8.8	8.0	0.9	6.6	3.1
88	Ex. 2	Cont.	10.1	8.6	3.3	12.8	8.6	8.9	12.5	6.7	13.3	13.3	7.0	9.5
88	Ex. 3	Cont.	8.9	17.8	13.4	12.2	17.4	15.6	14.4	10.8	15.8	10.0	12.6	12.6
88	Active	Cont.	18.3	20.2	19.9	16.0	18.3	19.3	19.1	18.1	16.4	15.2	15.1	11.3
90	Ex. 2	Cont.	17.3	21.5	19.4	14.0	15.3	16.2	23.3	19.4	18.1	15.4	18.2	20.2
90	Ex. 3	Cont.	14.2	12.3	11.8	14.9	15.5	8.7	15.3	12.9	16.8	14.9	9.7	9.4
90	Active	Cont.	14.6	10.5	11.4	9.6	11.8	12.5	19.0	17.2	10.5	17.9	16.1	15.8

A7. (cont'd)

			Right End Range Values (degrees) ("+" ipsilateral & "-" contralateral)						Left End Range Values (degrees) ("+" ipsilateral & "-" contralateral)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
96	Ex. 2	Cont.	9.4	8.9	8.9	11.6	17.5	12.1	12.0	13.8	10.2	10.1	10.4	13.5
96	Ex. 3	Cont.	11.7	7.5	10.4	9.5	8.4	6.8	11.0	13.3	9.9	7.5	7.9	11.7
96	Active	Cont.	11.7	7.5	10.4	9.5	8.4	6.8	11.0	13.3	9.9	7.5	7.9	11.7
106	Ex. 2	Cont.	10.4	12.6	12.6	9.2	9.9	11.7	17.2	16.4	14.2	16.5	14.2	16.9
106	Ex. 3	Cont.	13.5	21.4	18.1	15.1	16.7	14.4	15.0	5.8	13.7	20.4	17.9	22.7
106	Active	Cont.	16.5	9.9	18.3	27.8	24.6	20.2	14.6	13.6	12.8	12.0	11.0	9.7
111	Ex. 2	Cont.	8.6	7.5	12.8	2.2	14.3	4.2	17.4	16.5	12.3	18.4		7.9
111	Ex. 3	Cont.	7.1	9.1	9.2	17.3	8.0	10.2	7.0	9.5	9.0	13.3	11.5	19.9
111	Active	Cont.	22.7	22.4	25.5	20.1	23.1	28.1	13.7	10.7	10.3	20.2	17.4	19.3
117	Ex. 2	Cont.	12.1	8.0	7.4	5.8	5.6	7.8	13.1	5.5	11.5	10.1	13.5	20.3
117	Ex. 3	Cont.	10.8	10.0	10.0	11.1	10.2	8.0	4.1	1.3	8.8	8.4	2.7	4.8
117	Active	Cont.	12.5	10.7	9.3	12.2	11.4	13.8	10.7	10.4	8.4	18.4	13.2	17.3

Pre-Treatment

			Right End Range Values (degrees) ("+" ipsilateral & "-" contralateral)						Left End Range Values (degrees) ("+" ipsilateral & "-" contralateral)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
6	Ex. 2	Exp.	11.6	14.1	9.8	13.2	11.1	6.6	9.1	9.6	11.2	1.9	5.7	7.1
6	Ex. 3	Exp.	18.5	16.0	13.5	7.6	8.6	9.7	1.8	5.0	-0.1	6.8	3.8	7.1
6	Active	Exp.	19.4			21.1	16.7	13.4	15.4	0.0	0.0	22.9	21.1	28.1
9	Ex. 2	Exp.	3.4	2.1	6.4	11.5	14.0	9.5	10.1	13.3	11.0	7.7	5.7	9.4
9	Ex. 3	Exp.	7.0	6.5	4.1	9.0	6.0	4.3	11.2	10.8	9.2	10.9	8.4	11.6
9	Active	Exp.	15.8	18.4	17.6	3.4	6.0	-1.6	10.6	11.7	10.6	9.6	10.4	11.3
12	Ex. 2	Exp.	16.4	13.5	14.9	13.0	12.1	12.2	15.0	10.6	13.4	15.2	18.6	18.8
12	Ex. 3	Exp.	11.0	20.5	15.0	7.0	16.6	14.9	3.7	5.0	5.5	5.6	5.0	7.1
12	Active	Exp.	22.0	22.4	21.7	20.5	23.8	19.7	9.2	13.0	12.4	11.1	11.3	14.9

A7. (cont'd)

Pre-Treatment

			Right End Range Values (degrees) ("+" ipsilateral & "-" contralateral)						Left End Range Values (degrees) ("+" ipsilateral & "-" contralateral)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
14	Ex. 2	Exp.	12.6	13.1	18.3	11.6	10.8	19.3	7.4	7.0	9.0	6.0	18.2	9.2
14	Ex. 3	Exp.	16.4	14.2	12.1	11.4	5.6	7.6	6.1	10.0	12.1	13.3	-1.5	6.6
14	Active	Exp.	18.4	28.9	11.6	19.3	-6.3	3.0	-0.5	3.0	-9.7	16.0	-2.2	3.3
23	Ex. 2	Exp.	6.1	7.6	5.3	9.1	12.0	14.5	7.2	9.4	10.8	3.5	3.1	-0.9
23	Ex. 3	Exp.	13.5	15.2	13.9	5.4	3.4	8.2	4.6	7.7	6.1	2.4	3.7	3.3
23	Active	Exp.	9.5	7.8	6.9	5.2	5.6	4.5	8.6	12.7	46.2	7.3	9.3	9.7
25	Ex. 2	Exp.	1.5	7.2	4.6	2.3	8.3	3.3	-2.8	-2.0	-5.0	0.3	1.7	-0.7
25	Ex. 3	Exp.	0.3	5.3	5.8	6.4	6.8	6.1	2.3	-0.1	0.0	-0.5	-2.2	0.0
25	Active	Exp.	6.1	10.3	10.0	6.6	11.8	13.6	10.6	9.7	10.7	9.3	6.6	5.2
54	Ex. 2	Exp.	3.0	8.0	7.2	-0.2	7.0	4.8	-5.4	-6.1	-5.5	7.8	-1.6	-0.6
54	Ex. 3	Exp.	6.2	3.5	7.1	-1.4	-4.3	2.8	-10.4	-13.3	-8.4	-7.9	-4.6	-12.3
54	Active	Exp.	7.5	6.1	5.0	5.4	3.8	3.9	-1.1	2.9	4.7	5.7	7.8	6.9
55	Ex. 2	Exp.	6.7	12.1		8.2	10.4	7.5	11.8	22.8		16.3	15.8	16.5
55	Ex. 3	Exp.	5.9	5.5	4.3	3.9	7.1	6.4	0.3	6.6	2.2	3.8	6.1	2.8
55	Active	Exp.	5.6	3.9	1.7	7.5	7.1	8.1	5.9	8.8	0.0	2.6	3.3	3.1
57	Ex. 2	Exp.	9.4	9.6	10.2	10.8	7.5	10.8	14.5	19.6	15.9	21.3	19.9	19.0
57	Ex. 3	Exp.	9.9	4.8	4.8	6.2	5.0	2.2	11.1	7.9	6.8	11.1	9.1	10.1
57	Active	Exp.	2.8	4.8	7.9	2.6	9.6	4.3	6.1	6.2	6.5	3.2	8.5	3.1
70	Ex. 2	Exp.	15.0	15.0	13.4	18.3	18.1	13.7	8.6	-0.1	7.6	7.7	6.4	5.5
70	Ex. 3	Exp.	8.0	10.7	11.1	8.4	12.6	10.6	-0.9	-4.6	-1.8	-3.2	-0.4	-5.0
70	Active	Exp.	17.7	19.5	19.0	15.6	16.3	21.1	11.0	5.2	7.7	17.3	15.5	14.6
72	Ex. 2	Exp.	8.3	9.2	8.8	6.0	14.2	11.6	6.8	9.5	3.1	9.1	8.5	8.0
72	Ex. 3	Exp.	11.9	11.7	9.3	4.1	6.2	8.8	0.5	5.1	1.6	0.7	2.6	1.9
72	Active	Exp.	0.1	-10.4	-7.4	-9.8	-7.5	-7.2	4.9	-5.8	-15.9	-14.3	-10.0	-17.0
80	Ex. 2	Exp.	9.7	10.8	14.6	10.7	7.3	13.3	16.2	17.0	13.5	14.4	17.6	17.7
80	Ex. 3	Exp.	7.7	10.1	7.2	7.9	8.4	9.9	7.5	7.9	8.5	13.9	12.3	13.1
80	Active	Exp.	15.1	16.3	16.3	13.7	19.7	15.2	18.5	16.2	13.6	10.2	8.7	7.2

A7. (cont'd)

Pre-Treatment

			Right End Range Values (degrees) ("+" ipsilateral & "-" contralateral)						Left End Range Values (degrees) ("+" ipsilateral & "-" contralateral)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
84	Ex. 2	Exp.	7.4	7.7	6.4	11.0	15.2	20.2	17.2	5.2	13.0	17.4	9.3	9.8
84	Ex. 3	Exp.	10.2	11.3	12.4	11.0	10.6	9.5	13.3	13.2	11.2	18.5	13.6	22.8
84	Active	Exp.	18.7	19.4	21.1	23.3	25.1	23.4	20.6	25.5	24.3	21.7	27.0	25.9
91	Ex. 2	Exp.	8.6	8.4	8.7	10.2	7.2	9.0	7.2	3.2	3.0	5.0	-6.0	0.0
91	Ex. 3	Exp.	10.4	10.3	8.5	15.4	11.7	11.9	-1.1	4.2	0.0	6.1	1.1	4.1
91	Active	Exp.	9.5	11.3	11.7	10.5	9.0	10.7	-0.8	-1.5	-5.1	1.7	8.3	4.2
95	Ex. 2	Exp.	11.3	14.2	15.2	9.4	13.2	17.8	9.4	6.7	11.7	6.4	9.0	9.0
95	Ex. 3	Exp.	11.1	12.0	10.8	11.7	10.8	11.3	2.4	-0.5	1.6	3.2	2.7	0.2
95	Active	Exp.	12.5	12.1	15.9	11.6	15.1	15.3	5.3	2.9	4.0	-0.4	5.0	8.0
98	Ex. 2	Exp.	11.2	13.9	13.4	17.5	16.8	15.8	24.2	22.1	23.9	26.4	20.5	22.5
98	Ex. 3	Exp.	18.8	20.5	17.0	18.0	17.1	16.5	22.8	23.5	15.3	20.2	18.6	13.5
98	Active	Exp.	30.1	28.0	27.3	36.0	30.5	25.2	35.3	29.8	16.0	22.0	23.7	25.3
112	Ex. 2	Exp.	22.5	18.5	16.7	19.3	10.8	16.3	13.0	10.3	11.8	19.5	16.1	15.7
112	Ex. 3	Exp.	14.5	13.0	14.3	14.5	12.2	11.7	8.1	7.1	16.6	12.8	12.9	16.3
112	Active	Exp.	14.6	16.6	16.5	13.7	15.7	12.0	17.9	11.9	16.5	8.0	12.0	17.1
115	Ex. 2	Exp.	16.9	10.4	17.9	20.1	22.8	27.1	30.4	35.5	0.0	26.6	26.9	29.7
115	Ex. 3	Exp.	16.8	17.0	17.2	13.6	14.3	13.8	22.2	22.8	27.3	31.6	26.4	26.8
115	Active	Exp.	20.2	22.4	28.4				29.8	30.1	32.3			
125	Ex. 2	Exp.	13.2	17.1	13.8	12.9	11.6	8.8	12.0	18.5	16.9	18.9	18.6	21.0
125	Ex. 3	Exp.	11.9	15.2	14.4	12.7	14.8	12.5	7.6	7.9	8.0	8.9	2.2	4.5
125	Active	Exp.	22.1	25.7	27.0	21.8	28.8	25.8	29.1	32.9	37.4	24.6	30.6	30.0

A7. (cont'd)

Post-Treatment

			Right End Range Values (degrees) ("+" ipsilateral & "-" contralateral)						Left End Range Values (degrees) ("+" ipsilateral & "-" contralateral)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
6	Ex. 2	Exp.	10.8	13.4	16.1	8.7	9.8	12.4	15.9	14.0	12.7	13.5	15.6	7.8
6	Ex. 3	Exp.	14.6	17.8	14.5	10.9	8.9	9.3	5.3	3.2	7.1	7.9	5.0	5.2
6	Active	Exp.	23.5	25.8	30.9	17.4	19.5	18.8	20.8	26.8	24.1	22.7	25.7	27.7
9	Ex. 2	Exp.	7.4	0.8	2.4	10.8	12.4	10.8	15.5	17.4	21.9	15.0	16.4	15.1
9	Ex. 3	Exp.	4.6	11.3	9.0	12.4	-8.2	-8.2	5.9	3.6	6.3	20.3	-11.7	2.8
9	Active	Exp.	15.0	25.6	16.5	17.9	19.5	21.3	9.2	9.6	8.8	17.6	15.9	7.7
12	Ex. 2	Exp.	9.8	9.2	13.2	9.6	9.7	13.1	20.5	15.5	11.8	15.7	9.4	1.0
12	Ex. 3	Exp.	7.0	10.4	10.1	7.1	11.6	9.1	3.7	1.5	6.5	5.0	6.2	11.5
12	Active	Exp.	19.8	22.1	24.2	18.5	23.4	19.0	8.8	12.8	12.2	11.8	11.5	15.0
14	Ex. 2	Exp.	10.9	9.8	6.9	11.9	16.3	14.3	-7.2	4.4	-3.5	9.1	16.6	15.1
14	Ex. 3	Exp.	8.3	10.5	9.6	4.4	5.5	5.5	1.2	-3.9	-1.4	-0.5	-6.6	-0.6
14	Active	Exp.	8.3	-0.4	-8.7	4.0	-9.4	-10.3	-10.9	19.1	13.5	10.6	-5.8	18.6
23	Ex. 2	Exp.	4.4	3.2	-2.4	7.6	6.1	4.2	6.5	2.4	-1.5	-1.5	-5.8	-9.0
23	Ex. 3	Exp.	8.7	8.3	4.2	7.4	8.7	7.1	6.5	8.2	7.2	10.4	8.1	9.1
23	Active	Exp.	9.7	9.5	10.6	4.2	11.3	8.9	9.8	11.9	11.8	6.8	10.0	6.0
25	Ex. 2	Exp.	-0.4	0.9	6.1	8.5	12.1	13.6	-0.7	-0.7	3.2	1.9	0.6	0.9
25	Ex. 3	Exp.	5.3	10.2	10.2	7.0	6.8	6.4	-3.0	-3.7	-7.0	-3.7	-3.1	-5.5
25	Active	Exp.	1.9	7.4	6.4	9.7	12.1	12.9	7.9	7.4	7.0	6.2	3.0	0.6
54	Ex. 2	Exp.	8.0	9.6	3.0	14.1	10.7	8.1	4.5	2.5	6.4	1.7	16.6	9.0
54	Ex. 3	Exp.	-0.2	7.4	5.0	0.8	-2.3	-1.7	-10.9	-12.9	-14.7	-2.4	-2.9	3.8
54	Active	Exp.	11.3	5.7	8.3	10.6	14.0	17.0	3.1	2.9	4.5	2.7	4.7	12.2
55	Ex. 2	Exp.	6.8	9.1	8.1	11.3	12.9	10.3	16.9	14.6	14.8	11.5	6.5	8.0
55	Ex. 3	Exp.	1.0	4.9	4.9	0.6	3.6	1.7	3.7	4.8	4.7	5.6	4.9	1.7
55	Active	Exp.	2.9	2.4	3.4	6.4	3.3	4.1	9.9	8.4	8.7	9.3	9.6	9.6
57	Ex. 2	Exp.	7.0	11.5	9.3	6.0	6.3	10.7	12.4	16.0	13.0	17.5	10.2	18.7
57	Ex. 3	Exp.	4.8	2.6	-1.2	9.2	7.4	6.3	8.3	5.8	8.2	7.8	3.4	1.8
57	Active	Exp.	7.6	14.3	10.2	13.6	14.3	10.8	12.2	1.9	3.3	5.7	7.3	3.2

A7. (cont'd)

Post-Treatment

			Right End Range Values (degrees) ("+" ipsilateral & "-" contralateral)						Left End Range Values (degrees) ("+" ipsilateral & "-" contralateral)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
70	Ex. 2	Exp.	13.9	13.4	15.7	12.7	16.6	15.2	11.2	21.6	19.1	12.5	18.5	14.4
70	Ex. 3	Exp.	7.2	14.6	15.6	13.4	20.2	22.9	4.9	1.7	2.1	5.3	6.2	3.6
70	Active	Exp.	14.7	15.6	18.5	19.2	22.1	24.2	15.1	17.5	16.1	20.0	18.9	19.7
72	Ex. 2	Exp.	8.5	8.8	5.1	6.3	4.9	7.1	2.1	7.8	4.0	0.3	-3.2	4.8
72	Ex. 3	Exp.	-0.2	0.4	2.1	0.9	2.4	2.0	0.2	-1.0	-3.0	4.1	1.2	2.3
72	Active	Exp.	-0.6	-9.1	-10.2	-8.8	-19.1	-16.1	-1.6	-3.9	-9.6	-1.6	0.8	-8.5
80	Ex. 2	Exp.	10.4	14.1	13.5	8.6	14.1	15.5	17.0	21.6	17.0	15.3	15.1	16.6
80	Ex. 3	Exp.	5.4	7.6	5.7	11.4	8.6	6.5	8.6	12.9	13.3	13.5	12.1	11.7
80	Active	Exp.	15.4	15.5	12.2	11.5	12.1	11.0	12.3	12.4	9.9	9.3	5.3	7.1
84	Ex. 2	Exp.	13.4	14.6	11.6	12.6	14.2	13.5	10.6	11.4	11.3	15.6	11.9	10.7
84	Ex. 3	Exp.	7.4	7.7	10.8	10.8	9.5	5.6	16.8	13.4	18.8	14.3	16.5	17.8
84	Active	Exp.	17.0	23.1	20.2	19.0	25.3	24.7	26.1	29.8	21.0	19.6	23.5	26.3
91	Ex. 2	Exp.	10.7	10.1	10.3	10.3	11.5	10.5	6.3	6.2	11.5	3.9	8.1	6.1
91	Ex. 3	Exp.	11.9	13.1	10.1	13.2	14.3	13.1	0.1	-5.2	-1.5	3.4	5.1	4.8
91	Active	Exp.	8.6	8.9	9.6	10.5	13.0	17.8	4.4	5.2	2.3	-4.1	1.5	6.5
95	Ex. 2	Exp.	13.2	19.0	14.5	15.5	17.2	18.3	11.7	12.6	6.5	10.6	12.5	8.0
95	Ex. 3	Exp.				14.8	13.4	11.2				4.4	0.8	4.3
95	Active	Exp.	10.9	11.1	11.9	11.4	9.6	15.8	-0.8	5.8	13.6	4.8	5.9	-3.3
98	Ex. 2	Exp.	12.9	13.9	11.8	13.6	20.1	22.1	21.2	15.6	13.9	22.4	16.8	15.1
98	Ex. 3	Exp.	20.8	16.3	17.5	18.2	19.2	18.1	18.7	11.9	13.7	14.8	13.4	11.4
98	Active	Exp.	31.0	27.8	24.7	27.8	29.3	32.7	20.2	19.5	10.8	15.6	22.3	21.0
112	Ex. 2	Exp.	19.1	16.8	17.6	17.2	15.7	17.9	13.2	9.9	11.0	14.1	15.6	23.6
112	Ex. 3	Exp.	10.9	12.0	14.8	11.2	10.7	14.4	11.1	14.6	19.1	15.4	14.3	18.2
112	Active	Exp.	14.6	14.1	12.6	10.1	9.6	9.4	10.3	11.8	9.3	12.2	10.9	9.6

A7. (cont'd)

Post-Treatment

			Right End Range Values (degrees) ("+" ipsilateral & "-" contralateral)						Left End Range Values (degrees) ("+" ipsilateral & "-" contralateral)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
115	Ex. 2	Exp.	19.2	21.1	19.0	22.2	24.7	25.6	27.0	24.1	9.6	24.1	26.8	6.3
115	Ex. 3	Exp.	19.1	15.6	18.6	16.4	16.6	18.2	20.2	22.0	23.3	24.7	28.7	25.3
115	Active	Exp.	13.1	14.1	24.1	17.3	27.4	21.2	23.4	48.8	32.8	20.9	30.0	44.5
125	Ex. 2	Exp.	13.2	17.1	13.8	12.9	11.6	8.8	12.0	18.5	16.9	18.9	18.6	21.0
125	Ex. 3	Exp.	11.9	15.2	14.4	12.7	14.8	12.5	7.6	7.9	8.0	8.9	2.2	4.5
125	Active	Exp.	22.1	25.7	27.0	21.8	28.8	25.8	29.1	32.9	37.4	24.6	30.6	30.0

			ROM (End Range Left + End Range Right) (degrees)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**
4	Ex. 2	Cont.	16.8	20.0	15.1	9.9	20.8	22.4
4	Ex. 3	Cont.	9.2	11.5	15.2	10.4	14.0	12.4
4	Active	Cont.	27.9	7.6	16.7	23.1	19.7	26.8
5	Ex. 2	Cont.	16.8	20.0	15.1	13.7	18.0	15.8
5	Ex. 3	Cont.	9.2	14.8	16.1	8.7	11.5	15.3
5	Active	Cont.	27.9	7.6	16.7	7.6	2.7	3.0
27	Ex. 2	Cont.	4.3	6.3	8.9	10.2	1.7	3.3
27	Ex. 3	Cont.	-1.4	-3.2	1.5	7.1	5.9	-0.7
27	Active	Cont.	10.0	3.1	1.9	11.4	4.5	2.7
41	Ex. 2	Cont.	4.5	10.4	16.2	5.0	11.2	-3.4
41	Ex. 3	Cont.	4.7	6.9	5.3	4.7	6.2	8.2
41	Active	Cont.	11.4	15.2	19.7	14.6	32.4	31.8
46	Ex. 2	Cont.	22.0	12.2	6.6	18.9	18.9	9.2
46	Ex. 3	Cont.	12.4	14.1	12.2	15.4	12.2	14.7
46	Active	Cont.	29.6	28.9	32.0	32.3	28.0	32.9

A7. (cont'd)

			ROM (End Range Left + End Range Right) (degrees)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**
51	Ex. 2	Cont.	18.6			15.4	28.5	
51	Ex. 3	Cont.	7.9	10.0	8.5	6.4	-0.8	7.3
51	Active	Cont.	11.3	10.6	9.2	7.0	17.4	10.7
56	Ex. 2	Cont.	18.6	23.5	25.9	21.7	20.6	23.4
56	Ex. 3	Cont.	15.1	18.5	18.1	18.0	16.9	15.1
56	Active	Cont.	13.3	16.9	19.1	24.8	26.0	25.7
59	Ex. 2	Cont.	15.9	15.4	13.6	24.5	16.1	
59	Ex. 3	Cont.	6.5	4.5	14.7	14.4	13.7	9.1
59	Active	Cont.	3.7	6.7	7.6	7.6	4.4	8.8
63	Ex. 2	Cont.	30.0	27.7	28.7	31.2	33.0	34.4
63	Ex. 3	Cont.	23.6	17.3	18.9	25.6	22.1	24.7
63	Active	Cont.	38.0	36.4	41.1	39.6	41.9	39.8
67	Ex. 2	Cont.	15.6	18.4	16.6	21.5	16.3	24.1
67	Ex. 3	Cont.	16.2	16.2	15.4	10.6	13.8	11.2
67	Active	Cont.	25.7	26.4	31.4	34.1	33.3	32.8
68	Ex. 2	Cont.	19.1	25.2	21.3	12.4	12.1	16.9
68	Ex. 3	Cont.	6.6	9.2	11.0	12.8	13.3	20.7
68	Active	Cont.	13.8	25.5	22.5	16.7	19.9	18.5
69	Ex. 2	Cont.	35.3	24.2	24.4	40.2	24.1	35.7
69	Ex. 3	Cont.	22.5	23.4	23.3	18.0	18.1	21.2
69	Active	Cont.	18.1	32.9	23.6	26.5	23.7	25.2
77	Ex. 2	Cont.	14.4	17.1	17.3	18.1	16.7	18.9
77	Ex. 3	Cont.	14.8	17.3	17.7	11.7	9.6	4.6
77	Active	Cont.	19.0	3.7	3.0	10.0	8.3	6.2
79	Ex. 2	Cont.	24.2	24.8	19.7	26.9	23.0	18.9
79	Ex. 3	Cont.	19.9	17.8	18.8	17.4	14.6	16.3
79	Active	Cont.	26.9	24.9	25.3	32.1	31.5	29.8

A7. (cont'd)

			ROM (End Range Left + End Range Right) (degrees)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**
83	Ex. 2	Cont.	9.5	8.9	6.9	9.1	10.6	4.3
83	Ex. 3	Cont.	4.7	9.4	6.7	2.7	8.3	2.5
83	Active	Cont.	18.0	9.5	11.4	19.8	10.4	12.8
85	Ex. 2	Cont.	17.4	19.1	15.1	17.5	15.7	19.9
85	Ex. 3	Cont.	13.2	17.3	10.5	11.1	12.2	15.8
85	Active	Cont.	8.9	15.6	13.6	3.1	13.6	9.4
88	Ex. 2	Cont.	22.6	15.4	16.6	26.0	15.6	18.4
88	Ex. 3	Cont.	23.3	28.6	29.2	22.2	29.9	28.2
88	Active	Cont.	37.4	38.3	36.3	31.2	33.4	30.6
90	Ex. 2	Cont.	40.7	40.9	37.5	29.4	33.5	36.4
90	Ex. 3	Cont.	29.5	25.2	28.6	29.9	25.2	18.1
90	Active	Cont.	33.6	27.7	21.8	27.5	27.9	28.4
96	Ex. 2	Cont.	21.4	22.6	19.1	21.7	27.9	25.5
96	Ex. 3	Cont.	22.6	20.8	20.4	17.0	16.3	18.5
96	Active	Cont.	22.6	20.8	20.4	17.0	16.3	18.5
106	Ex. 2	Cont.	27.6	29.0	26.8	25.8	24.1	28.6
106	Ex. 3	Cont.	28.6	27.2	31.7	35.5	34.6	37.1
106	Active	Cont.	31.1	23.5	31.1	39.8	35.6	29.9
111	Ex. 2	Cont.	26.0	24.0	25.1	20.6		12.1
111	Ex. 3	Cont.	14.1	18.6	18.2	30.7	19.5	30.1
111	Active	Cont.	36.4	33.1	35.8	40.2	40.5	47.5
117	Ex. 2	Cont.	25.2	13.4	18.9	15.9	19.1	28.1
117	Ex. 3	Cont.	14.9	11.3	18.7	19.5	12.9	12.8
117	Active	Cont.	23.2	21.1	17.7	30.6	24.5	31.2

A7. (cont'd)

			Pre-Treatment						Post-Treatment					
			ROM (End Range Left + End Range Right) (degrees)						ROM (End Range Left + End Range Right) (degrees)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
6	Ex. 2	Exp.	20.7	23.7	21.0	15.1	16.8	13.7	26.7	27.4	28.8	22.2	25.3	20.2
6	Ex. 3	Exp.	20.3	21.0	13.3	14.4	12.5	16.8	19.8	21.0	21.7	18.8	13.9	14.5
6	Active	Exp.	34.8			44.0	37.8	41.6	44.3	52.6	55.0	40.0	45.2	46.5
9	Ex. 2	Exp.	13.5	15.4	17.5	19.2	19.8	18.9	22.9	18.2	24.3	25.7	28.9	25.9
9	Ex. 3	Exp.	18.2	17.3	13.2	19.9	14.3	15.9	10.4	15.0	15.4	32.7	-19.9	-5.4
9	Active	Exp.	26.3	30.1	28.1	13.0	16.3	9.8	24.1	35.2	25.3	35.5	35.4	29.0
12	Ex. 2	Exp.	31.4	24.0	28.3	28.2	30.8	31.0	30.3	24.7	25.1	25.2	19.2	14.1
12	Ex. 3	Exp.	14.6	25.4	20.6	12.6	21.6	22.0	10.7	11.9	16.6	12.0	17.9	20.6
12	Active	Exp.	31.2	35.4	34.0	31.6	35.2	34.5	28.5	34.9	36.4	30.3	35.0	34.0
14	Ex. 2	Exp.	20.0	20.2	27.3	17.6	28.9	28.4	3.7	14.1	3.4	21.0	32.9	29.4
14	Ex. 3	Exp.	22.5	24.2	24.1	24.6	4.1	14.1	9.5	6.6	8.2	3.9	-1.1	4.9
14	Active	Exp.	17.9	31.9	1.9	35.3	-8.5	6.3	-2.6	18.7	4.8	14.6	-15.2	8.3
23	Ex. 2	Exp.	13.2	17.0	16.1	12.6	15.0	13.7	10.9	5.6	-3.9	6.2	0.4	-4.8
23	Ex. 3	Exp.	18.0	22.9	20.0	7.8	7.1	11.5	15.2	16.4	11.4	17.8	16.7	16.2
23	Active	Exp.	18.1	20.5	53.1	12.5	14.9	14.2	19.5	21.4	22.4	11.0	21.3	14.9
25	Ex. 2	Exp.	-1.3	5.2	-0.4	2.6	9.9	2.6	-1.1	0.2	9.3	10.4	12.7	14.4
25	Ex. 3	Exp.	2.6	5.2	5.8	5.8	4.6	6.1	2.3	6.5	3.2	3.3	3.7	0.9
25	Active	Exp.	16.7	19.9	20.7	15.9	18.5	18.8	9.8	14.8	13.4	15.9	15.0	13.5
54	Ex. 2	Exp.	-2.3	1.9	1.7	7.6	5.4	4.1	12.4	12.1	9.4	15.8	27.3	17.1
54	Ex. 3	Exp.	-4.2	-9.7	-1.3	-9.3	-8.9	-9.5	-11.1	-5.4	-9.7	-1.7	-5.2	2.2
54	Active	Exp.	6.4	9.1	9.7	11.1	11.6	10.8	14.3	8.6	12.7	13.3	18.7	29.2
55	Ex. 2	Exp.	18.5	34.9		24.4	26.3	24.0	23.8	23.7	22.9	22.8	19.4	18.4
55	Ex. 3	Exp.	6.2	12.1	6.5	7.7	13.2	9.1	4.7	9.7	9.6	6.2	8.5	3.4
55	Active	Exp.	11.5	12.7		10.1	10.4	11.2	12.8	10.8	12.0	15.7	12.9	13.7
57	Ex. 2	Exp.	23.8	29.3	26.0	32.2	27.4	29.8	19.5	27.6	22.3	23.5	16.4	29.4
57	Ex. 3	Exp.	21.0	12.7	11.6	17.3	14.0	12.3	13.1	8.5	6.9	17.0	10.8	8.2
57	Active	Exp.	8.9	11.0	14.4	5.8	18.1	7.4	19.8	16.2	13.5	19.3	21.6	13.9

A7. (cont'd)

			Pre-Treatment						Post-Treatment					
			ROM (End Range Left + End Range Right) (degrees)						ROM (End Range Left + End Range Right) (degrees)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
70	Ex. 2	Exp.	23.6	15.0	21.0	26.1	24.5	19.2	25.2	35.0	34.8	25.2	35.1	29.5
70	Ex. 3	Exp.	7.1	6.0	9.3	5.2	12.1	5.6	12.1	16.3	17.7	18.7	26.4	26.4
70	Active	Exp.	28.6	24.7	26.7	32.8	31.8	35.6	29.8	33.1	34.6	39.2	40.9	43.9
72	Ex. 2	Exp.	15.0	18.7	11.9	15.0	22.7	19.5	10.6	16.6	9.1	6.6	1.7	11.8
72	Ex. 3	Exp.	12.4	16.9	10.9	4.8	8.8	10.8	-0.1	-0.6	-0.9	4.9	3.6	4.3
72	Active	Exp.	5.0	-16.3	-23.3	-24.1	-17.5	-24.2	-2.3	-13.0	-19.8	-10.4	-18.3	-24.6
80	Ex. 2	Exp.	25.8	27.8	28.1	25.1	24.9	31.0	27.4	35.7	30.5	23.9	29.1	32.1
80	Ex. 3	Exp.	15.2	18.0	15.7	21.8	20.7	22.9	13.9	20.5	19.0	24.9	20.7	18.2
80	Active	Exp.	33.7	32.5	29.9	23.9	28.4	22.4	27.7	27.9	22.1	20.9	17.4	18.1
84	Ex. 2	Exp.	24.6	12.8	19.4	28.3	24.4	30.0	24.0	26.0	22.9	28.1	26.1	24.1
84	Ex. 3	Exp.	23.5	24.5	23.6	29.5	24.2	32.3	24.2	21.1	29.6	25.2	25.9	23.4
84	Active	Exp.	39.4	44.9	45.4	45.0	52.2	49.3	43.1	52.8	41.2	38.6	48.7	51.1
91	Ex. 2	Exp.	15.8	11.6	11.7	15.2	1.1	9.0	17.0	16.3	21.8	14.2	19.6	16.6
91	Ex. 3	Exp.	9.4	14.4	8.5	21.5	12.9	16.0	12.0	7.9	8.6	16.6	19.4	17.9
91	Active	Exp.	8.8	9.8	6.6	12.2	17.3	14.9	13.0	14.2	11.8	6.5	14.5	24.3
95	Ex. 2	Exp.	20.7	20.9	26.9	15.8	22.2	26.8	24.9	31.6	20.9	26.1	29.7	26.3
95	Ex. 3	Exp.	13.5	11.4	12.4	14.9	13.4	11.5				19.2	14.3	15.5
95	Active	Exp.	17.8	14.9	19.8	11.2	20.1	23.2	10.1	16.9	25.5	16.2	15.5	12.5
98	Ex. 2	Exp.	35.4	36.0	37.3	43.9	37.2	38.3	34.2	29.5	25.7	36.0	37.0	37.2
98	Ex. 3	Exp.	41.6	44.0	32.3	38.2	35.7	29.9	39.5	28.2	31.2	33.1	32.7	29.5
98	Active	Exp.	65.5	57.8	43.3	58.0	54.1	50.4	51.2	47.3	35.6	43.4	51.5	53.6

A7. (cont'd)

			Pre-Treatment						Post-Treatment					
			ROM (End Range Left + End Range Right) (degrees)						ROM (End Range Left + End Range Right) (degrees)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
112	Ex. 2	Exp.	35.5	28.7	28.5	38.8	26.9	32.0	32.3	26.7	28.6	31.3	31.3	41.4
112	Ex. 3	Exp.	22.6	20.0	30.9	27.3	25.1	28.0	22.0	26.6	33.9	26.6	25.0	32.6
112	Active	Exp.	32.5	28.5	33.0	21.7	27.7	29.1	24.9	25.9	21.9	22.2	20.6	18.9
115	Ex. 2	Exp.	47.2	45.9		46.8	49.7	56.8	46.1	45.2	28.6	46.3	51.4	31.9
115	Ex. 3	Exp.	39.0	39.8	44.4	45.2	40.7	40.5	39.2	37.6	28.2	41.0	45.3	43.5
115	Active	Exp.	49.9	52.5	60.7				36.5	62.9	56.9	38.2	57.4	65.7
125	Ex. 2	Exp.	25.2	35.6	30.7	31.8	30.2	29.9	25.2	35.6	30.7	31.8	30.2	29.9
125	Ex. 3	Exp.	19.4	23.0	22.4	21.6	17.0	17.0	19.4	23.0	22.4	21.6	17.0	17.0
125	Active	Exp.	51.2	58.7	64.4	46.4	59.4	55.8	51.2	58.7	64.4	46.4	59.4	55.8

A8. Rates of Lateral Flexions (Slope)

			Rate of Right Lateral Flexion (right-slope) (degrees/second)						Rate of Left Lateral Flexion (left-slope) (degrees/second)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
4	Ex. 2	Cont.	7.2	6.5	9.0	8.6	8.1	8.2	4.9	7.0	8.3	7.5	6.7	7.8
4	Ex. 3	Cont.	5.6	7.7	8.5	6.4	7.9	7.4	10.0	7.2	6.5	8.2	6.9	9.1
4	Active	Cont.	7.1	9.8	11.3	7.0	9.6	9.8	8.3	10.6	11.7	9.0	11.5	9.0
5	Ex. 2	Cont.	7.2	6.4	9.0	16.8	18.7	21.8	4.9	6.4	7.8	19.8	16.6	18.6
5	Ex. 3	Cont.	14.9	12.7	16.3	10.0	16.5	14.1	14.3	14.2	18.9	18.2	17.3	16.0
5	Active	Cont.	12.2	22.9	21.4	15.8	32.1	25.5	19.2	27.8	27.7	22.4	23.5	25.8
27	Ex. 2	Cont.	10.2	11.6	12.7	9.0	13.0	11.4	13.8	12.4	17.7	14.1	11.4	17.8
27	Ex. 3	Cont.	10.7	14.7	13.6	9.3	12.5	14.0	16.2	15.0	18.2	15.5	16.3	18.3
27	Active	Cont.	16.3	18.0	18.8	18.8	20.9	24.8	16.9	17.4	18.7	19.0	22.3	23.0
41	Ex. 2	Cont.	12.7	8.7	11.0	10.5	8.8	8.7	9.9	10.3	11.8	9.1	10.9	9.1
41	Ex. 3	Cont.	8.5	11.1	10.0	8.7	10.2	8.9	12.7	11.3	11.8	13.6	12.6	12.0
41	Active	Cont.	10.2	15.8	18.4	8.7	12.9	18.7	13.2	17.5	22.6	12.6	15.1	19.2
46	Ex. 2	Cont.	10.9	9.6	9.8	15.2	13.5	11.3	10.5	8.5	9.4	13.1	9.4	10.6
46	Ex. 3	Cont.	10.7	13.1	14.3	14.4	14.9	16.0	8.4	11.7	13.4	12.4	12.5	11.8
46	Active	Cont.	20.5	27.6	29.4	21.0	18.5	22.6	19.9	27.2	24.7	15.7	18.7	22.9
51	Ex. 2	Cont.	10.4	7.6	6.3	10.4	8.9	10.3	8.3			8.5	8.6	
51	Ex. 3	Cont.	12.4	12.7	13.4	14.1	14.6	17.3	12.7	16.1	10.5	12.5	15.5	17.7
51	Active	Cont.	9.8	10.8	16.0	9.6	14.3	13.7	11.9	15.2	14.0	13.3	15.7	16.2
56	Ex. 2	Cont.	13.1	12.1	10.8	13.5	12.6	12.1	13.5	11.4	11.6	12.4	13.8	12.3
56	Ex. 3	Cont.	13.2	13.2	11.4	10.9	12.3	11.8	12.6	14.0	13.5	14.0	12.9	15.5
56	Active	Cont.	16.8	15.3	23.9	16.6	18.5	19.9	16.4	19.6	22.8	18.0	19.0	21.9
59	Ex. 2	Cont.	12.5	10.5	10.6	10.6	8.2	8.1	10.4	10.3	10.1	7.9	10.3	
59	Ex. 3	Cont.	13.8	12.3	11.4	9.5	12.3	12.9	14.0	16.0	12.1	10.3	11.2	11.4
59	Active	Cont.	13.8	19.4	19.6	11.2	17.9	19.7	16.0	18.8	21.8	13.2	18.1	21.0
63	Ex. 2	Cont.	8.2	8.0	7.4	7.5	9.4	8.2	8.3	7.3	8.0	6.8	5.6	7.9
63	Ex. 3	Cont.	6.9	3.6	6.1	6.3	5.6	6.9	7.6	8.8	9.5	7.7	6.7	6.9
63	Active	Cont.	10.9	11.8	14.9	10.9	13.3	12.2	8.9	12.9	18.2	10.7	15.2	14.6

A8. (cont'd)

			Rate of Right Lateral Flexion (right-slope) (degrees/second)						Rate of Left Lateral Flexion (left-slope) (degrees/second)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
67	Ex. 2	Cont.	12.5	15.0	15.4	16.1	16.9	14.0	13.7	11.7	14.5	13.6	10.6	13.1
67	Ex. 3	Cont.	14.3	16.4	13.4	12.1	15.8	12.8	12.5	13.2	12.6	13.0	13.8	13.2
67	Active	Cont.	18.6	21.2	21.9	18.7	14.1	19.3	17.7	17.4	19.1	18.1	16.3	19.2
68	Ex. 2	Cont.	8.0	6.4	5.1	8.8	8.6	7.7	7.9	7.7	7.0	7.8	8.0	9.3
68	Ex. 3	Cont.	6.4	8.5	9.4	7.5	9.6	7.7	9.0	6.4	8.0	6.2	7.3	10.9
68	Active	Cont.	14.0	18.5	22.6	11.3	17.2	18.6	12.5	17.2	19.2	11.3	16.7	18.0
69	Ex. 2	Cont.	12.1	12.8	12.9	14.4	14.6	13.8	12.3	12.0	10.8	13.7	12.0	13.5
69	Ex. 3	Cont.	11.9	12.7	14.3	11.4	9.9	11.3	13.6	11.6	10.7	12.6	10.1	12.9
69	Active	Cont.	17.2	21.8	28.5	18.2	22.4	23.1	21.0	24.2	27.6	21.9	24.0	27.5
77	Ex. 2	Cont.	11.5	14.0	8.7	11.1	11.7	12.2	9.0	10.3	9.3	11.0	11.7	9.6
77	Ex. 3	Cont.	10.1	9.2	12.5	11.2	11.7	12.4	13.2	9.5	11.9	10.3	9.3	10.0
77	Active	Cont.	10.3	20.3	22.8	19.4	22.8	19.5	19.9	19.6	22.0	23.7	21.7	27.8
79	Ex. 2	Cont.	9.9	10.0	9.9	9.5	14.9	11.0	8.1	12.6	10.9	12.7	12.7	9.4
79	Ex. 3	Cont.	16.1	23.0	21.7	13.9	16.7	20.8	16.4	18.2	20.2	16.4	19.8	18.5
79	Active	Cont.	12.6	18.9	20.8	11.9	14.9	18.8	17.2	22.6	21.6	15.9	16.7	16.8
83	Ex. 2	Cont.	10.3	10.9	10.5	9.5	11.0	10.7	9.8	10.9	11.0	10.2	10.0	10.9
83	Ex. 3	Cont.	12.9	12.7	13.0	18.0	15.1	14.0	9.3	10.7	15.6	14.0	18.5	14.1
83	Active	Cont.	11.4	13.7	14.1	9.4	14.4	14.2	13.2	15.8	17.4	12.0	14.8	14.4
85	Ex. 2	Cont.	12.0	11.4	15.5	15.1	13.1	13.4	12.1	14.7	15.0	14.7	12.4	13.6
85	Ex. 3	Cont.	10.6	12.6	13.0	8.1	13.3	11.2	13.1	12.1	16.6	13.8	17.6	16.5
85	Active	Cont.	8.8	9.5	11.0	8.3	10.3	11.5	10.4	11.0	11.7	13.2	9.3	12.2
88	Ex. 2	Cont.	9.0	9.4	8.4	10.4	9.4	8.6	9.1	9.6	10.5	11.3	8.8	9.0
88	Ex. 3	Cont.	6.4	7.8	8.2	7.1	9.6	12.2	7.2	6.9	9.5	7.4	8.7	9.6
88	Active	Cont.	9.7	15.4	16.6	10.9	17.4	20.5	13.0	16.0	16.1	18.5	18.3	18.4
90	Ex. 2	Cont.	19.9	13.9	11.9	18.9	17.5	12.8	14.7	11.3	12.7	16.2	14.4	16.8
90	Ex. 3	Cont.	10.3	13.5	17.5	19.0	18.4	12.1	16.5	14.3	14.1	11.2	14.2	15.4
90	Active	Cont.	26.2	28.9	26.6	27.8	20.6	26.4	27.8	28.1	40.8	26.8	35.5	37.1

A8. (cont'd)

			Rate of Right Lateral Flexion (right-slope) (degrees/second)						Rate of Left Lateral Flexion (left-slope) (degrees/second)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
96	Ex. 2	Cont.	15.2	7.8	6.4	13.4	9.5	9.2	17.7	11.6	13.2	16.1	12.4	12.0
96	Ex. 3	Cont.	7.9	6.3	6.2	8.2	7.2	6.9	12.3	9.0	10.0	14.2	10.9	11.4
96	Active	Cont.	14.8	13.0	10.5	11.4	11.1	10.0	16.6	13.2	16.4	18.4	15.8	15.9
106	Ex. 2	Cont.	10.9	9.2	10.6	13.4	11.3	11.3	13.3	9.9	11.3	10.7	10.2	11.8
106	Ex. 3	Cont.	7.5	6.9	7.2	10.0	7.6	8.8	9.8	8.5	9.1	11.3	9.8	9.9
106	Active	Cont.	9.3	15.0	17.7	11.8	14.2	18.7	16.6	20.1	26.7	14.7	17.6	18.4
111	Ex. 2	Cont.	14.5	14.5	15.7	16.9	18.0	12.9	13.8	13.9	17.8	15.5		13.9
111	Ex. 3	Cont.	11.9	8.7	9.5	13.2	11.7	12.7	11.3	10.0	11.7	11.3	11.4	13.2
111	Active	Cont.	12.0	14.3	15.0	10.9	16.5	17.1	14.2	20.2	15.2	16.4	20.8	21.5
117	Ex. 2	Cont.	9.6	8.3	4.2	8.8	7.0	5.7	8.5	6.6	5.5	7.6	5.5	4.9
117	Ex. 3	Cont.	7.0	7.0	9.1	8.9	9.2	10.5	5.9	5.8	6.4	7.9	7.4	7.8
117	Active	Cont.	9.9	14.8	17.9	12.3	16.3	14.7	11.7	17.4	19.0	13.1	16.9	15.2

Pre-Treatment

			Rate of Right Lateral Flexion (right-slope) (degrees/second)						Rate of Left Lateral Flexion (left-slope) (degrees/second)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
6	Ex. 2	Exp.	9.1	9.5	7.4	8.4	5.9	4.2	7.1	5.0	5.0	8.0	4.9	5.8
6	Ex. 3	Exp.	6.1	8.2	7.3	7.1	3.9	5.8	3.9	6.9	5.0	5.1	4.2	4.0
6	Active	Exp.	4.1			7.6	12.3	13.3	3.4			9.6	9.8	12.7
9	Ex. 2	Exp.	8.9	6.4	5.8	5.9	7.5	5.4	10.2	9.3	7.8	7.7	5.2	6.5
9	Ex. 3	Exp.	5.9	8.0	8.6	7.1	5.0	9.8	8.2	8.1	8.7	8.9	8.9	8.3
9	Active	Exp.	9.7	11.4	9.4	7.2	9.9	7.9	10.3	15.0	13.4	11.0	13.8	14.8
12	Ex. 2	Exp.	12.7	9.6	8.4	8.6	6.2	5.9	7.5	6.7	6.7	6.1	5.5	7.2
12	Ex. 3	Exp.	4.4	5.5	3.8	4.7	6.2	4.2	5.1	6.5	6.1	6.6	6.6	5.7
12	Active	Exp.	7.4	9.9	11.9	7.6	10.2	9.1	7.6	9.2	9.4	7.4	11.4	11.7

A8. (cont'd)

Pre-Treatment

			Rate of Right Lateral Flexion (right-slope) (degrees/second)						Rate of Left Lateral Flexion (left-slope) (degrees/second)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
14	Ex. 2	Exp.	11.2	9.5	8.2	12.1	11.3	10.0	11.6	11.2	11.7	12.6	14.5	18.1
14	Ex. 3	Exp.	16.8	11.4	11.1	16.6	12.4	13.2	11.8	7.5	11.8	16.8	16.4	9.5
14	Active	Exp.	12.6	27.1	14.4	22.7	24.1	20.1	21.7	26.8	22.3	25.0	15.9	21.9
23	Ex. 2	Exp.	11.6	15.3	18.7	14.3	18.1	16.5	15.0	14.3	12.3	16.4	12.8	14.3
23	Ex. 3	Exp.	12.4	11.5	12.7	12.3	13.0	12.8	13.0	13.5	14.6	14.1	13.4	15.0
23	Active	Exp.	13.0	16.8	20.6	13.1	19.3	20.3	15.6	17.5	19.3	12.5	16.7	18.3
25	Ex. 2	Exp.	7.3	6.5	6.4	8.1	7.2	5.5	6.6	6.5	7.3	7.3	5.5	6.8
25	Ex. 3	Exp.	7.8	7.1	8.3	7.3	9.0	10.6	8.2	10.1	8.0	8.0	6.2	6.4
25	Active	Exp.	6.2	9.9	10.2	9.8	12.8	14.0	7.3	8.8	11.2	8.1	10.9	10.5
54	Ex. 2	Exp.	8.2	6.9	7.3	7.6	8.0	7.7	9.2	10.7	10.3	8.8	8.6	10.8
54	Ex. 3	Exp.	9.7	10.5	10.7	8.0	11.6	10.8	9.8	11.6	12.8	10.3	12.6	12.1
54	Active	Exp.	14.0	14.1	18.8	17.0	13.3	20.6	18.7	23.8	25.0	21.6	22.3	22.9
55	Ex. 2	Exp.	5.3	4.4		5.2	5.6	4.8	4.4	4.3		5.1	4.7	4.2
55	Ex. 3	Exp.	8.9	8.4	6.1	8.4	9.9	7.3	7.0	9.2	5.2	7.5	11.3	5.1
55	Active	Exp.	3.3	5.1	7.2	4.9	4.9	5.8	5.0	5.4		6.7	8.7	6.4
57	Ex. 2	Exp.	11.3	11.1	11.1	11.6	11.2	9.0	10.0	9.6	9.3	10.3	12.7	7.8
57	Ex. 3	Exp.	8.3	8.3	9.9	9.4	9.8	13.0	8.0	8.4	11.2	9.6	12.1	8.9
57	Active	Exp.	9.3	13.1	18.0	10.1	14.2	16.5	16.2	17.0	20.9	15.8	15.3	19.3
70	Ex. 2	Exp.	12.6	12.5	12.9	10.0	9.8	9.4	10.8	10.7	10.2	11.4	9.3	8.0
70	Ex. 3	Exp.	8.4	8.2	9.9	10.2	10.6	11.2	9.5	8.6	10.8	7.8	10.9	8.3
70	Active	Exp.	12.9	15.3	19.9	16.9	18.5	19.1	14.5	18.1	35.0	21.3	28.6	26.9
75	Ex. 2	Exp.	10.8	9.0	8.4	8.3	7.9	9.5	8.8	8.7	8.4	8.7	7.8	9.8
75	Ex. 3	Exp.	7.6	9.0	10.0	10.8	7.8	7.7	6.9	9.2	7.8	12.1	8.4	10.6
75	Active	Exp.	5.8	8.5	10.1	14.6	17.4	19.7	7.8	11.7	14.2	16.5	18.8	16.6
80	Ex. 2	Exp.	13.4	12.8	12.6	13.9	13.6	11.8	10.9	10.3	11.0	12.1	10.7	9.4
80	Ex. 3	Exp.	11.3	17.4	14.1	11.7	16.9	15.4	13.5	13.5	14.5	13.9	17.0	17.8
80	Active	Exp.	19.9	22.4	20.6	18.7	28.2	20.5	20.0	20.5	20.5	22.8	22.6	23.0

A8. (cont'd)

Pre-Treatment

			Rate of Right Lateral Flexion (right-slope) (degrees/second)						Rate of Left Lateral Flexion (left-slope) (degrees/second)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
84	Ex. 2	Exp.	7.4	5.4	6.5	7.4	5.5	6.1	6.6	6.3	6.0	5.9	4.8	4.5
84	Ex. 3	Exp.	7.5	12.2	7.3	8.4	11.5	9.5	7.9	6.8	9.1	7.9	8.7	9.1
84	Active	Exp.	11.0	9.4	9.6	12.6	10.0	9.4	13.1	11.3	11.2	12.3	12.1	9.1
91	Ex. 2	Exp.	11.8	12.5	13.0	13.7	10.8	12.0	12.1	11.3	13.1	10.9	11.8	11.0
91	Ex. 3	Exp.	10.6	15.9	12.8	12.0	16.0	14.6	12.7	10.7	12.7	12.2	14.3	14.1
91	Active	Exp.	18.5	27.3	23.0	20.7	25.7	22.1	18.5	21.5	19.2	19.3	23.4	25.9
95	Ex. 2	Exp.	13.4	13.6	14.8	9.6	13.0	13.6	12.8	15.4	18.7	13.8	15.8	16.6
95	Ex. 3	Exp.	18.1	14.5	14.7	12.9	17.4	13.8	13.3	13.7	13.1	13.1	14.7	15.3
95	Active	Exp.	14.0	11.4	14.4	17.4	11.7	16.3	11.5	15.9	17.7	14.5	12.8	15.0
98	Ex. 2	Exp.	8.5	8.5	8.9	9.8	8.9	9.0	9.2	9.0	8.5	8.9	7.7	6.5
98	Ex. 3	Exp.	8.9	9.4	12.2	7.4	8.0	9.2	9.2	11.8	10.8	10.4	8.8	9.1
98	Active	Exp.	18.8	24.2	20.9	10.8	15.0	16.6	21.4	19.4	25.4	19.9	19.1	21.0
112	Ex. 2	Exp.	11.8	12.0	12.5	12.6	10.3	9.5	9.9	10.7	9.8	9.9	7.2	9.2
112	Ex. 3	Exp.	8.5	11.7	9.9	9.2	13.5	10.0	9.0	10.5	6.3	7.0	10.0	9.8
112	Active	Exp.	9.1	14.6	16.5	11.1	17.0	16.7	9.4	12.5	15.1	12.0	14.9	16.7
115	Ex. 2	Exp.	5.1	5.2	5.5	6.7	5.9	5.6	5.3	5.0		7.0	4.8	7.2
115	Ex. 3	Exp.	5.4	6.2	5.5	6.3	6.6	6.1	4.6	4.7	6.6	8.4	7.6	8.1
115	Active	Exp.	14.9	18.3	21.9				29.1	20.9	22.7			
125	Ex. 2	Exp.	8.1	8.2	7.0	8.2	8.1	7.7	9.4	8.5	8.2	8.1	6.3	8.3
125	Ex. 3	Exp.	9.6	8.2	9.5	8.8	8.3	9.1	13.1	7.0	7.3	9.6	10.5	8.1
125	Active	Exp.	9.1	8.9	9.2	10.9	11.8	14.0	11.5	9.7	10.9	12.2	11.2	12.0

A8. (cont'd)

			Post-Treatment											
			Rate of Right Lateral Flexion (right-slope) (degrees/second)						Rate of Left Lateral Flexion (left-slope) (degrees/second)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
6	Ex. 2	Exp.	7.9	6.3	6.9	6.4	6.6	5.0	5.9	5.6	4.6	6.1	5.5	5.7
6	Ex. 3	Exp.	5.8	6.0	8.3	5.4	6.0	5.6	6.4	5.4	8.3	5.6	7.1	7.4
6	Active	Exp.	9.4	12.2	13.8	7.5	12.0	15.7	9.7	10.3	10.6	11.9	11.5	13.3
9	Ex. 2	Exp.	10.1	10.4	8.8	11.9	11.8	11.4	10.3	9.3	10.3	8.8	9.3	10.9
9	Ex. 3	Exp.	8.7	10.0	8.0	8.8	9.7	7.5	8.5	7.7	9.5	7.7	9.0	10.8
9	Active	Exp.	10.1	13.5	15.6	10.0	14.0	15.9	9.7	15.0	15.1	11.6	11.0	15.7
12	Ex. 2	Exp.	6.7	5.9	6.7	7.8	6.3	7.4	7.2	6.2	7.3	7.5	6.3	7.3
12	Ex. 3	Exp.	5.6	7.3	6.0	4.8	5.1	6.9	6.9	6.0	5.2	4.8	6.0	5.6
12	Active	Exp.	7.5	8.7	11.3	7.7	11.3	10.8	9.1	9.8	10.4	9.5	9.4	10.6
14	Ex. 2	Exp.	12.4	10.2	7.6	9.6	10.1	7.8	9.3	11.2	8.7	10.5	8.6	7.1
14	Ex. 3	Exp.	14.3	9.0	8.7	15.1	9.0	13.4	5.7	9.5	10.8	15.2	19.4	18.0
14	Active	Exp.	19.5	36.0	28.4	21.5	21.4	35.2	25.0	38.2	14.6	15.0	32.9	27.0
23	Ex. 2	Exp.	10.1	12.5	9.0	11.3	10.9	10.2	11.4	10.2	12.5	12.8	9.4	9.5
23	Ex. 3	Exp.	11.2	11.4	15.9	11.0	14.6	9.7	14.5	12.2	16.1	13.0	17.2	12.6
23	Active	Exp.	11.4	13.8	15.2	12.9	13.3	16.3	12.6	14.4	15.1	11.3	13.8	16.2
25	Ex. 2	Exp.	8.0	9.7	7.9	10.7	9.2	8.1	5.9	5.8	7.0	7.6	6.8	9.5
25	Ex. 3	Exp.	9.5	9.4	8.9	8.4	9.3	9.9	8.6	8.4	9.0	10.6	8.3	10.5
25	Active	Exp.	6.7	10.3	10.3	6.9	11.6	11.1	6.3	9.0	7.8	7.7	9.5	10.5
54	Ex. 2	Exp.	11.8	10.5	12.4	9.2	8.6	7.7	12.5	9.9	11.8	11.0	10.9	10.4
54	Ex. 3	Exp.	12.2	11.5	12.2	11.6	9.9	9.1	9.2	12.6	16.3	11.5	13.2	18.0
54	Active	Exp.	12.9	17.6	20.3	18.7	14.9	19.8	19.4	21.5	27.6	22.9	22.6	26.6
55	Ex. 2	Exp.	7.0	6.5	6.7	7.4	8.4	6.1	4.9	5.9	7.1	5.9	4.9	6.5
55	Ex. 3	Exp.	7.6	7.8	8.7	7.2	8.1	7.6	5.5	6.4	8.4	8.9	9.1	6.4
55	Active	Exp.	6.3	8.0	7.8	6.6	9.3	10.8	9.1	7.9	8.8	9.3	11.3	12.0
57	Ex. 2	Exp.	12.0	13.4	10.3	11.4	16.6	11.6	10.0	10.1	7.9	10.6	11.9	7.8
57	Ex. 3	Exp.	8.9	10.5	12.1	8.8	11.3	15.3	12.5	11.4	10.5	9.8	9.4	11.7
57	Active	Exp.	13.5	16.5	24.6	13.0	19.3	21.4	14.2	16.4	23.8	18.8	19.0	21.8

A8. (cont'd)

			Post-Treatment											
			Rate of Right Lateral Flexion (right-slope) (degrees/second)						Rate of Left Lateral Flexion (left-slope) (degrees/second)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
70	Ex. 2	Exp.	9.9	10.3	9.7	11.7	10.1	10.2	8.9	9.1	10.9	10.1	9.0	7.7
70	Ex. 3	Exp.	8.6	8.7	9.6	9.7	9.8	7.4	7.9	9.5	10.9	10.3	11.1	11.4
70	Active	Exp.	13.3	18.9	17.7	15.3	13.9	18.4	17.5	16.5	25.7	16.3	15.3	20.3
72	Ex. 2	Exp.	9.8	8.1	9.1	7.7	9.8	7.1	6.5	7.6	6.5	7.3	5.3	6.1
72	Ex. 3	Exp.	5.8	6.4	9.0	8.1	9.6	9.7	8.1	6.4	7.7	10.9	8.6	9.0
72	Active	Exp.	11.4	13.8	16.0	13.3	15.7	16.1	13.2	14.9	15.7	15.0	18.1	16.2
80	Ex. 2	Exp.	12.9	11.4	10.9	11.1	9.2	11.8	12.0	10.2	11.0	10.4	9.8	9.7
80	Ex. 3	Exp.	11.2	13.0	11.8	14.1	10.5	12.3	11.2	14.1	14.3	7.5	9.9	13.0
80	Active	Exp.	14.9	14.4	23.1	13.5	18.9	20.0	14.1	14.6	17.2	16.8	14.8	17.7
84	Ex. 2	Exp.	10.6	8.6	7.1	7.9	8.0	7.1	7.5	6.5	6.5	8.5	7.2	7.9
84	Ex. 3	Exp.	10.3	9.3	10.6	9.4	10.1	6.7	8.4	6.8	10.1	9.4	6.6	8.1
84	Active	Exp.	9.0	9.9	9.0	8.9	9.6	9.9	10.8	11.1	10.7	12.7	12.3	11.8
91	Ex. 2	Exp.	20.0	16.8	15.0	15.0	13.8	11.7	15.4	14.4	13.7	12.6	12.0	13.7
91	Ex. 3	Exp.	10.8	14.3	11.8	10.9	18.4	18.7	12.4	10.9	12.9	13.4	21.3	15.7
91	Active	Exp.	18.2	25.0	28.8	19.8	18.2	25.3	22.4	24.0	22.4	23.3	22.4	25.5
95	Ex. 2	Exp.	13.1	12.1	9.3	12.4	11.3	10.2	10.1	6.9	9.5	13.6	9.3	9.4
95	Ex. 3	Exp.				12.7	18.2	17.0				14.9	16.7	11.0
95	Active	Exp.	13.9	17.8	14.2	13.7	13.0	11.6	14.1	13.4	13.6	11.6	8.5	14.2
98	Ex. 2	Exp.	8.7	8.7	7.4	4.8	7.9	11.2	8.7	7.5	6.7	8.6	7.5	7.4
98	Ex. 3	Exp.	9.5	8.3	9.5	8.0	9.6	9.7	9.5	7.4	9.3	8.3	8.4	12.4
98	Active	Exp.	12.8	15.3	11.4	8.9	8.3	12.8	15.1	11.7	18.0	12.6	10.3	13.7
112	Ex. 2	Exp.	12.1	11.7	12.1	12.6	13.6	10.5	9.2	9.9	9.4	11.4	10.5	10.3
112	Ex. 3	Exp.	9.8	9.0	12.2	11.2	8.3	12.1	6.9	7.4	9.2	9.3	8.7	8.3
112	Active	Exp.	13.5	17.8	21.0	13.0	18.2	17.0	13.1	14.9	21.7	13.7	18.6	16.8

A8. (cont'd)

Post-Treatment

			Rate of Right Lateral Flexion (right-slope) (degrees/second)						Rate of Left Lateral Flexion (left-slope) (degrees/second)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
115	Ex. 2	Exp.	10.1	6.6	6.3	8.3	6.3	6.1	7.8	7.1	7.4	6.2	5.1	5.1
115	Ex. 3	Exp.	7.0	5.7	6.3	7.0	9.7	8.2	6.9	6.5	6.8	7.5	8.2	9.0
115	Active	Exp.	11.4	16.5	15.5	16.2	15.7	20.0	23.9	20.3	20.9	25.1	5.8	13.7
125	Ex. 2	Exp.	8.2	6.8	6.5	6.0	5.0	5.5	6.8	5.9	6.2	5.7	4.0	5.0
125	Ex. 3	Exp.	8.9	9.8	11.7	13.9	13.6	11.8	9.6	8.0	7.9	12.1	10.7	9.3
125	Active	Exp.	10.1	11.1	11.5	11.8	11.6	11.8	11.5	10.1	11.7	10.7	14.6	13.7

Pre-Treatment

			Rate of Right Lateral Flexion (right-slope) (degrees/second)						Rate of Left Lateral Flexion (left-slope) (degrees/second)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
126	Ex. 2	Long.	9.6	8.2	8.4	9.7	10.2	9.6	9.8	10.6	9.8	8.6	9.4	8.5
126	Ex. 3	Long.	10.1	11.5	11.8	10.5	12.0	11.2	10.5	8.2	12.4	12.3	11.2	9.3
126	Active	Long.	13.4	12.8	12.6	13.9	13.6	11.8	10.9	10.3	11.0	12.1	10.7	9.4
127	Ex. 2	Long.	7.6	7.5	8.1	7.9	7.1	7.1	6.8	4.9	4.6	6.8	6.8	6.6
127	Ex. 3	Long.	9.2	10.4	9.7	9.6	8.9	9.8	9.1	9.3	10.0	11.9	8.3	7.1
127	Active	Long.	10.2	14.2	14.4	13.3	18.0	19.0	10.5	15.4	15.4	16.4	18.0	17.0
128	Ex. 2	Long.	11.0	10.1	10.4	11.3	10.9	12.5	12.5	12.9	13.8	11.8	12.7	14.3
128	Ex. 3	Long.	11.6	11.4	11.8	12.6	13.7	12.3	11.1	11.6	16.1	10.6	13.3	15.5
128	Active	Long.	16.0	18.3	17.5	16.7	16.0	19.3	19.7	19.6	21.8	16.3	20.4	24.6
129	Ex. 2	Long.	4.7	4.1	4.4	3.8	5.9	5.4	6.1	7.4	6.4	6.5	8.2	6.6
129	Ex. 3	Long.	10.4	8.9	6.4	7.2	7.0	6.0	8.1	7.5	10.1	7.8	8.5	8.9
129	Active	Long.	13.5	14.3	20.4	17.5	16.9	19.1	19.3	19.6	17.9	22.6	18.2	15.8
131	Ex. 2	Long.	10.0	9.7	8.1	11.0	11.0	9.5	7.9	7.9	9.5	9.6	9.0	10.7
131	Ex. 3	Long.	10.0	13.2	12.8	10.5	10.8	12.7	9.1	9.2	10.2	9.0	8.5	11.1
131	Active	Long.	16.8	16.8	18.1	11.2	13.9	14.5	13.5	19.2	17.1	16.5	12.0	18.0

A8. (cont'd)

			Post-Treatment											
			Rate of Right Lateral Flexion (right-slope) (degrees/second)						Rate of Left Lateral Flexion (left-slope) (degrees/second)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
126	Ex. 2	Long.	10.9	7.9	7.7	9.0	9.3	7.8	9.2	8.5	7.8	7.8	5.0	6.7
126	Ex. 3	Long.	10.4	11.1	12.6	13.7	12.2	9.2	9.5	9.8	11.3	12.3	10.7	9.8
126	Active	Long.	10.8	15.9	19.6	10.8	18.7	21.0	16.7	17.5	21.7	16.1	20.0	19.7
127	Ex. 2	Long.	7.5	7.5	8.6	9.0	6.4	6.1	6.5	6.2	8.6	8.4	6.6	5.9
127	Ex. 3	Long.	8.5	8.8	10.4	9.3	11.4	10.0	6.5	8.6	9.3	11.2	11.6	10.9
127	Active	Long.	10.4	12.8	12.7	12.0	13.6	13.9	11.4	14.6	16.0	15.8	15.0	16.1
128	Ex. 2	Long.	10.6	12.6	10.5	10.8	9.4	8.4	10.0	11.1	9.0	8.9	9.3	7.9
128	Ex. 3	Long.	12.0	14.3	10.9	11.0	12.6	12.3	11.8	13.5	13.6	10.9	12.5	12.6
128	Active	Long.	13.7	14.4	15.8	13.8	13.0	16.9	13.5	15.8	19.6	12.7	17.7	16.0
129	Ex. 2	Long.	10.0	6.9	6.8	7.1	7.8	7.1	6.6	7.8	6.4	8.7	8.3	12.8
129	Ex. 3	Long.	6.9	5.4	8.4	9.5	7.9	9.0	8.0	10.7	9.8	11.6	8.1	10.7
129	Active	Long.	16.8	17.4	15.3	17.3	18.6	15.5	15.5	21.7	21.9	16.8	16.6	19.2
131	Ex. 2	Long.	11.0	9.2	10.4	10.4	10.8	10.4	9.4	9.4	9.8	10.9	10.6	11.1
131	Ex. 3	Long.	10.3	12.8	12.3	12.6	14.9	15.5	9.3	10.5	8.9	12.1	13.5	13.8
131	Active	Long.	13.8	17.4	18.3	13.6	14.6	15.9	15.3	16.5	20.8	16.7	13.1	17.1

A8. (cont'd)

72-Hours Post-Treatment

			Rate of Right Lateral Flexion (right-slope) (degrees/second)						Rate of Left Lateral Flexion (left-slope) (degrees/second)					
Subject	**Test**	**Group**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
126	Ex. 2	Long.	12.0	12.5	11.6	14.6	12.8	10.9	11.0	12.3	11.5	14.8	11.1	11.1
126	Ex. 3	Long.	11.3	13.5	14.9	12.6	11.3	15.4	8.7	10.4	9.9	11.3	7.6	10.9
126	Active	Long.	14.1	16.7	19.8	18.1	18.0	16.8	11.8	14.0	18.6	18.0	16.0	20.5
127	Ex. 2	Long.	10.9	9.4	9.2	9.4	8.9	8.9	11.9	9.0	9.2	9.5	8.8	7.5
127	Ex. 3	Long.	8.4	12.0	10.0	8.4	9.8	12.7	6.3	9.3	10.4	9.9	7.3	10.0
127	Active	Long.	10.8	14.2	13.7	14.0	14.1	15.6	13.5	14.3	16.2	15.9	15.9	17.3
128	Ex. 2	Long.	12.1	13.9	13.6	17.4	16.1	12.1	15.4	16.0	15.3	14.5	13.4	13.0
128	Ex. 3	Long.	10.1	8.6	11.9	14.7	12.1	13.5	12.0	11.2	13.1	12.9	13.0	12.6
128	Active	Long.	18.1	19.8	22.9	20.3	20.8	22.5	19.4	21.6	22.5	19.1	20.6	23.9
129	Ex. 2	Long.	8.0	6.5	6.1	9.1	5.2	7.1	7.3	7.6	5.9	9.2	9.5	5.9
129	Ex. 3	Long.	6.9	8.6	7.3	7.6	9.5	9.9	7.5	7.5	9.0	7.6	10.2	10.4
129	Active	Long.	15.9	14.6	16.8	16.8	16.8	18.4	18.1	18.2	17.1	20.5	16.6	13.4
131	Ex. 2	Long.	11.8	10.3	11.8	10.6	10.2	13.8	10.9	12.2	12.4	10.4	12.0	12.5
131	Ex. 3	Long.	9.8	11.3	10.3	10.5	10.6	12.5	9.5	10.0	10.3	9.7	10.6	11.4
131	Active	Long.	12.7	14.0	14.4	12.2	14.0	16.8	13.7	12.6	14.5	13.1	13.2	17.0

A9. RMSE of Dissected Cycles

			Right Lateral Flexion (degrees)			Left Lateral Flexion (degrees)			Lateral Flexion Cycle (degrees)			RMSE Total (degrees)		
Subject	**Test**	**Group**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**Right**	**Left**	**Cycle**
4	Ex. 2	Cont.	0.7	1.1	0.8	2.1	5.0	0.8	1.6	3.6	0.8	0.9	3.2	2.3
4	Ex. 3	Cont.	1.2	2.3	1.1	0.4	2.5	4.1	0.9	2.4	3.0	1.6	2.8	2.3
4	Active	Cont.	2.5	2.5	1.9	1.4	0.9	3.9	2.0	1.8	3.1	2.3	2.4	2.4
5	Ex. 2	Cont.	10.4	9.7	8.0	10.7	8.3	12.0	10.6	9.0	10.2	9.4	10.5	9.9
5	Ex. 3	Cont.	2.2	5.1	3.9	4.9	7.4	2.9	3.8	6.4	3.4	3.9	5.4	4.7
5	Active	Cont.	3.0	3.5	3.9	1.8	2.3	1.7	2.5	3.0	3.0	3.5	2.0	2.8
27	Ex. 2	Cont.	4.3	2.9	3.4	3.8	2.1	2.0	4.1	2.6	2.8	3.6	2.8	3.2
27	Ex. 3	Cont.	2.2	3.8	5.9	4.7	1.5	4.2	3.7	2.9	5.1	4.3	3.7	4.0
27	Active	Cont.	2.5	2.0	2.6	2.5	1.8	1.2	2.5	1.9	2.0	2.4	1.9	2.2
41	Ex. 2	Cont.	3.2	0.9	1.8	2.9	3.5	4.1	3.0	2.6	3.1	2.2	3.5	2.9
41	Ex. 3	Cont.	0.9	3.0	0.9	1.7	2.0	1.1	1.4	2.6	1.0	1.9	1.7	1.8
41	Active	Cont.	3.6	2.1	0.7	2.5	2.0	2.1	3.1	2.0	1.6	2.4	2.2	2.3
46	Ex. 2	Cont.	3.2	4.8	1.5	1.2	2.5	2.3	2.4	3.8	2.0	3.4	2.1	2.8
46	Ex. 3	Cont.	2.5	0.6	1.6	2.3	1.4	4.7	2.4	1.1	3.5	1.8	3.1	2.5
46	Active	Cont.	1.0	2.4	0.7	1.6	1.8	2.2	1.3	2.1	1.6	1.6	1.9	1.7
51	Ex. 2	Cont.	2.4	3.9	3.6	1.8			2.2			3.4	1.8	3.1
51	Ex. 3	Cont.	1.2	3.2	1.1	1.9	1.9	2.1	1.6	2.7	1.7	2.1	2.0	2.0
51	Active	Cont.	4.6	0.9	3.8	1.5	2.1	3.0	3.4	1.6	3.4	3.5	2.3	2.9
56	Ex. 2	Cont.	2.7	1.7	1.3	1.5	2.7	3.3	2.2	2.3	2.5	2.0	2.6	2.3
56	Ex. 3	Cont.	0.6	4.0	2.0	3.2	3.5	3.3	2.3	3.8	2.8	2.6	3.3	3.0
56	Active	Cont.	0.5	2.6	0.9	2.0	1.8	2.7	1.4	2.2	2.0	1.6	2.2	1.9
59	Ex. 2	Cont.	1.2	2.6	2.6	2.3	4.1		1.8	3.4		2.2	3.3	2.7
59	Ex. 3	Cont.	6.1	3.3	1.1	1.5	2.6	2.5	4.4	3.0	1.9	4.0	2.3	3.3
59	Active	Cont.	2.8	2.3	2.5	3.1	2.8	6.5	3.0	2.5	4.9	2.5	4.4	3.6
63	Ex. 2	Cont.	2.1	0.8	2.0	0.6	2.6	4.2	1.5	1.9	3.3	1.7	2.9	2.4
63	Ex. 3	Cont.	0.6	1.9	1.3	0.7	1.3	0.8	0.7	1.6	1.1	1.4	1.0	1.2
63	Active	Cont.	5.3	5.1	0.8	2.4	6.2	1.1	4.1	5.7	1.0	4.3	3.9	4.1

A9. (cont'd)

			Right Lateral Flexion (degrees)			Left Lateral Flexion (degrees)			Lateral Flexion Cycle (degrees)			RMSE Total (degrees)		
Subject	**Test**	**Group**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**Right**	**Left**	**Cycle**
67	Ex. 2	Cont.	4.3	4.5	4.1	0.6	1.3	2.5	3.1	3.3	3.4	4.3	1.7	3.3
67	Ex. 3	Cont.	0.6	3.4	4.2	3.9	2.6	0.9	2.8	3.1	3.0	3.1	2.7	2.9
67	Active	Cont.	5.0	5.7	4.3	1.6	4.4	1.8	3.7	5.1	3.3	5.0	2.9	4.1
68	Ex. 2	Cont.	1.9	2.8	5.6	3.3	3.7	4.2	2.7	3.3	5.0	3.8	3.8	3.8
68	Ex. 3	Cont.	5.8	3.0	3.4	3.1	2.7	1.7	4.6	2.9	2.7	4.2	2.6	3.5
68	Active	Cont.	0.9	3.1	2.8	1.5	2.8	1.5	1.3	3.0	2.3	2.5	2.0	2.3
69	Ex. 2	Cont.	3.6	1.5	2.0	2.6	4.6	6.1	3.2	3.4	4.5	2.5	4.7	3.8
69	Ex. 3	Cont.	3.9	5.4	1.2	3.1	3.7	1.0	3.5	4.7	1.1	3.9	2.9	3.4
69	Active	Cont.	1.1	3.2	1.9	3.1	4.0	4.3	2.3	3.6	3.3	2.2	3.8	3.1
77	Ex. 2	Cont.	2.8	3.1	2.2	2.0	3.5	1.8	2.4	3.3	2.0	2.7	2.5	2.6
77	Ex. 3	Cont.	6.8	1.2	1.7	4.2	2.4	1.1	5.7	1.9	1.4	4.1	2.9	3.5
77	Active	Cont.	6.0	2.3	7.0	3.3	5.1	4.0	4.8	4.0	5.7	5.5	4.2	4.9
79	Ex. 2	Cont.	3.2	5.4	4.0	1.1	3.5	1.0	2.4	4.5	2.9	4.3	2.2	3.4
79	Ex. 3	Cont.	4.7	6.0	3.6	2.0	4.2	1.4	3.6	5.2	2.7	4.9	2.8	4.0
79	Active	Cont.	3.7	4.4	1.7	2.6	1.6	1.3	3.2	3.3	1.5	3.4	1.9	2.8
83	Ex. 2	Cont.	3.3	1.7	3.6	5.0	0.6	0.9	4.2	1.3	2.6	3.0	3.0	3.0
83	Ex. 3	Cont.	2.4	1.2	2.5	6.2	1.8	3.1	4.7	1.5	2.8	2.1	4.1	3.3
83	Active	Cont.	2.5	2.8	1.9	3.3	2.6	1.3	2.9	2.7	1.6	2.4	2.5	2.5
85	Ex. 2	Cont.	1.7	0.9	1.4	0.9	2.7	1.9	1.3	2.0	1.7	1.4	1.9	1.7
85	Ex. 3	Cont.	0.5	2.7	0.8	3.0	2.4	1.8	2.1	2.6	1.4	1.7	2.4	2.1
85	Active	Cont.	2.4	1.8	1.3	2.0	2.4	2.9	2.2	2.1	2.3	1.9	2.5	2.2
88	Ex. 2	Cont.	1.9	1.1	3.7	1.0	1.3	2.2	1.5	1.2	3.0	2.5	1.6	2.1
88	Ex. 3	Cont.	1.4	0.5	0.8	0.8	1.2	0.9	1.1	0.9	0.9	1.0	1.0	1.0
88	Active	Cont.	1.0	3.2	2.2	10.0	7.5	5.1	7.1	5.8	3.9	2.3	7.8	5.8
90	Ex. 2	Cont.	2.0	1.1	2.6	2.4	1.9	3.0	2.2	1.6	2.8	2.0	2.5	2.3
90	Ex. 3	Cont.	4.5	4.9	2.4	7.3	1.2	3.0	6.1	3.6	2.7	4.1	4.6	4.4
90	Active	Cont.	0.8	3.7	2.5	1.3	7.2	4.0	1.1	5.7	3.4	2.6	4.8	3.9

A9. (cont'd)

			Right Lateral Flexion (degrees)			Left Lateral Flexion (degrees)			Lateral Flexion Cycle (degrees)			RMSE Total (degrees)		
Subject	**Test**	**Group**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**Right**	**Left**	**Cycle**
96	Ex. 2	Cont.	3.1	2.3	3.8	1.5	0.8	2.4	2.4	1.7	3.2	3.1	1.7	2.5
96	Ex. 3	Cont.	2.6	6.1	2.0	1.9	1.1	1.8	2.3	4.4	1.9	4.0	1.7	3.1
96	Active	Cont.	2.3	3.0	1.4	1.7	3.2	1.4	2.0	3.1	1.4	2.4	2.2	2.3
106	Ex. 2	Cont.	5.0	3.2	1.2	1.5	5.0	2.6	3.7	4.2	2.1	3.5	3.4	3.4
106	Ex. 3	Cont.	2.0	1.9	1.6	1.1	3.2	1.2	1.6	2.6	1.4	1.9	2.1	2.0
106	Active	Cont.	0.9	1.6	1.3	3.6	2.2	4.0	2.6	1.9	3.0	1.3	3.4	2.6
111	Ex. 2	Cont.	1.0	2.6	2.7	2.2		1.8	1.7		2.3	2.2	1.6	2.0
111	Ex. 3	Cont.	2.5	6.2	4.3	3.4	1.3	1.4	3.0	4.5	3.2	4.6	2.3	3.6
111	Active	Cont.	4.5	3.2	4.0	0.9	3.8	3.1	3.3	3.6	3.6	4.0	2.9	3.5
117	Ex. 2	Cont.	3.0	0.8	5.5	1.4	2.1	3.7	2.4	1.6	4.7	3.7	2.6	3.2
117	Ex. 3	Cont.	2.5	1.7	1.1	2.8	4.6	1.6	2.6	3.5	1.4	1.8	3.2	2.6
117	Active	Cont.	0.9	3.9	1.0	1.0	3.1	2.1	0.9	3.5	1.7	2.4	2.2	2.3

Pre-Treatment

			Right Lateral Flexion (degrees)			Left Lateral Flexion (degrees)			Lateral Flexion Cycle (degrees)			RMSE Total (degrees)		
Subject	**Test**	**Group**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**Right**	**Left**	**Cycle**
6	Ex. 2	Exp.	3.5	11.2	5.9	1.5	0.7	2.6	2.7	8.0	4.6	7.6	1.8	5.5
6	Ex. 3	Exp.	2.6	5.7	4.2	4.9	1.4	2.2	3.9	4.2	3.3	4.4	3.2	3.8
6	Active	Exp.	1.7			4.3			3.2			1.7	4.3	3.2
9	Ex. 2	Exp.	2.9	4.3	3.1	4.3	6.4	2.8	3.7	5.4	2.9	3.5	4.7	4.1
9	Ex. 3	Exp.	0.7	3.5	3.9	2.8	1.2	3.6	2.0	2.6	3.7	3.0	2.7	2.9
9	Active	Exp.	8.7	4.2	8.2	4.3	1.1	1.9	6.9	3.1	6.0	7.3	2.8	5.5
12	Ex. 2	Exp.	5.9	3.7	5.6	1.2	0.5	4.1	4.2	2.7	4.9	5.2	2.5	4.0
12	Ex. 3	Exp.	1.5	2.8	0.7	0.8	0.6	0.5	1.2	2.1	0.6	1.9	0.7	1.4
12	Active	Exp.	5.7	6.6	5.0	1.5	7.4	5.2	4.1	7.0	5.1	5.8	5.3	5.5

A9. (cont'd)

Pre-Treatment

			Right Lateral Flexion (degrees)			Left Lateral Flexion (degrees)			Lateral Flexion Cycle (degrees)			RMSE Total (degrees)		
Subject	**Test**	**Group**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**Right**	**Left**	**Cycle**
14	Ex. 2	Exp.	1.1	1.2	2.4	1.6	2.0	3.6	1.3	1.7	3.1	1.7	2.5	2.2
14	Ex. 3	Exp.	3.8	2.5	1.1	3.0	4.1	5.4	3.4	3.4	3.9	2.7	4.3	3.6
14	Active	Exp.	4.6	6.1	4.2	9.9	4.8	6.9	7.7	5.5	5.7	5.0	7.5	6.4
23	Ex. 2	Exp.	2.1	2.2	3.1	5.1	4.5	1.5	3.9	3.6	2.5	2.5	4.0	3.4
23	Ex. 3	Exp.	0.6	1.2	4.0	1.3	1.3	1.6	1.0	1.2	3.1	2.4	1.4	2.0
23	Active	Exp.	2.4	1.6	2.2	4.5	3.4	2.6	3.6	2.7	2.4	2.1	3.6	2.9
25	Ex. 2	Exp.	1.1	1.3	3.4	1.5	4.0	2.4	1.3	3.0	2.9	2.2	2.8	2.5
25	Ex. 3	Exp.	4.0	6.6	3.5	1.8	3.4	3.1	3.1	5.3	3.3	4.9	2.9	4.0
25	Active	Exp.	1.7	3.3	3.8	0.8	2.4	1.0	1.3	2.9	2.7	3.1	1.6	2.4
54	Ex. 2	Exp.	1.6	4.9	0.8	3.3	3.2	6.6	2.6	4.2	4.7	3.0	4.7	3.9
54	Ex. 3	Exp.	4.4	1.6	1.3	6.2	5.3	4.1	5.4	4.0	3.0	2.8	5.3	4.2
54	Active	Exp.	2.0	2.0	1.4	4.4	5.1	2.4	3.4	3.9	2.0	1.8	4.2	3.2
55	Ex. 2	Exp.	0.7	1.1		1.2	0.6		1.0	0.9		0.9	0.9	0.9
55	Ex. 3	Exp.	4.4	7.2	1.9	2.1	4.8	1.6	3.4	6.1	1.7	5.0	3.2	4.2
55	Active	Exp.	2.1	3.8	1.6	2.5	2.2		2.3	3.1		2.7	2.4	2.6
57	Ex. 2	Exp.	1.4	2.3	2.1	7.1	2.5	1.8	5.1	2.4	2.0	2.0	4.4	3.4
57	Ex. 3	Exp.	1.9	5.0	3.7	1.7	2.5	4.2	1.8	4.0	3.9	3.8	3.0	3.4
57	Active	Exp.	1.8	1.9	1.7	3.2	1.2	1.6	2.6	1.6	1.6	1.8	2.2	2.0
70	Ex. 2	Exp.	3.8	2.1	5.1	0.6	0.9	2.4	2.7	1.6	4.0	3.9	1.5	2.9
70	Ex. 3	Exp.	3.4	2.0	1.2	1.0	1.8	1.7	2.5	1.9	1.5	2.4	1.6	2.0
70	Active	Exp.	1.3	0.8	2.0	2.2	1.9	1.7	1.8	1.4	1.9	1.5	1.9	1.7
72	Ex. 2	Exp.	1.7	0.5	1.1	2.3	1.5	4.5	2.0	1.1	3.3	1.2	3.0	2.3
72	Ex. 3	Exp.	0.8	3.4	4.6	7.7	0.7	1.9	5.5	2.5	3.5	3.3	4.6	4.0
72	Active	Exp.	5.1	2.1	1.6	2.9	4.0	2.9	4.1	3.2	2.3	3.3	3.3	3.3
80	Ex. 2	Exp.	2.2	1.2	0.9	2.5	3.0	0.9	2.4	2.3	0.9	1.6	2.3	2.0
80	Ex. 3	Exp.	1.6	1.0	1.7	1.5	3.3	1.9	1.5	2.5	1.8	1.4	2.4	2.0
80	Active	Exp.	3.7	1.8	2.0	0.7	3.4	1.8	2.7	2.7	1.9	2.7	2.2	2.5

A9. (cont'd)

Pre-Treatment

			Right Lateral Flexion (degrees)			Left Lateral Flexion (degrees)			Lateral Flexion Cycle (degrees)			RMSE Total (degrees)		
Subject	**Test**	**Group**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**Right**	**Left**	**Cycle**
84	Ex. 2	Exp.	1.8	5.1	4.4	0.5	1.2	2.1	1.3	3.7	3.4	4.0	1.4	3.0
84	Ex. 3	Exp.	2.6	4.6	4.1	1.2	1.7	2.3	2.0	3.4	3.3	3.8	1.8	3.0
84	Active	Exp.	1.0	2.1	3.2	4.1	10.1	6.2	3.0	7.3	5.0	2.3	7.2	5.4
91	Ex. 2	Exp.	1.7	1.0	2.0	3.2	2.0	4.3	2.6	1.6	3.4	1.6	3.3	2.6
91	Ex. 3	Exp.	2.6	2.6	3.0	1.8	2.7	3.8	2.3	2.7	3.4	2.8	2.9	2.8
91	Active	Exp.	1.5	2.7	3.4	2.4	2.2	1.3	2.0	2.5	2.6	2.7	2.0	2.4
95	Ex. 2	Exp.	2.8	2.5	1.1	4.4	0.8	1.1	3.7	1.9	1.1	2.3	2.7	2.5
95	Ex. 3	Exp.	1.7	3.6	5.6	2.4	4.0	2.2	2.1	3.8	4.3	4.0	3.0	3.5
95	Active	Exp.	2.0	3.4	2.6	6.0	4.1	3.1	4.4	3.8	2.9	2.7	4.6	3.8
98	Ex. 2	Exp.	1.4	1.8	2.1	2.2	2.7	7.5	1.8	2.3	5.5	1.8	4.8	3.6
98	Ex. 3	Exp.	3.7	4.0	2.2	4.1	2.6	3.8	3.9	3.4	3.1	3.4	3.5	3.5
98	Active	Exp.	9.8	4.7	2.2	3.6	5.3	4.4	7.4	5.0	3.5	6.4	4.5	5.5
112	Ex. 2	Exp.	1.9	0.9	4.9	1.7	1.2	2.5	1.8	1.0	3.9	3.1	1.9	2.6
112	Ex. 3	Exp.	1.2	3.4	1.6	2.4	0.8	1.1	1.9	2.4	1.4	2.3	1.6	2.0
112	Active	Exp.	4.1	2.0	2.5	0.8	1.8	2.1	2.9	1.9	2.3	3.0	1.6	2.4
115	Ex. 2	Exp.	2.7	3.1	2.7	1.2	1.1		2.1	2.3		2.8	1.1	2.3
115	Ex. 3	Exp.	2.7	2.5	1.0	6.6	3.7	2.4	5.1	3.2	1.9	2.2	4.6	3.6
115	Active	Exp.												
125	Ex. 2	Exp.	0.9	0.5	2.4	1.0	1.8	2.2	0.9	1.3	2.3	1.5	1.7	1.6
125	Ex. 3	Exp.	1.5	0.9	3.8	1.6	1.3	1.5	1.5	1.1	2.9	2.4	1.5	2.0
125	Active	Exp.	2.4	2.6	3.4	2.3	1.5	1.5	2.3	2.1	2.6	2.8	1.8	2.4

A9. (cont'd)

Post-Treatment

			Right Lateral Flexion (degrees)			Left Lateral Flexion (degrees)			Lateral Flexion Cycle (degrees)			RMSE Total (degrees)		
Subject	**Test**	**Group**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**Right**	**Left**	**Cycle**
6	Ex. 2	Exp.	4.6	2.7	3.7	2.4	2.1	1.4	3.7	2.4	2.8	3.8	2.0	3.0
6	Ex. 3	Exp.	1.2	1.0	1.5	1.6	2.2	2.4	1.4	1.7	2.0	1.2	2.1	1.7
6	Active	Exp.	2.0	0.5	0.9	3.0	4.3	2.1	2.6	3.1	1.6	1.3	3.3	2.5
9	Ex. 2	Exp.	7.2	8.5	7.4	5.6	1.5	4.0	6.5	6.1	5.9	7.7	4.0	6.2
9	Ex. 3	Exp.	2.3	1.3	6.2	2.0	0.8	2.1	2.2	1.1	4.6	3.9	1.7	3.0
9	Active	Exp.	2.2	3.9	3.3	2.4	2.1	1.3	2.3	3.1	2.5	3.2	2.0	2.7
12	Ex. 2	Exp.	0.7	3.5	4.0	2.8	4.1	2.6	2.1	3.8	3.4	3.1	3.2	3.2
12	Ex. 3	Exp.	1.9	1.0	0.7	2.3	0.5	2.1	2.1	0.8	1.6	1.3	1.8	1.6
12	Active	Exp.	3.4	2.0	2.0	4.7	1.9	4.4	4.1	2.0	3.4	2.6	3.9	3.3
14	Ex. 2	Exp.	3.0	10.7	6.2	5.1	5.1	3.7	4.2	8.4	5.1	7.3	4.7	6.2
14	Ex. 3	Exp.	2.0	2.0	3.2	15.6	11.3	9.5	11.1	8.1	7.1	2.5	12.4	8.9
14	Active	Exp.	4.9	3.5	1.1	3.9	1.4	11.0	4.5	2.7	7.8	3.6	6.8	5.4
23	Ex. 2	Exp.	1.5	4.3	3.5	5.7	4.7	3.1	4.1	4.5	3.3	3.3	4.6	4.0
23	Ex. 3	Exp.	0.8	2.1	2.7	2.9	5.1	3.0	2.2	3.9	2.8	2.0	3.8	3.1
23	Active	Exp.	2.9	2.2	3.3	4.3	2.5	1.1	3.7	2.3	2.4	2.8	3.0	2.9
25	Ex. 2	Exp.	2.0	1.0	2.4	1.7	1.4	3.1	1.9	1.2	2.8	1.9	2.2	2.1
25	Ex. 3	Exp.	1.0	1.6	1.5	2.8	6.2	1.3	2.1	4.5	1.4	1.4	4.0	3.0
25	Active	Exp.	1.4	5.0	2.1	7.2	6.9	6.5	5.2	6.0	4.8	3.2	6.9	5.4
54	Ex. 2	Exp.	2.2	1.7	3.5	3.3	1.2	1.1	2.8	1.5	2.6	2.6	2.1	2.4
54	Ex. 3	Exp.	3.5	3.8	3.0	1.2	1.5	1.4	2.6	2.9	2.3	3.4	1.4	2.6
54	Active	Exp.	3.1	5.3	2.3	2.0	3.4	2.6	2.6	4.5	2.5	3.8	2.8	3.3
55	Ex. 2	Exp.	2.1	1.1	2.2	0.9	1.7	1.5	1.6	1.4	1.9	1.8	1.4	1.6
55	Ex. 3	Exp.	1.4	1.7	5.0	1.7	0.8	6.1	1.6	1.3	5.6	3.1	3.7	3.4
55	Active	Exp.	1.7	1.7	1.2	4.2	3.6	2.1	3.2	2.8	1.7	1.6	3.4	2.7
57	Ex. 2	Exp.	2.1	3.3	1.7	1.2	1.5	3.8	1.7	2.6	2.9	2.4	2.5	2.4
57	Ex. 3	Exp.	1.2	1.6	4.5	2.3	2.3	2.1	1.8	2.0	3.5	2.8	2.2	2.5
57	Active	Exp.	3.7	3.4	2.8	2.4	1.9	4.7	3.1	2.7	3.9	3.3	3.3	3.3

A9. (cont'd)

Post-Treatment

			Right Lateral Flexion (degrees)			Left Lateral Flexion (degrees)			Lateral Flexion Cycle (degrees)			RMSE Total (degrees)		
Subject	**Test**	**Group**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**Right**	**Left**	**Cycle**
70	Ex. 2	Exp.	2.9	1.1	2.2	5.4	2.7	3.6	4.4	2.1	3.0	2.2	4.1	3.3
70	Ex. 3	Exp.	1.9	3.0	3.4	0.7	1.5	3.7	1.4	2.4	3.5	2.8	2.3	2.6
70	Active	Exp.	5.3	5.0	0.9	2.0	5.3	2.2	4.0	5.2	1.7	4.2	3.5	3.9
72	Ex. 2	Exp.	2.0	0.9	4.9	4.5	6.1	2.0	3.5	4.4	3.8	3.1	4.5	3.9
72	Ex. 3	Exp.	6.5	4.2	1.7	3.6	2.0	1.7	5.2	3.3	1.7	4.6	2.6	3.7
72	Active	Exp.	1.9	1.6	2.4	1.9	3.1	1.4	1.9	2.5	2.0	2.0	2.2	2.1
80	Ex. 2	Exp.	2.9	3.7	2.0	0.6	2.2	1.3	2.1	3.0	1.7	3.0	1.5	2.4
80	Ex. 3	Exp.	1.3	1.2	1.1	2.8	1.3	1.3	2.2	1.3	1.2	1.2	1.9	1.6
80	Active	Exp.	2.1	3.9	1.1	3.1	2.0	1.2	2.7	3.1	1.1	2.6	2.2	2.5
84	Ex. 2	Exp.	3.0	0.5	1.3	1.6	0.9	1.2	2.4	0.8	1.3	1.9	1.3	1.6
84	Ex. 3	Exp.	2.3	4.3	2.2	1.1	1.3	1.8	1.8	3.2	2.0	3.1	1.4	2.4
84	Active	Exp.	4.5	4.7	6.0	4.4	3.8	2.6	4.5	4.3	4.7	5.1	3.7	4.5
91	Ex. 2	Exp.	2.4	1.7	1.7	2.5	1.8	1.4	2.4	1.7	1.6	1.9	1.9	1.9
91	Ex. 3	Exp.	3.7	4.2	1.2	3.6	3.5	2.6	3.6	3.8	2.1	3.3	3.3	3.3
91	Active	Exp.	2.5	7.3	3.7	2.1	4.3	4.8	2.3	6.0	4.3	4.9	3.9	4.5
95	Ex. 2	Exp.	3.5	1.9	0.8	0.6	1.5	0.7	2.5	1.7	0.8	2.4	1.0	1.8
95	Ex. 3	Exp.												
95	Active	Exp.	2.1	2.9	1.3	1.7	1.1	3.7	1.9	2.2	2.8	2.2	2.4	2.3
98	Ex. 2	Exp.	6.1	1.4	1.8	3.3	0.9	1.2	4.9	1.2	1.5	3.8	2.1	3.0
98	Ex. 3	Exp.	3.6	2.3	0.8	3.7	2.5	2.0	3.6	2.4	1.6	2.5	2.8	2.7
98	Active	Exp.	1.9	3.3	1.2	1.0	1.1	1.5	1.5	2.4	1.3	2.3	1.2	1.8
112	Ex. 2	Exp.	1.6	2.1	1.8	3.0	2.7	3.7	2.4	2.4	2.9	1.8	3.2	2.6
112	Ex. 3	Exp.	2.6	1.6	2.0	0.9	1.9	1.1	2.0	1.7	1.6	2.1	1.3	1.8
112	Active	Exp.	1.2	3.9	1.5	2.4	2.3	2.4	1.9	3.2	2.0	2.5	2.4	2.4

A9. (cont'd)

Post-Treatment

			Right Lateral Flexion (degrees)			Left Lateral Flexion (degrees)			Lateral Flexion Cycle (degrees)			RMSE Total (degrees)		
Subject	**Test**	**Group**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**Right**	**Left**	**Cycle**
115	Ex. 2	Exp.	2.9	2.5	3.9	2.5	0.7	1.7	2.7	1.8	3.0	3.1	1.8	2.6
115	Ex. 3	Exp.	1.2	3.3	2.4	1.8	1.9	1.2	1.6	2.7	1.9	2.4	1.7	2.1
115	Active	Exp.	6.3	2.5	5.8	2.0	20.8	21.9	4.7	14.8	16.0	5.2	17.5	12.9
125	Ex. 2	Exp.	2.5	1.9	1.6	0.8	1.3	0.9	1.9	1.6	1.3	2.1	1.0	1.6
125	Ex. 3	Exp.	6.2	5.8	4.9	3.2	5.8	5.2	4.9	5.8	5.0	5.6	4.9	5.3
125	Active	Exp.	2.9	4.5	1.4	1.4	1.8	1.8	2.3	3.5	1.6	3.2	1.7	2.6

Pre-Treatment

			Right Lateral Flexion (degrees)			Left Lateral Flexion (degrees)			Lateral Flexion Cycle (degrees)			RMSE Total (degrees)		
Subject	**Test**	**Group**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**Right**	**Left**	**Cycle**
126	Ex. 2	Long.	1.5	4.0	3.5	2.2	2.4	1.0	1.9	3.3	2.6	3.2	2.0	2.7
126	Ex. 3	Long.	1.3	0.6	1.2	1.4	1.4	3.1	1.4	1.1	2.3	1.1	2.1	1.7
126	Active	Long.	2.2	1.2	0.9	2.5	3.0	0.9	2.4	2.3	0.9	1.6	2.3	2.0
127	Ex. 2	Long.	1.3	1.8	1.8	1.8	2.4	4.4	1.6	2.2	3.4	1.7	3.1	2.5
127	Ex. 3	Long.	3.1	3.6	2.8	0.8	3.0	3.6	2.2	3.3	3.2	3.2	2.7	3.0
127	Active	Long.	2.7	3.3	1.5	2.5	1.5	1.8	2.6	2.6	1.7	2.6	2.0	2.3
128	Ex. 2	Long.	1.9	1.4	3.2	3.8	1.1	1.1	3.0	1.3	2.4	2.3	2.4	2.3
128	Ex. 3	Long.	0.6	2.0	3.7	2.3	4.9	1.5	1.7	3.8	2.8	2.5	3.2	2.9
128	Active	Long.	1.1	2.4	0.7	2.9	0.5	0.7	2.2	1.7	0.7	1.5	1.8	1.7
129	Ex. 2	Long.	1.3	1.7	2.6	1.0	1.7	1.9	1.2	1.7	2.3	2.0	1.6	1.8
129	Ex. 3	Long.	4.0	3.0	6.8	1.1	5.6	2.9	2.9	4.4	5.2	4.8	3.7	4.3
129	Active	Long.	1.1	0.9	3.2	4.5	0.9	6.1	3.3	0.9	4.9	2.0	4.4	3.4
131	Ex. 2	Long.	2.1	2.4	0.9	5.1	3.5	2.5	3.9	3.0	1.9	1.9	3.9	3.1
131	Ex. 3	Long.	1.8	3.4	2.8	4.0	2.2	1.9	3.1	2.9	2.4	2.8	2.8	2.8
131	Active	Long.	2.1	4.2	4.6	1.8	3.5	2.8	2.0	3.9	3.8	3.8	2.8	3.3

A9. (cont'd)

Post-Treatment

			Right Lateral Flexion (degrees)			Left Lateral Flexion (degrees)			Lateral Flexion Cycle (degrees)			RMSE Total (degrees)		
Subject	**Test**	**Group**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**Right**	**Left**	**Cycle**
126	Ex. 2	Long.	1.7	4.1	5.6	3.5	1.9	2.1	2.8	3.2	4.2	4.1	2.6	3.5
126	Ex. 3	Long.	2.9	3.1	1.4	2.0	3.1	0.7	2.5	3.1	1.1	2.6	2.2	2.4
126	Active	Long.	3.2	3.5	0.9	1.6	3.1	2.7	2.5	3.3	2.0	2.8	2.6	2.7
127	Ex. 2	Long.	1.3	1.3	3.9	1.6	1.2	0.8	1.5	1.3	2.8	2.5	1.3	2.0
127	Ex. 3	Long.	3.4	3.3	0.7	3.8	2.0	3.0	3.6	2.7	2.2	2.7	3.0	2.9
127	Active	Long.	5.1	5.1	1.9	1.7	3.6	3.7	3.8	4.4	3.0	4.3	3.1	3.8
128	Ex. 2	Long.	1.7	3.8	2.2	1.6	3.4	1.7	1.7	3.6	2.0	2.7	2.4	2.6
128	Ex. 3	Long.	1.6	1.7	1.8	6.0	1.6	2.4	4.4	1.7	2.1	1.7	3.8	3.0
128	Active	Long.	2.7	4.2	1.4	2.5	0.5	1.9	2.6	3.0	1.7	3.0	1.8	2.5
129	Ex. 2	Long.	1.9	4.2	5.0	2.0	6.4	6.6	1.9	5.4	5.9	3.9	5.4	4.7
129	Ex. 3	Long.	3.6	3.9	2.1	3.2	1.6	2.1	3.4	3.0	2.1	3.3	2.4	2.9
129	Active	Long.	3.2	1.1	0.9	4.0	1.0	3.9	3.6	1.1	2.9	2.0	3.3	2.7
131	Ex. 2	Long.	2.6	2.1	1.2	0.6	1.2	0.8	1.9	1.7	1.0	2.0	0.9	1.6
131	Ex. 3	Long.	1.6	1.7	4.8	1.8	2.4	1.6	1.7	2.1	3.6	3.1	2.0	2.6
131	Active	Long.	0.9	2.4	1.7	2.5	2.5	2.0	1.9	2.5	1.9	1.8	2.4	2.1

A9. (cont'd)

72-Hours Post-Treatment

			Right Lateral Flexion (degrees)			Left Lateral Flexion (degrees)			Lateral Flexion Cycle (degrees)			RMSE Total (degrees)		
Subject	**Test**	**Group**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**Right**	**Left**	**Cycle**
126	Ex. 2	Long.	1.8	1.6	2.6	1.0	1.7	3.2	1.5	1.7	2.9	2.1	2.1	2.1
126	Ex. 3	Long.	1.6	5.9	1.6	3.0	2.3	2.6	2.4	4.5	2.2	3.7	2.6	3.2
126	Active	Long.	1.0	1.4	1.7	1.5	3.3	3.3	1.3	2.5	2.6	1.4	2.8	2.2
127	Ex. 2	Long.	0.5	0.8	1.8	0.9	1.9	1.2	0.8	1.5	1.5	1.2	1.4	1.3
127	Ex. 3	Long.	2.9	1.7	2.1	1.5	1.3	0.9	2.3	1.5	1.6	2.3	1.3	1.9
127	Active	Long.	2.0	0.5	1.0	1.1	1.2	1.4	1.6	0.9	1.2	1.3	1.3	1.3
128	Ex. 2	Long.	1.4	3.0	2.3	7.4	6.6	2.6	5.4	5.1	2.5	2.3	6.0	4.5
128	Ex. 3	Long.	1.8	2.5	3.4	0.8	3.2	1.6	1.4	2.9	2.6	2.6	2.1	2.4
128	Active	Long.	1.9	1.9	1.6	2.4	4.0	6.0	2.2	3.1	4.4	1.8	4.4	3.4
129	Ex. 2	Long.	1.5	1.0	2.5	2.6	3.9	1.5	2.1	2.9	2.1	1.8	2.8	2.4
129	Ex. 3	Long.	0.7	3.2	4.2	3.2	0.6	2.7	2.3	2.3	3.5	3.1	2.4	2.8
129	Active	Long.	3.6	0.7	1.4	2.3	3.8	1.5	3.0	2.8	1.4	2.3	2.7	2.5
131	Ex. 2	Long.	1.1	1.5	1.5	0.8	1.5	0.8	1.0	1.5	1.2	1.4	1.1	1.2
131	Ex. 3	Long.	0.6	1.5	4.2	1.6	1.3	1.2	1.2	1.4	3.1	2.6	1.4	2.1
131	Active	Long.	1.1	0.6	1.2	2.7	2.9	1.7	2.0	2.1	1.5	1.0	2.5	1.9

A10. RMSE of Complete Time Series

Subject	Test	Group	RMSE (degrees)
4	Ex. 2	Cont.	12.6
4	Ex. 3	Cont.	6.6
4	Active	Cont.	17.6
5	Ex. 2	Cont.	12.9
5	Ex. 3	Cont.	8.3
5	Active	Cont.	22.7
27	Ex. 2	Cont.	7.8
27	Ex. 3	Cont.	6.1
27	Active	Cont.	8.6
41	Ex. 2	Cont.	7.6
41	Ex. 3	Cont.	11.2
41	Active	Cont.	5.6
46	Ex. 2	Cont.	7.7
46	Ex. 3	Cont.	18.5
46	Active	Cont.	9.7
51	Ex. 2	Cont.	8.8
51	Ex. 3	Cont.	10.1
51	Active	Cont.	15.1
56	Ex. 2	Cont.	6.1
56	Ex. 3	Cont.	5.1
56	Active	Cont.	13.6
59	Ex. 2	Cont.	8.0
59	Ex. 3	Cont.	5.2
59	Active	Cont.	10.9
63	Ex. 2	Cont.	8.2
63	Ex. 3	Cont.	4.7
63	Active	Cont.	12.0

			RMSE (degrees)	
Subject	Test	Group	Pre-Treatment	Post-Treatment
6	Ex. 2	Exp.	7.3	5.4
6	Ex. 3	Exp.	9.0	10.7
6	Active	Exp.	4.2	6.3
9	Ex. 2	Exp.	12.0	7.5
9	Ex. 3	Exp.	6.1	
9	Active	Exp.	6.9	8.8
12	Ex. 2	Exp.	6.6	5.8
12	Ex. 3	Exp.	3.9	6.8
12	Active	Exp.	6.7	12.1
14	Ex. 2	Exp.	16.7	18.5
14	Ex. 3	Exp.	17.9	10.9
14	Active	Exp.	38.2	21.8
23	Ex. 2	Exp.	8.7	12.2
23	Ex. 3	Exp.	4.2	11.6
23	Active	Exp.	5.4	10.2
25	Ex. 2	Exp.	5.6	7.9
25	Ex. 3	Exp.	6.9	5.9
25	Active	Exp.	14.0	22.2
54	Ex. 2	Exp.	10.3	8.5
54	Ex. 3	Exp.	5.9	4.1
54	Active	Exp.	6.0	10.7
55	Ex. 2	Exp.	3.0	5.4
55	Ex. 3	Exp.	9.8	10.5
55	Active	Exp.	3.8	9.3
57	Ex. 2	Exp.	7.3	7.6
57	Ex. 3	Exp.	8.1	9.2
57	Active	Exp.	19.5	10.0

A10. (cont'd)

Subject	Test	Group	RMSE (degrees)
67	Ex. 2	Cont.	11.6
67	Ex. 3	Cont.	5.3
67	Active	Cont.	10.4
68	Ex. 2	Cont.	8.1
68	Ex. 3	Cont.	7.6
68	Active	Cont.	4.7
69	Ex. 2	Cont.	7.0
69	Ex. 3	Cont.	7.7
69	Active	Cont.	19.7
77	Ex. 2	Cont.	3.6
77	Ex. 3	Cont.	12.6
77	Active	Cont.	36.9
79	Ex. 2	Cont.	8.3
79	Ex. 3	Cont.	5.5
79	Active	Cont.	7.9
83	Ex. 2	Cont.	6.1
83	Ex. 3	Cont.	11.1
83	Active	Cont.	3.2
85	Ex. 2	Cont.	4.5
85	Ex. 3	Cont.	10.0
85	Active	Cont.	8.4
88	Ex. 2	Cont.	3.8
88	Ex. 3	Cont.	3.4
88	Active	Cont.	5.7
90	Ex. 2	Cont.	7.1
90	Ex. 3	Cont.	11.2
90	Active	Cont.	16.3

			RMSE (degrees)	
Subject	Test	Group	Pre-Treatment	Post-Treatment
70	Ex. 2	Exp.	8.5	7.2
70	Ex. 3	Exp.	3.0	14.7
70	Active	Exp.	13.7	4.3
72	Ex. 2	Exp.	8.8	8.3
72	Ex. 3	Exp.	10.1	6.7
72	Active	Exp.	6.6	4.9
80	Ex. 2	Exp.	10.6	5.4
80	Ex. 3	Exp.	5.5	7.2
80	Active	Exp.	5.7	5.7
84	Ex. 2	Exp.	5.6	5.3
84	Ex. 3	Exp.	4.9	5.9
84	Active	Exp.	7.1	4.8
91	Ex. 2	Exp.	7.1	16.7
91	Ex. 3	Exp.	5.1	12.8
91	Active	Exp.	13.6	8.1
95	Ex. 2	Exp.	10.8	8.8
95	Ex. 3	Exp.	11.4	
95	Active	Exp.	5.0	11.4
98	Ex. 2	Exp.	6.1	6.8
98	Ex. 3	Exp.	11.0	8.6
98	Active	Exp.	12.0	10.3
112	Ex. 2	Exp.	12.2	11.7
112	Ex. 3	Exp.	6.0	12.5
112	Active	Exp.	14.9	9.0
115	Ex. 2	Exp.	5.2	5.7
115	Ex. 3	Exp.	7.8	10.4
115	Active	Exp.		20.9

A10. (cont'd)

Subject	Test	Group	RMSE (degrees)
96	Ex. 2	Cont.	9.6
96	Ex. 3	Cont.	5.7
96	Active	Cont.	6.4
106	Ex. 2	Cont.	8.5
106	Ex. 3	Cont.	6.5
106	Active	Cont.	6.4
111	Ex. 2	Cont.	8.0
111	Ex. 3	Cont.	6.6
111	Active	Cont.	17.6
117	Ex. 2	Cont.	11.2
117	Ex. 3	Cont.	9.2
117	Active	Cont.	12.3

			RMSE (degrees)	
Subject	Test	Group	Pre-Treatment	Post-Treatment
125	Ex. 2	Exp.	5.4	6.2
125	Ex. 3	Exp.	7.5	5.0
125	Active	Exp.	4.6	3.4

A10. (cont'd)

			RMSE (degrees)		
Subject	**Test**	**Group**	**Pre-Treatment**	**Post-Treatment**	**72-Hours**
126	Ex. 2	Long.	3.7	7.7	11.3
126	Ex. 3	Long.	5.1	10.9	7.1
126	Active	Long.	10.6	5.0	15.1
127	Ex. 2	Long.	4.8	12.1	5.9
127	Ex. 3	Long.	6.0	9.6	5.6
127	Active	Long.	12.1	6.8	10.5
128	Ex. 2	Long.	11.7	3.9	6.7
128	Ex. 3	Long.	11.5	8.1	15.9
128	Active	Long.	13.6	5.8	16.6
129	Ex. 2	Long.	4.4	6.5	4.5
129	Ex. 3	Long.	7.5	7.2	7.4
129	Active	Long.	11.7	7.4	7.7
131	Ex. 2	Long.	5.8	4.1	4.0
131	Ex. 3	Long.	10.0	12.0	6.8
131	Active	Long.	9.3	15.8	10.6

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