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EMG Analysis of Lassimus Dorsi, Middle Trapezius, and Erector Spinae Muscle Activity During Spinal Rotation: A Pilot Study

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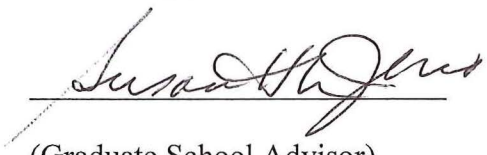
This scholarly Project, submitted by Katie Holzheimer, Ross Swartz, Keely Hutchens, and Joshua Still in partial fulfillment of the requirements for the degree of Doctor of Physical Therapy from the University of North Dakota, has been read by the Advisor and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.



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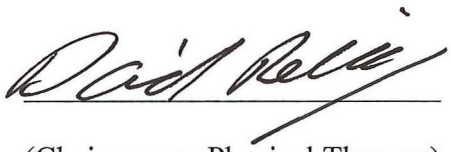

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PERMISSION

Title	EMG Analysis of Latissimus Dorsi, Middle Trapezius, and Erector Spinae Muscle Activity During Spinal Rotation: A Pilot Study
Department	Physical Therapy
Degree	Doctor of Physical Therapy

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We would also like to thank all of the participants who were able to find time in their schedules to volunteer to be a part of this study. Without your participation, we would not have been able to continue this pilot study. Lastly, we would like to thank all of the family friends in our lives who have continuously supported us, both throughout this research study and throughout the course of physical therapy school.

ABSTRACT

Purpose/Hypothesis: Spinal rotation is a very common movement that occurs multiple times each day during normal daily activities or even during certain sport performances. Since this motion is a contributing factor to back injuries, it will be important for physical therapists to consider this concept with rehabilitation programs for current back injuries as well as prevention of future injuries. The LD has attachments to many areas of the body, including the spine, humerus, scapula, and pelvis, which explains why this muscle also contributes to multiple actions at the trunk and upper extremity. Due to the attachment sites and the large size of the LD, this muscle is capable of influencing spinal motions during different activities. However, while there is some research regarding muscles involved with spinal rotation, there is currently limited findings for the LD and its contributing factors to spinal rotation. The purpose of this study was to improve the understanding and determine the muscle activity the LD has during spinal rotation and compare that muscle activity throughout different fixed and non-fixed positions.

Methods: Participants progressed through ten spinal rotation positions (standing non-fixed rotation right/left, quadruped rotation right/left, and standing rotation right and left with arms fixed on the wall at 45°, 90° and 120° of shoulder flexion). While performing pelvis rotation in testing positions, muscle activity was recorded using EMG surface electrodes. Muscle Activity was normalized by using Maximal Voluntary Contraction (MVC) to normalize muscle activity. Findings were analyzed for significance at α=.05.

Results: Significant differences were found in LD EMG activity in fixed and non-fixed movements with the ipsilateral LD being more active in fixed rotation. The ipsilateral LD EMG activity was found to be significantly greater in fixed rotation than right or left MT and ES, as well as the contralateral LD. During non-fixed spinal rotation, the ipsilateral ES EMG activity was found to be significantly greater than the right or left MT and LD, as well as the contralateral ES.

Discussion/Conclusion: The findings propose the LD contributes significantly more than the MT and ES during fixed ipsilateral spinal rotation. This implies that while performing closed-chain spinal rotation the LD has better positioning to participate in spinal rotation or spinal stabilization. During non-fixed positions the ipsilateral ES were most active during spinal rotation. This suggests that while performing non-fixed rotation the LD is not in optimal position to rotate or stabilize the spine. Future studies should analyze the impact on gender differences, hand dominance, and larger sample size in muscle activation.

Clinical Relevance: This study is for clinicians to better understand how the LD, MT, and ES contribute to rotation of the spine. Once clinicians understand how different muscle groups affect

spinal rotation, they will be able to improve the evaluation and intervention process in a variety of pathologies such as LBP. Physical therapists will be able to determine the source of pain more efficiently and prescribe more effective exercises. Understanding the actions of these muscles and how they affect spinal rotation will allow the rehabilitation process to be more time efficient and cost beneficial.

CHAPTER I

INTRODUCTION

Spinal rotation is incorporated within everyday physical function including mobility within the home and community such as bed mobility, opening doors, and shopping. Literature primarily focuses on Latissimus Dorsi (LD) and its relationship to upper extremity movements.[1] The LD moves the humerus at the glenohumeral joint and its actions include shoulder adduction, medial rotation, and extension.[2]

The erector Spinae (ES) muscle group is a primary muscle responsible for spinal extension and rotation due to its attachment at the posterior iliac crest and the sacrum (Moore). The three muscle groups that make up the ES have attachments to the lateral ribs, transverse process, as well as the spinous process. The ES attachments explains why the ES has an optimal pull for spinal rotation. In comparison to ES, Middle Trapezius (MD) and LD may also have a role in spinal rotation due to their attachment on the spinous process; however, the spinal rotation is the opposite direction as the ES.[2] The LD and MT contribution to spinal rotation is not yet clear in literature, and without adequate knowledge of the LD and MT and their associated affects on spinal rotation, interventions will not address the patient's comprehensive pathologies.

To improve the rehabilitation process and interventions in patients demonstrating spinal pathologies, the muscle activity of LD and spinal rotation must be understood by

all treating clinicians. Spinal pathologies such as low back pain (LBP) are one of the most common and costly forms of musculoskeletal pain.[3] The prevalence of LBP poses an economic burden to society, mainly in terms of the large number of work days lost (indirect costs) and less

so by direct treatment costs.[4]

Currently, physical therapists attempt to decrease the number of work days lost by using exercises for LBP that target transversus abdominis, internal and external obliques, ES, quadratus lumborum, pelvic floor muscles, and multifidus through motor control corrections (movement control, directional preference, therapeutic exercise). These muscles have been shown to improve LBP, but there is a possibility that rehabilitation of LD could improve LBP through proper stabilization, activation, and motor control. When spine stability is the presenting issue in patients with LBP, therapists need to consider the evaluation of LD along with transversus abdominis, internal and external obliques, ES, quadratus lumborum, pelvic floor muscles, and multifidus.

Problem Statement

Currently, based on what was stated previously, the muscle activity of the LD at the glenohumeral joint is understood by clinicians and researchers, although the LD's action is not fully understood at the spinal levels. Considering the LD has attachments on the spinous process (T7-T12) and the lumbar fascia on the pelvis it can be hypothesized that LD has an action on the spine during spinal rotation (Moore). When reviewing the literature for the LD and its relationship to spinal rotation, the effects this muscle has on spinal rotation is still not thoroughly understood or discussed, which can serve as a problem when developing intervention plans for spinal pathologies.

Purpose of Study

The purpose of this study was to examine muscle activity of different back muscles, including LD, MT, and ES while participants perform spinal rotation in various positions with and without upper extremity fixation. Evidence gathered from this study may allow practicing

physical therapists to better understand and develop proper exercise programs for their patients with spinal pathologies.

Spinal rotation is traditionally defined based on the shoulders over the pelvis, but the movements in this study incorporate pelvic motion beneath the shoulders. For the purpose of this study, rotation is defined as rotation of the segments to which each muscle has an attachment. Motion will be initiated from the pelvis for all test conditions.

Significance of Study

The significance of this study is for physical therapists to better understand how the LD, MT, and ES contribute to rotation of the spine. Once physical therapists understand how different muscle groups affect spinal rotation, they will be able to improve the evaluation and intervention process in a variety of pathologies such as LBP. Physical therapists will be able to determine the source of pain more efficiently and prescribe more effective exercises. Overall, understanding the actions of these muscles and how they affect spinal rotation will allow the rehabilitation process to be more time efficient and cost beneficial.

Research Questions

1. Will the LD be significantly more active during spinal rotation with fixed or non-fixed upper extremities?
2. Will the LD activation be significantly different than ipsilateral MT and ES during spinal rotation in standing and quadruped with fixed upper extremities?
3. Will the LD activation be significantly different than ipsilateral MT and ES during spinal rotation with non-fixed upper extremities?

Null Hypothesis

1. There is no significant difference in LD EMG activity (%MVC) for fixed and non-fixed spinal rotation.
2. There is no significant difference between LD activation compared to MT and ES activation during spinal rotation in quadruped with fixed upper extremities.
3. There is no significant difference between LD activation and MT and ES activation during spinal rotation with non-fixed upper extremities.

Alternative Hypothesis

1. There is a significant difference in LD EMG activity (%MVC) for fixed and non-fixed spinal rotation.
2. There is a significant difference between LD activation compared to MT and ES activation during spinal rotation in quadruped with fixed upper extremities.
3. There is a significant difference between LD activation and MT and ES activation during spinal rotation with non-fixed upper extremities.

CHAPTER II

LITERATURE REVIEW

The LD muscle is a large fan shaped muscle that broadly originates from the spinous processes of the thoracic and lumbar spine, as well as, from the thoracolumbar fascia, ribs, scapula, and iliac crest. The muscle spans superolaterally, externally rotates, and inserts on the intertubercular groove of the humerus.[5] Previous studies have focused on injuries, response latency, and movements of LD primarily at the humerus, overlooking the actions at the spine. There currently is minimal research on the involvement of LD in relation to trunk rotation.[5-11]

Trunk rotation is a key factor in many functional activities, but spinal rotation is often overlooked during the examination and rehabilitation process. Research indicates LBP is a complex and biopsychosocial disorder without clear pathoanatomic mechanisms; therefore, any improvement in assessments may improve the rehabilitation process, ultimately increasing functional outcomes.[6] There are many factors to consider when assessing the cause of LBP. One theory proposes that poor coordination of muscles, low muscle activity, substantial joint laxity, muscle fatigue and/or problems in sensory inputs (vision) lead to spinal instability.[12] In a classification based system, clinical instability is considered one of the LBP subgroups, therefore; a patient with spinal instability has an increased risk for developing LBP.[13,14]

Poor coordination of muscles, low muscle activity, joint laxity, and muscle fatigue can occur for multiple reasons. Literature focuses on the concept of superficial muscle activities changing in attempt to increase spinal stability or compensation for structural changes in deep

muscles and/or osteoligamentous insufficiency.[6,12,] Literature also indicates the ratio of deep trunk muscle activity vs superficial muscle activity on unstable surfaces may also be related to spinal instability.[11] The expectation of this study was to describe how the LD, MT, and ES contribute to spinal rotation in order to further understand musculature biomechanics and coordination of the superficial back muscles. Overall, it is important to evaluate dynamic and static positions during electromyography (EMG) activity of musculoskeletal systems in stable and unstable surfaces to adequately represent function movement patterns in activities of daily living.[15]

There is a deficient amount of information regarding the action of LD and spinal motion. Previous studies have been unsuccessful in individually assessing the role of LD and its role in spinal rotation dynamically and statically in a variety of positions, because of this, a study may be needed to understand the muscle activity of LD with spinal rotation in positions with and without fixation of the upper extremities to accommodate for all activities of daily living.[12,13,14] Although, there is a lack of research regarding spinal rotation, research is essential to understand the musculoskeletal structures of the spine.

Spinal Anatomy

In order to fully understand the musculature of the back and the associated actions on the body, it is important to first investigate the vertebral column (spine) consisting of the vertebrae and intervertebral discs. The spine consists of 33 vertebrae broken down into five regions (superior to inferior): 7 cervical (C1-7), 12 thoracic (T1-12), 5 lumbar (L1-5), 5 sacral (S1-5), and 4 coccygeal (Co1-4). Of the 33 vertebrae, motion occurs in the cervical, thoracic, and lumbar regions, as the sacral and coccygeal vertebrae are fused in adults (around 30 years old) to form the sacrum and coccyx. As the spine descends from the cervical to the lumbar vertebrae, the vertebrae become increasingly larger size in order to bear the body's weight, then it tapers and becomes narrow until the end of the coccyx.[2]

The spine is responsible for protecting the spinal cord and its spinal segmental nerves, supporting the weight of the body above the sacroiliac joint, and providing a flexible yet rigid column to aid in posture and locomotion. The spine's flexibility is possible due to the 25 superior vertebrae articulated by synovial zygapophysial (facet) joints and the intervertebral discs that separate and support each vertebra. The motion between each vertebra may be small, but as a collective unit, the spine is capable of significant movement and protection due to the anatomical structure of the vertebrae.[2]

The size, shape, and orientation of the vertebrae may change according to the region of the spine, but the fundamental structure remains the same. A typical vertebra is comprised of a vertebral body, a vertebral arch, and seven processes including: four articular processes containing facets for adjacent vertebrae, two transverse processes, and a spinous process.

The vertebral body is the large, cylindrical, anterior portion of the vertebra that provides strength to the spine and supports the weight of the body. The vertebral arch forms posteriorly from the vertebral body to form the vertebral foramen (spinal canal), which contains the spinal cord and also serves as the attachment for the seven processes. The four articular processes (two superior and two inferior) provide attachments to the adjacent inferior/superior articulating processes of adjacent vertebrae to form the facet joints. The facet joints are responsible for the movement permitted and restricted within each adjacent vertebra and to maintain proper alignment and stability. The spinous process extends posteriorly and inferiorly from the vertebral arch, and the transverse processes extend posterolaterally (left and right) from the vertebral arch. The spinous and transverse processes serve as the major muscle and ligament attachments for the muscles of the back and provide lever arms for the muscles to have a greater action on the movement of the spine.[2]

In between each vertebra, starting at C2-C3 and ending at L5-S1, there is an articulating

intervertebral disc that lies between each adjacent vertebrae. The intervertebral disc forms a continuous semirigid column within the spine and together account for 20-25% of the height of the spine. Similar to the vertebrae, the intervertebral discs get increasingly larger while descending the spine to support the increasing amount of body weight. Each intervertebral disc is comprised of an annulus fibrosus, an outer circumferential fibrocartilage that creates a strong bond between adjacent vertebrae, and a nucleus pulposus, or a central gelatinous mass. The nucleus pulposus is the core of the intervertebral disc and its semifluid composition is responsible for much of the flexibility and resilience of the spine as a whole, and serves as a major shock absorber from vertical forces.[2]

Due to the amount of support required by the lumbosacral spine, increased stabilization in this region is necessary. In addition to spinal ligaments, increased stabilization is provided by a large, broad connective tissue called the thoracolumbar fascia (TF). The TF is the primary fascial structure that covers the ES muscles to provide additional support and stability for the lower spinal segments. The LD originates from the TF, which attaches to the lumbar spinous processes and pelvis - giving the LD an indirect attachment with the lumbar spinous.[2]

The LD is a broad muscle of the back and has many points of attachment. The LD originates from the spinous processes of T7-T12 and the posterior iliac crest through the TF, the inferior 3 ribs (10-12), and the inferior angle of the scapula. From all of the muscle's origins, the LD inserts onto only the humerus via the floor of the intertubercular groove. Actions of the LD on the humerus include: adducting, extending, and medially rotating the arm. Actions of the LD when the humerus is fixed include: downwardly rotating the scapula, depressing the shoulder girdle, elevating the pelvis, and raising the body toward arms when arms are overhead. The LD's actions on the spine include: ipsilateral lateral trunk flexion and extending the trunk when working bilaterally.[2]

The MT and ES group are other muscles that may contribute to spinal rotation. The trapezius muscle consists of the upper, middle, and lower fibers with the middle trapezius muscle spanning laterally from the spinous processes of T1-T5 to the acromion process of the scapula. The MT primarily adducts or retracts the scapula, but when the scapula is fixed, in theory, it will rotate the vertebrae to the opposite side.[2]

The ES is divided into three different muscle groups (medial to lateral): spinalis, longissimus, and iliocostalis muscles, but the three will be collectively referred to as ES. The ES originates from a broad tendon that attaches to the sacroiliac ligaments, posterior sacrum, sacral and inferior lumbar spinous processes, posterior iliac crest, and supraspinous ligaments. The ES muscle runs the entire length of the spine and inserts onto the spinous processes in the mid to upper thoracic spine, the transverse processes and ribs in the thoracic region, the angle of ribs 1-12, transverse processes in the cervical region, and it blends with the semispinalis capitis muscle to insert onto the mastoid process of the skull. Since the ES attaches to almost every vertebrae posteriorly, it is biomechanically positioned to be the primary extensor of the spine and is responsible for maintaining posture. With the ES's attachments, the ES when working unilaterally, can also laterally flex and rotate the trunk to the same side.[2]

Surface Electromyography

Surface electromyography (EMG) measures the electrical activity of muscles during a contraction. Surface electrodes placed on the skin over a muscle being tested; detect the electrical activity of a muscle during contraction. The use of EMG is a safe, easy, and noninvasive method to monitor the electrical signal produced through muscle activity. The surface electrodes pick up the signals from the muscle fibers, which are then amplified by the wireless electromyography hardware and software. As the force requirement increases, more motor units are recruited for a stronger contraction, which is recorded by the electromyography hardware and software. The

surface electrodes only detect electrical activity during muscle contraction and not production of force; therefore, maximal voluntary contraction (MVC) is conducted to compare muscle activity during a maximal contraction and muscle activity.

Proper electrode placement is important and electrodes are placed directly over the motor units of the muscles being tested in order to decrease unwanted signals from other nearby muscles. To have optimal signals picked up by the EMG, the electrodes are placed over areas with little or no hair, and are placed parallel to the direction of the muscle fibers that are being tested.

Skin impedance is another factor to consider when placing electrodes. Skin impedance is defined as the amount of resistance the skin has to a direct current applied to it, which is measured as low as possible (between 5-10 kOhms).The skin impedance can be affected by different factors such as moisture of skin, oil on the skin, hair, adipose tissue, or the amount of dead skin cells. If the impedance is high, remove excess hair and abrade the skin using a fine grid sand paper and then clean the area with alcohol. Inspect the surface electrodes to ensure the conductive medium is not dry and the adhesive portion is properly secured to the skin.

Maximal Voluntary Contraction

Maximal voluntary contraction (MVC) is the highest amount of force that a muscle can produce during isometric resistance. Standards for documenting the force produced by the muscle have already been set by the International Society of Electrophysiology and Kinesiology. It is recommended that individuals should have the opportunity to practice MVC before collecting actual data. It has also been found that visual and verbal feedback during MVC can impact the results of the data collected and was avoided in order to have more accurate data. To collect MVC data for certain muscles, the individual was required to exert maximal effort in a specific motion.

The best test position for the LD to be activated is during shoulder extension in a prone position. Less force was produced in other testing positions such as caudal shoulder depression in prone, lifting the body up with shoulder depression while in seated position, upper trunk lateral bend while in a lateral decubitus position, and the LD pull-down in a seated position.[16]

The position for the ES MVC was done in the traditional manual muscle testing (MMT) position. The individual lies in a prone position with their arms at their side and was stabilized at the pelvis and ankles with straps connected to the table. The individual then raises their chest off the table and extending their spine as far as they are able to. Resistance was applied to the individual's upper back using a downward force by the researcher. The MVC testing position for the MT was done in the traditional MMT position as well, and that involves being in a prone position with the individual's shoulder abducted to 90 degrees and the elbow flexed.[17] Stabilization was applied to the opposite side of the trunk, while resistance was applied to the distal arm being tested.

Testing Positions

The testing positions in this study took into account the different functions of muscles and their joints in open and closed chain movements. Open chained movements consist of the most distal aspect of a movement being free to move or 'not fixed' (e.g. eating, raising arm to reach cabinet). Closed chain movements consist of the most distal aspect of a movement being fixed or not free to move (e.g. opening a heavy door, doing a push-up). In theory, closed chain movements activate more synergistic and core muscle activity than open chain movements, and in return may offer more support to the joint(s) in motion.[18]

Right Non-Fixed Standing Position: The subject is in standing position with feet shoulder-width apart and arms crossed across the chest. The subject rotates the right side of their pelvis posteriorly and the left side of their pelvis anteriorly in the horizontal plane to initiate right

pelvic rotation and lower segmental spinal rotation to the right. The subject's feet remain planted to the ground while the tester places both of his/her hands on the subject's shoulders. The subject's feet remain planted on the ground during the testing session.

Left Non-Fixed Standing Position: Follows the same instructions as Right Non-Fixed Standing Positions, but the subject rotates the right side of their pelvis anteriorly and the left side of their pelvis posteriorly in the horizontal plane to initiate left pelvic rotation and lower segmental spinal rotation to the left.

Right Fixed Quadruped Position: The subject is in the quadruped position and lifts their right knee straight off of the table while keeping both thighs parallel. This motion produces right pelvic rotation and right lower segmental spinal rotation.

Left Fixed Quadruped Position: The subject is in the quadruped position and lifts their left knee straight off of the table while keeping both thighs parallel. This motion produces left pelvic rotation and left lower segmental spinal rotation.

Right Standing Fixed Position a 45˚, 90˚, and 120˚: The subject is in standing position with their feet shoulder width apart. The trunk is fixed with the upper extremities placed at varying degrees of shoulder flexion (45˚, 90˚, and 120˚) while they hold onto a specialized, handled bar in which they squeeze and hold against the wall with extended arms. The subject moves the right side of their pelvis posteriorly and the left side of their pelvis anteriorly in the horizontal plane to initiate right pelvic rotation and right lower segmental spinal rotation. The subject's feet remain planted while they complete this motion.

Left Standing Fixed Position a 45˚, 90˚, and 120˚: The subject is in standing position with their feet shoulder width apart. The trunk is fixed with the upper extremities placed at varying degrees of shoulder flexion (45˚, 90˚, and 120˚) while they hold onto a specialized, handled bar in

which they squeeze and hold against the wall with extended arms. The subject moves the left side of their pelvis posteriorly and the right side of their pelvis anteriorly in the horizontal plane to initiate right pelvic rotation and right lower segmental spinal rotation. The subject's feet remain planted while they complete this motion. Furthermore, the next section will discuss the topics of EMG, MVC testing, and experimental testing positions in more detail in relation to the research.

CHAPTER III

METHODS

Subjects

This study was approved by the University of North Dakota Institutional Review Board and Research Development and Compliance (IRB 201504-329). Inclusion criteria to participate in the study included students enrolled at the University of North Dakota School of Medicine and Health Sciences (UND SMHS), age range between 22-42, being right hand dominant, and being able to tolerate quadruped and prone position for 20 minutes each. Exclusion criteria consistent of past or present shoulder or spine pathology requiring medical attention, pregnancy and allergies to latex or isopropyl alcohol.

There were 10 healthy subjects who volunteered to participate in the research study. Subject demographic variables are listed in Table 1. Subjects were recruited by flyers posted at the UND SMHS for students that are enrolled in classes. Subjects in the study were educated on the experimental procedure, purpose, and possible risks of the study. Subjects filled out a consent form (Appendix A) and completed a questionnaire to acquire demographic information (Appendix B) prior to participating in the study.

Instrumentation

Instruments used for the study included wireless electromyography hardware and software (Noraxon, USA, Scottsdale, Az). Self-adhesive, pre-surfaced EMG electrodes;

silver/aluminum adult electrodes with a 3.3 cm inter-electrode distance were used for the study (Ambu/Medicotest A/S, Denmark). Noraxon MyoResearchXP software (Noraxon, USA, Scottsdale, AZ) was used to analyse the raw EMG data.

Table 1. Demographic Data

	Age (years)	Height (inches)	Weight (pounds)	
Mean	25.3	69.00	155.00	
Standard Deviation	6.015	3.232	32.656	
Gender	Frequency	Percent	Valid Percent	Cumulative Percent
Female	7	70.0	70.0	70.0
Male	3	30.0	30.0	30.0
Total	10	100.0	100.0	100.0

Electromyography

The researchers tested equipment prior to starting study to ensure proper signal reception and transmission. Data collection was performed at the UND SMHS. The room was private to provide confidentiality for the subjects of the study. Prior to starting, subjects were verbally informed on the nature of the study and able to inquire about concerns or questions they may have on the study or procedures. Each subject participated in a 60 minute session. To ensure the electrodes had direct contact with the skin, subjects were asked to wear shorts to the session. Male subjects were asked to remove their shirt and female subjects were asked to wear a tank top, halter top, or swimsuit top to allow placement of the electrodes. The researchers followed Cram's Introduction to Surface Electromyography guidelines for placement of the electrodes. Electrode placement site preparation was performed in a standardized manner to ensure proper application

for collection of EMG data. Next, the surface of the skin was wiped with a 400-grit sandpaper, then cleaned with isopropyl alcohol prior to placing an electrode.

In order to increase reliability and decrease error the same researchers applied electrodes to the subjects. Electrode placement over the LD, MT and ES muscles were placed parallel with muscle fibers. During this process the subjects were prone with head neutral and arms in anatomical position (Fig.1). Electrodes were placed on the LD muscle belly 5 cm below and 3 cm lateral to the inferior angle of the scapula along an imaginary line between the posterior axillary fold and the S2 spinous process. Electrodes for the MT were placed side by side 4 cm lateral to the spinous process of T3. Electrodes for the ES were placed parallel with the L3-4 interspaces, 4 cm lateral to the spine. A Noraxon impedance analyzer (Noraxon USA, Scottsdale, AZ) was placed over pairs of electrodes to assess impedance. Skin impedance was assessed to be less than or equal to 10 KOhm for each pair of electrodes. The Telemyo 900 transmitter was connected to each pair of electrodes and held in place to subject's skin using double sided tape. The EMG data was transferred to the Telemyo 900 transmitter and stored on a laptop computer for later analysis (Hewlett PAckard, Palo Alto, CA).

To assess a better view of rotation, reflective markers were placed on both the right and left anterior superior iliac spine (ASIS) and the right and left acromion processes following data collection of the MVC (Figure. 1). All tests were video recorded to reference during data analysis. A meter stick was attached to a wooden box to be used as a vertical reference point when examining the amount of spinal rotation.

Maximal Voluntary Contraction

A MVC was collected for the LD, MT, ES bilaterally after electrodes placement for all subjects. To test MVCs, subject was positioned in prone with head in neutral. Subjects were instructed to exert maximal force against the dynamometer (microFET2) (Hoggan Health

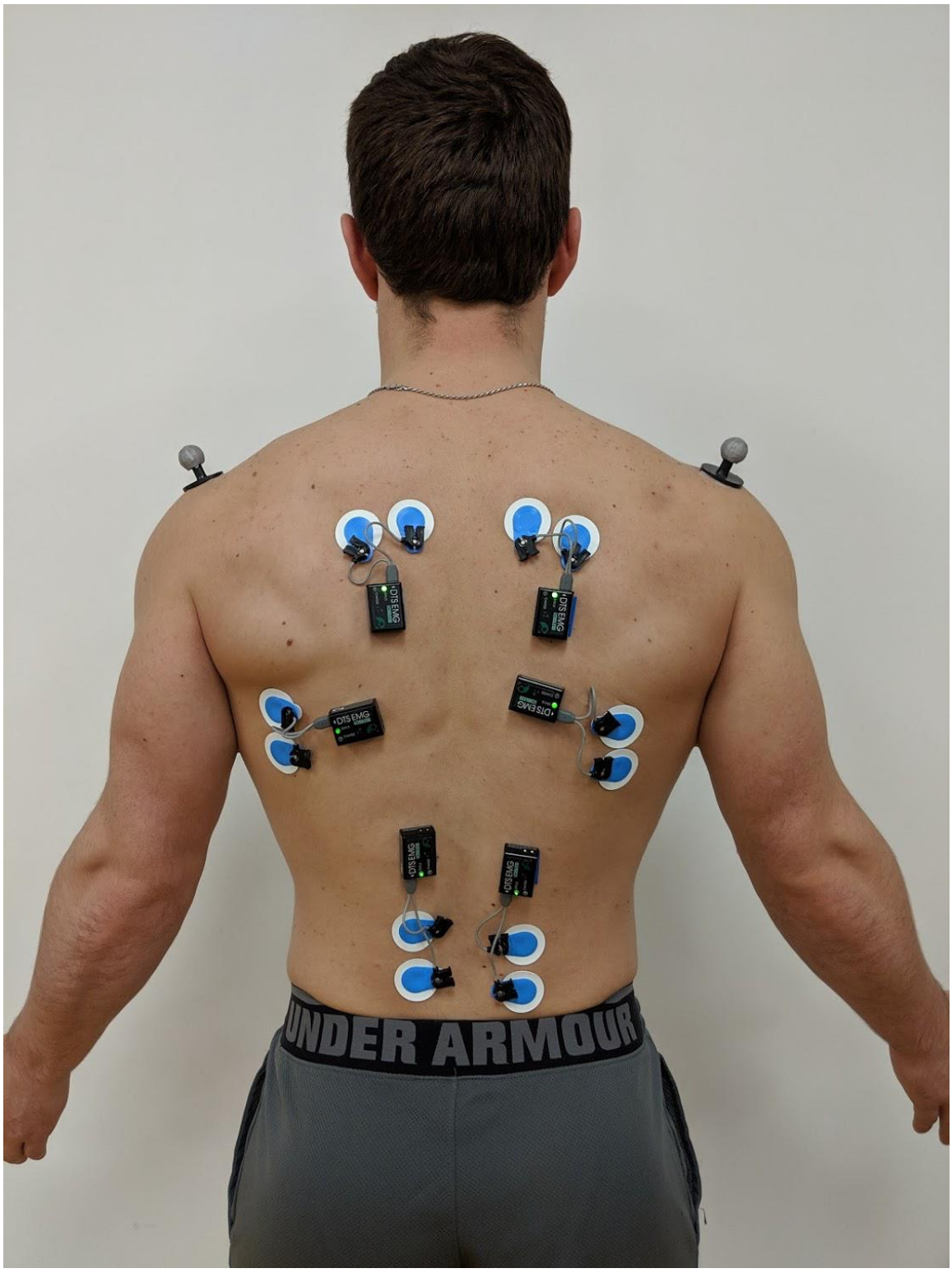

Figure. 1: The electrode placement for LD, MT, and ES.

Industries, West Jordan, UT, USA) during each MVC trial. The same researcher instructed the subject through the positions and movements when using the microFET2 for consistency and increase reliability. A metronome set at 60 beats per minute was used during subject movements for consistent timing. Subjects were given 1 second to move into the desired MVC position, hold the MVC for 3 seconds, then given another 1 second interval to return to the starting position. A researcher verbally cued to the subject during the MVC to the beat of the metronome, saying, "Ready, set, go, 1, 2, 3, down." Subjects were given the opportunity to practice the MVC testing positions until they were comfortable performing the MVC in the correct position at the correct timing.

A computer randomly arranged the order for MVC testing positions for each subject. Each MVC position was performed for 3 trials. Subjects were given 30 seconds of rest between each trial. Subjects were informed of their resistance values after each trial to encourage maximal effort as well as instructed to give best effort prior to the trials. No additional encouragement was provided during the MVC. In order to produce the best results, subjects were asked to contract slowly and fully without jerking. MicroFET2 values were recorded in each testing position for reliability. All MVC trials within a position were required to be within 5 lbs of one another, as recorded by the MicroFET2. If a trial was outside of the 5 lb interval, the MVC was repeated until three recorded trials were within the 5 lb interval for each testing position.

When testing the LD MVC, the lateral deltoid of the side being tested was in line with the edge of the plinth and upper extremity placed off the plinth in a dependent position. The subject was then asked to flex their elbow to 90 degrees and extend their shoulder to be parallel with the trunk. The researcher, using MicroFET2, applied resistance to the distal humerus during upper extremity adduction and extension. Stabilization was applied to the ipsilateral scapula and contralateral pelvis with the subject looking towards the arm that was contracting (Figure. 2).

When testing the LD MVC, the subject's upper extremity was placed in 90 degrees of abduction, neutral rotation, and 90 degrees of elbow flexion. The same researcher, using the MicroFET2, applied resistance to the distal humerus during scapular adduction. Stabilization was applied to the contralateral scapula and bilateral pelvis with subject looking toward the arm that was being tested (Figure. 3).

When testing the MT MVC, The subject's upper extremities were placed at their sides. The pelvis and lower extremities were stabilized using the velcro belts attached to the table. Additional stabilization was applied to the subject's ankle by another velcro belt. The subject was instructed to lift their chest off the plinth into trunk extension through full range of motion while maintaining a neutral head position. Resistance was applied by the same researcher to bilateral scapula in a downward motion (Figure. 4). Consistent effort was measured by assessing full range of motion prior to testing and ensuring full range of motion was achieved with each trail. Following MVC testing, experimental testing began.

Experimental Testing

The experimental testing was performed following completion of all MVC testing. A computer generated a random sequence of testing conditions for each subject to eliminate bias of selection and training effect. Before beginning the first testing condition and between each experimental testing condition, two minutes of rest was allowed for the subject. Subjects were able to practice each testing motion until they felt comfortable with the motion. A 30 second rest period was given before performing the first trial. Each movement was paced to a recorded metronome set at a speed of 92 beats per minute. Following the beat of the metronome, subjects were instructed to move three counts into their full range of motion followed by three counts back to the neutral starting position. A researcher verbally cued to the subject during the motion to the beat of the metronome, saying, "Start, Two, Three, Reverse, two three…" The subjects completed

three trials of five repetitions for each movement. There was a rest period of 30 seconds between each trail. A fifteen-inch wooden block with a meter stick attached perpendicular to the testing surface was placed on the testing side to allow for visualization of spinal rotation.

For the standing spinal rotation (non-fixed) testing position, subjects were asked to stand with feet flat on the floor, shoulder-width apart, and arms crossed over their chest. A researcher stabilized the subject's shoulders to avoid movement of the upper trunk (Figure. 5). The subjects were instructed to rotate their pelvis by bringing their right ASIS posteriorly and left ASIS anteriorly (Rotation of Pelvis to the Right). This was repeated on the opposite side by bringing the left ASIS posteriorly and right ASIS anteriorly (Rotation of Pelvis to the Left). The rotation was performed keeping their feet in contact with the floor and knees straight. The video camera was placed at the height of the subject's ASIS for consistency.

For the quadruped spinal rotation (fixed) testing position, subjects were in quadruped with hands and knees shoulder-width apart. The fifteen-inch wooden box was placed adjacent to the subject's knee on the testing side. A towel was placed between the box and the subject's leg for greater ease of movement. The subjects were asked to lift their knee off the plinth while maintaining contact with the box to prevent abduction of the thigh and to promote spinal rotation (Figure. 6).

For the standing spinal rotation fixed position, subjects were asked to stand with feet flat on the floor, shoulder-width apart, while holding the specialized bar against the wall. The subjects were asked to direct their force against the wall and toward midline as in attempting to squeeze the ends of the bar together. No additional stabilization was applied to the shoulders (Figure. 7). The subjects were instructed to rotate their pelvis by bringing their right ASIS posteriorly and left ASIS anteriorly (Rotation of Pelvis to the Right). The motion was repeated on the opposite side by bringing the left ASIS posteriorly and right ASIS anteriorly (Rotation of Pelvis to the Left).

Figure. 2: The testing position for the maximal voluntary contraction of LD.

Figure. 3: The testing position for the maximal voluntary contraction of MT.

Figure. 4: The testing Position for the maximal voluntary contraction ES.

The rotation was performed keeping their feet in contact with the floor and knees straight. The video camera was placed at the height of the subject's ASIS and lateral to the subject's tested side for consistency.

Data was collected during the entire cycle for each MVC and three trials of each testing position were stored in separate files. Once all data collection was completed, the electrodes and motion analysis reflectors were removed from the subject, and the skin was cleaned with isopropyl alcohol, and subjects were thanked for their participation in the study.

Data Analysis

Data analysis was performed using MyoResearchXP software. The EMG data for MVCs was recorded during a 5 second interval, and seconds 2-4 used for data analysis. The EMG data at each trial position was recorded during a 3-count interval for going into position and returning from position; repetitions 2-4 were used for analysis of each experimental trial. After these values were obtained, all data was transferred to the Statistical Package for Social Sciences (SPSS) for Windows, Ver. 24. (IBM, Armonk, New York, USA) for analysis. To determine a significant effect of each muscle in a fixed and non-fixed position on the EMG activity, a repeated measures ANOVA was used (α=0.05). A Bonferroni post hoc test was used to find significant differences between muscles.

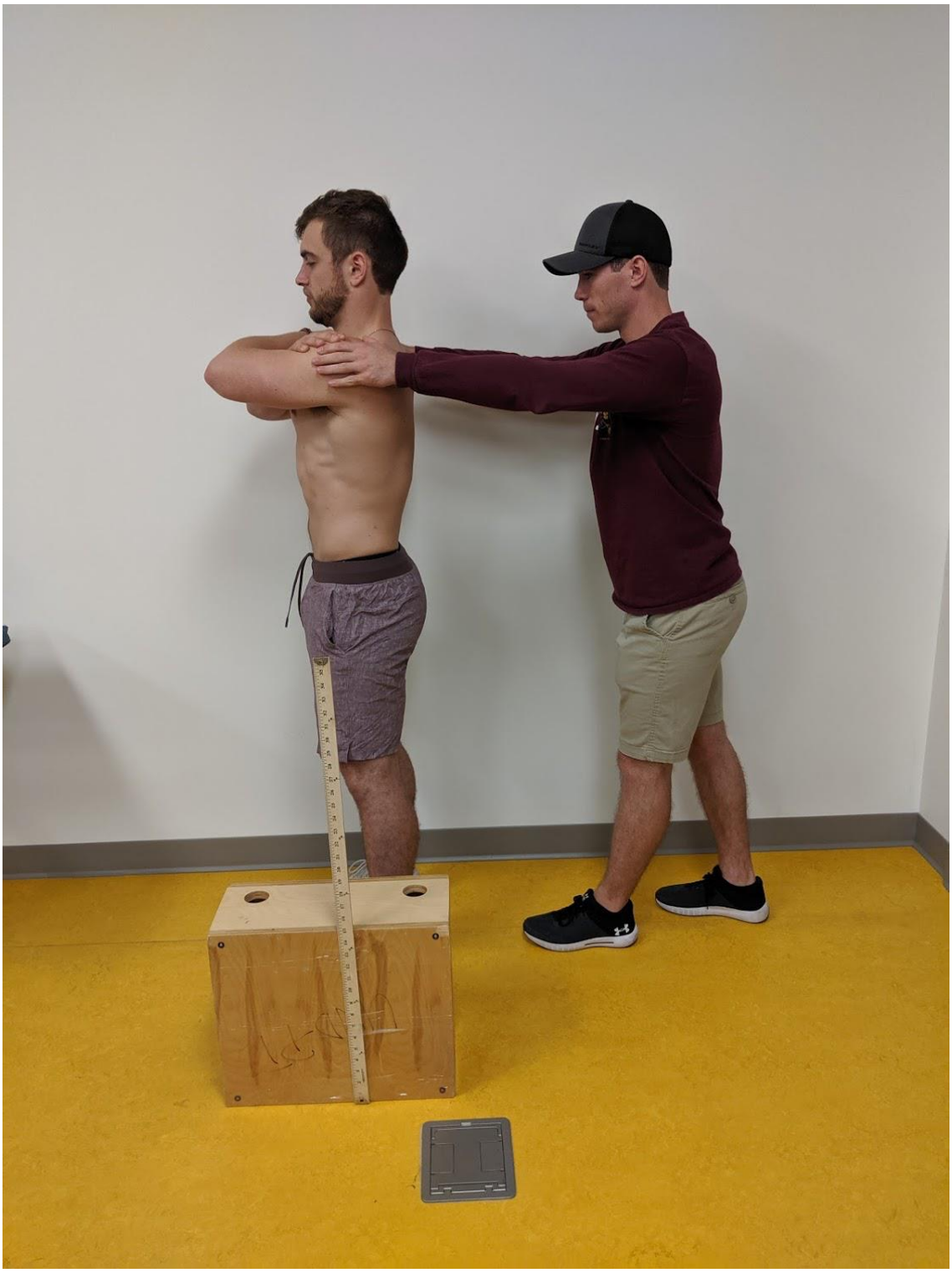

Figure 5: The standing spinal rotation (non-fixed) testing position.

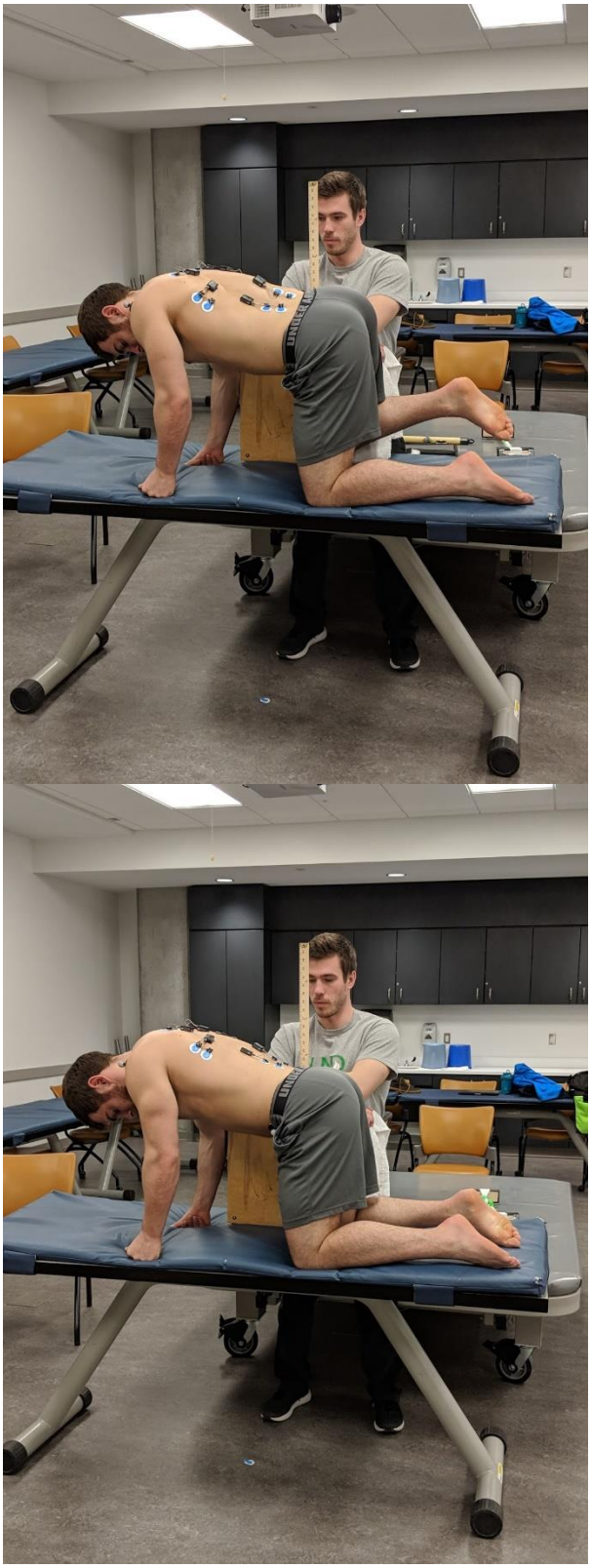

Figure. 6: The quadruped spinal rotation (fixed) testing position.

Figure. 7: The standing spinal rotation fixed position at 45˚, 90˚, 120˚ of shoulder flexion.

CHAPTER IV

RESULTS

Repeated measures ANVOA with Bonferroni post hoc was used to analyze significant differences in EMG activity for LD, MT, and ES under ten conditions. For an ANOVA to be found significant, the planned pairwise comparisons were compared using a least significant difference (LSD) post hoc test.

The first research question addressed the EMG activity of the right and left LD in fixed and non-fixed upper extremity positions during spinal rotation. A Repeated Measure ANVOA for the right LD demonstrated a significant difference in activation across conditions ($F(1,9)=11.430$, $p=<0.01$, power=0.852). The right LD is most active during quadruped fixed rotation to the right (Table 2). A Repeated Measure ANOVA for the left LD demonstrated a significant difference in activation across conditions ($F(1,9)=14.094$, $p=<0.01$, power=0.915)(Table 2). The left LD is most active in quadruped fixed rotation to the left.

The second question addressed the EMG activity of ipsilateral muscle activity of LD, MT, and ES in fixed standing and quadruped during spinal rotation. A Repeated Measure ANOVA for fixed left rotation demonstrated a significant difference in activation across right ipsilateral muscles (LD, MT, and ES) ($F(2,18)=15.627$, $p=<0.01$, power=0.997) (Table 3). The right LD is most active during fixed rotation to the right (Figure 8). A Repeated Measure ANOVA for fixed rotation demonstrated a significant difference in activation across left ipsilateral muscles (LD, MT, and ES) ($F(2,18)= 50.501$,$p=<0.01$, power=1)(Table 3). The left LD is most active during fixed rotation to the left (Figure 9).

Table 2: Repeated Measures ANOVA: Difference of EMG activity in non-fixed and fixed positions for R and L movement for the right and left LD

Condition	n	Mean	df	F	p	Power	Sig dif. Between conditions
Right Latissimus Dorsi (Non-Fixed/Fixed)							
NF Right	10	7.06	9	11.43	<0.01	0.852	3,4,5,6,7,8,9, &10
NF Left	10	8.53					3,4,5,6,7,9, &10
F Right	10	45.52					1,2,4,5,6,7,8,9,&10
F Left	10	22.95					1,2,3,&6
F Right 45 deg	10	19.07					1&3
F Left 45 deg	10	14.15					1,3,4,7,8,&10
F Right 90 deg	10	25.24					1,2,3,&6
F Left 90 deg	10	23.23					1,2,3,&6
F Right 120 deg	10	22.82					1,2,&3
F Left 120 deg	10	23.70					1,2,3,&6
Left Latissimus Dorsi (Non-Fixed/Fixed)							
NF Right	10	9.79	9	14.094	<0.01	0.915	3,4,5,6,7,8,9,&10
NF Left	10	9.88					3,4,5,6,7,8,9,&10
F Right	10	23.99					1,2,&4
F Left	10	44.84					1,2,3,5,6,7,8,9,&10
F Right 45 deg	10	19.68					1,2,4,7,&8
F Left 45 deg	10	23.01					1,2,4,&8
F Right 90 deg	10	26.99					1,2,4,5,8,
F Left 90 deg	10	32.55					1,2,4,5,6,&7
F Right 120 deg	10	25.13					1,2,&4
F Left 120 deg	10	25.67					1,2,&4
*Bonferroni post hoc analysis							

The third question addressed the EMG activity of ipsilateral muscle activity of LD, MT, and ES in non-fixed standing during spinal rotation. A Repeated Measure ANOVA for non-fixed rotation demonstrated a significant difference in activation across right ipsilateral muscles (LD, MT, and ES) (F(2,18)=23.392,p=<0.01,power=1)(Table 4). The right ES is most active during non-fixed rotation to the right (Figure 10). A Repeated Measure ANOVA for non-fixed rotation demonstrated a significant difference in activation across left ipsilateral muscles (LD, MT, and ES) (F(2,18)= 15.16,p=<0.01, power=0.997)(Table 4). The left ES is most active during non-fixed rotation to the left (Figure 11).

Table 3: Repeated Measures ANOVA: Difference of EMG activity in fixed positions for R and L movement for the right and left LD, MT, and ES

Position	Movement Direction	Muscle	N	Mean	SD	F	df	Sig	power
Fixed	Right	R LD	10	45.5241	27.91167	15.627	2	<0.01	0.997
		R MT	10	7.8568	3.76478				
		R ES	10	13.8294	9.75816				
	Left	R LD	10	22.9463	12.0625	14.334	2	<0.01	0.995
		R MT	10	10.94	5.66405				
		R ES	10	5.8132	1.7266				
Fixed	Right	L LD	10	23.9889	6.94177	43.824	2	<0.01	1
		L MT	10	7.6963	4.83187				
		L ES	10	6.7922	3.10156				
	Left	L LD	10	44.8356	14.6796	50.501	2	<0.01	1
		L MT	10	6.2571	3.79001				
		L ES	10	7.4713	5.66151				
*Bonferroni post hoc analysis									

Table 4: Repeated Measures ANOVA: Difference of EMG activity in non-fixed positions for R and L movement for the right and left LD, MT, and ES

Position	Movement Direction	Muscle	N	Mean	SD	F	df	Sig	power
Non-Fixed	Right	R LD	10	7.062	3.9763	23.392	2	<0.01	1
		R MT	10	3.466	2.33879				
		R ES	10	14.398	5.98224				
	Left	R LD	10	8.5283	4.26002	2.276	2	0.131	4.553
		R MT	10	6.4993	4.92655				
		R ES	10	9.2507	4.08371				
Non-Fixed	Right	L LD	10	9.7928	3.83178	2.384	2	0.121	4.769
		L MT	10	6.608	5.37372				
		L ES	10	9.39	4.85358				
	Left	L LD	10	9.8778	4.39383	15.16	2	<0.01	0.997
		L MT	10	2.9562	2.33093				
		L ES	10	12.9657	6.07078				
*Bonferroni post hoc analysis									

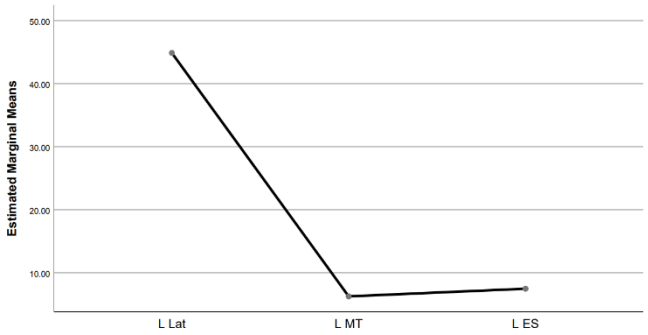

Figure. 8: The Estimated Marginal Means of Fixed Left Rotation.

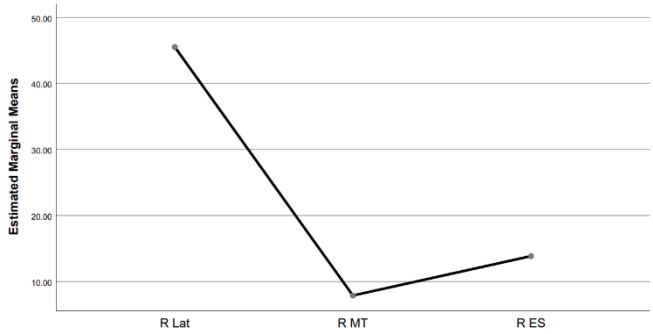

Figure. 9: The Estimated Marginal Means of Fixed Right Rotation.

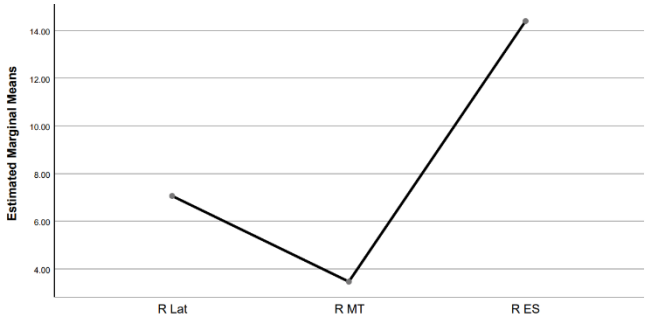

Figure. 10: The Estimated Marginal Means of Non-Fixed Right Rotation.

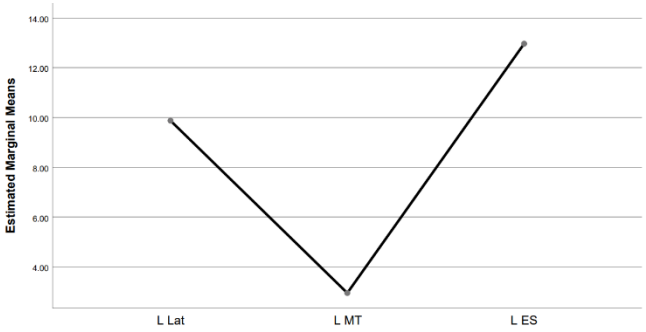

Figure. 11: The Estimated Marginal Means of Non-Fixed Left Rotation.

CHAPTER V

DISCUSSION AND CONCLUSION

Discussion

The purpose of this study was to determine EMG activity of LD, MT, ES during spinal rotation in fixed and non-fixed positions to gain a better understanding of the muscle function to improve patient outcomes.While currently there is not an extensive amount of research on the LD's role during spinal rotation, our research findings have shown that the LD significanlty contributes to ipsilateral spinal rotation in fixed positions and ES had the greatest muscle activation when contributing to ipsilateral spinal rotation in non-fixed positions. Our findings do not support the ongoing research stating that the LD was the most active muscle during contralateral spinal rotation when in the quadruped position, compared to ipsilateral spinal rotation.[19-22]

As stated above, the ES was most active during non-fixed rotation. This suggests that while performing non-fixed spinal rotation LD may not be in optimal position to rotate or stabilize the spine, therefore; when the body is in a closed-chain (upper extremities fixed) position the LD has significantly more activation and can properly assist in spinal stabilization depending on where the subjects initiated movement. This correlates with Vera-Garcia confirming that the muscular activation levels and the amplitude of the lumbar spine varies depending on whether the motion was being driven from the thorax or from the pelvis.[23] Activation of the LD is similar to external oblique (EO) activation levels during thoracic rotation, indicating that LD is important for controlling upper trunk motions.[23] Whether motion is initiated at the pelvis or the thorax is relevant to our current pilot study due to the recruitment patterns of

LD and EO while performing spinal rotation in different testing positions. Another concept to include in future research should examine the activation of external and internal obliques as well as the LD, MT, and ES during spinal rotation.

In on going studies examining LD function more females have been analyzed than males,[19-22] therefore; the difference in muscle force production between male and female need to be considered for this current study. Literature has examined muscle forces, contraction velocity, as well as fatigability during contractions by different genders.[24] In agreement with Sandra Hunter, there are distinct differences between males and females due to the physiology and anatomy of the human body, for example, men are naturally stronger, more powerful, and faster than women.[24] However, at a slower velocity contraction females are less fatigable than men even though men are more powerful than females at maximal voluntary isometric contractions.[24] One explanation for the differences between males and females during the fast-velocity contractions may involve energy utilization of the different fiber types during varying velocity contractions.[24] Muscle contraction velocity is relevant to our current pilot study because the velocity was constant and controlled to a metronome, which may have affected the overall results and the males fatigability during contractions during the different movements compared to females. Due to these findings and differences found from previous studies, [19-22] this may be another concept to further examine in future research.

The amount of motion around a joint can affect muscle strength and activation. The variability between subjects can be explained by differences in age and gender.[25] The variability of range of motion and its effect on EMG correlates with Carlo De Luca confirming that the relationship between surface EMG and muscle activity is indirect,[26] as the electrical activity recorded at the skin results from physiological processes of muscle activation and not actual muscle tension. Initial muscle length, shortening velocity, and signal attenuation through surface

tissue layers will affect the relationship between surface EMG amplitude and muscle force, therefore; an analysis of the subject's video should be completed to assess their range of motion and ability to achieve end range.[27]

This study has several limitations. First, there was a small sample size consisting of only 10 subjects. Second, all of the subjects, except one, were within a narrow age range of 22-25 years old. Third, the subjects' ability to smoothly coordinate desired actions with the ability to accurately synchronize movements with the metronome rhythm may have varied between each subject. Lastly, two of the electrodes initially used in this study had to be switched out for some of the subjects due to the lack of battery life in those electrodes. This may have added a level of inconsistency in data collection, however efforts were made to minimize these effects. Additional inconsistencies may be present due to the researchers inability to consistently apply equal pressure with dynamometer while counteracting subjects force during MVC testing.

Further research that could be analyzed more in future studies could include a larger sample size, analyzing gender differences in muscle activation, assessing hand dominance differences, as well as a more specific degree of muscle position to determine differences in overall muscle activation. With more research and evidence-based knowledge, clinicians may properly identify when these muscles are most activated when trying to provide the best plan of care for their patients who may have spinal pathologies.

Conclusion

In conclusion, it was found that the LD was more active in ipsilateral fixed positions during spinal rotation compared to ipsilateral non fixed spinal rotation. When comparing LD to MT and ES in fixed quadruped the LD activation was significantly greater than ipsilateral MT and ES and contralateral LD, MT, and ES during spinal rotation. When comparing LD, MT, and

ES in non-fixed standing the ES activation was significantly greater than ipsilateral LD, MT and contralateral LD, MT, and ES.

The contributions of LD muscles in spinal rotation are highlighted in this study and the previous four pilot studies. Rotational movement is a part of ongoing research, which the LD may play a role in with individuals with and without LBP. Many activities of daily living require rotation of the spine musculature to increase quality of life. Interventions for LBP often include both standing and quadruped exercises. In the future, the LD and spinal rotation should be evaluated when assessing a client with LBP.

APPENDIX A

ID #_____

Patient Questionnaire

Name_____

Date of Birth_____ Height_____ Weight_____

Dominant Arm_____

Sensitivity to: Latex Y N Isopropyl Alcohol skin sensitivity Y N

If yes, please explain_____

_____

Do you have any history of shoulder pain/pathology? Y N

If yes, please explain_____

_____

Do you have any history of back or spinal disc/pathology? Y N

If yes, please explain_____

_____

Are you pregnant? Y N

Do you have any condition for which lying on your stomach would be a problem? Y N

If yes, please explain_____

_____

All the information provided in this questionnaire has been answered accurately and to the best of my knowledge.

_____

Signature of participant Date

APPENDIX B

THE UNIVERSITY OF NORTH DAKOTA
CONSENT TO PARTICIPATE IN RESEARCH

TITLE:	*Electromyographic Analysis of Latissimus Dorsi, Erector Spinae and Middle Trapezius Muscle Activity During Trunk Rotation*
PROJECT DIRECTOR:	*Susan H N Jeno, PT, PhD*
PHONE#	*701 777-3662*
DEPARTMENT:	*Physical Therapy*

STATEMENT OF RESEARCH
A person who is to participate in the research must give his or her informed consent to such participation. This consent must be based on an understanding of the nature and risks of the research. This document provides information that is important for this understanding. Research projects include only subjects who choose to take part. Please take your time in making your decision as to whether to participate. If you have questions at any time, please ask.

WHAT IS THE PURPOSE OF THIS STUDY?
You are invited to be in a research study about muscle activity during trunk rotation because you are a student in the UND School of Medicine and Health Sciences.

The purpose of this study is to determine the level of muscle activity of several back muscles including latissimus dorsi, middle trapezius, and erector spinae muscles with trunk rotation with and without fixation of the upper extremities. The conclusions drawn from this study will allow practicing clinicians to better develop the exercise programs provided to their clients with back or upper extremity pathology.

HOW MANY PEOPLE WILL PARTICIPATE?
Approximately 100 people will take part in this study at the University of North Dakota

HOW LONG WILL I BE IN THIS STUDY?
Your participation in the study will last approximately 75 minutes. You will need to visit the Department of Physical Therapy 1 time to participate in this study.

WHAT WILL HAPPEN DURING THIS STUDY?
After you agree to participate in this study, you will be asked to complete a questionnaire pertaining to information about you. You are free to skip any question that you would prefer not to answer. This study will involve the collection of electrical activity of some of the muscles in your back while you perform trunk rotation activities while standing upright and while on your hands and knees. In order to access the muscles on your back and for comfort during the test

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University of North Dakota IRB

Date __ __ __ __
Subject Initials: _ _ _

procedures, female subjects will be asked to wear shorts and a swimsuit top or sports bra to expose the appropriate areas of your back for placement of the electrodes. For male subjects, you will be asked to wear shorts and remove your shirt to expose your back. You will be asked to lie on your stomach on a padded table and marks will be placed on your skin where the electrodes will be placed over the muscles on both sides of your back (see attached diagram). Pre-gelled, self-adhesive electrodes placed over the muscles will collect the electrical signal the muscles produce when they contract. In order to obtain the best signal from the muscles, the skin where the electrodes will be placed will be prepared in standard fashion which includes clipping any excess hair with an electric razor, lightly rubbing the skin with fine grit sandpaper followed by cleaning the area with rubbing alcohol wipes. This process is intended to reduce the resistance of the skin to allow of better signal collection by the electrodes. Wireless transmitters will be attached to the electrodes. Elech·ical signals are sent from the transmitter to a computer for recording and analysis.

Once the electrodes are in place, you will be asked lie on your stomach and to perform a maximal voluntary contraction (MVC)- a full effort contraction - of each of the muscles which will be used for comparison of muscle activity. A hand-held device will be used to record the amount of force created by each contraction. For each MVC, you will be asked to push against a fixed device as hard as you can for 5 seconds. This will be repeated 3 times for each muscle with 30-60 seconds rest between trials. You will be allowed to practice the testing procedure before data collection.

Following the collection of the MVC data, you will be asked to perform a series of trunk rotations both to the right and to the left from a standing position with arms at your side, and holding a bar against a wall in 3 different positions and from a position on your hands and knees. Each rotation will be timed with a metronome for a 3 count motion to obtain full rotation and a 3 count motion to return to a resting position. You will be allowed to practice to be sure the timing of the motions is clear. The rotation measurements will be randomized through a computer randomization program. You will perform 5 repetitions of each rotation timed by a metronome for each trial. You will be given 30-60 seconds rest between each trial. The rotational motions will be recorded on the computer for use in analyzing the data.

WHAT ARE THE RISKS OF THE STUDY?

Although there is some degree of risk involved in physical activity testing, the researchers believe the risk of injury and discomfort is minimal; however, minor muscle soreness may occur following repeated activity. The use of a spotter will minimize any risk from loss of balance during the activity. Reddening of the skin in the areas where the electrodes are placed is possible due to the adhesive material. The EMG equipment will only monitor muscle activity and the equipment will not cause discomfort. If at any time you experience pain, discomfort, fatigue, or any other uncomfortable symptoms, you may stop your participation in this study.

Date
Subject Initials: _ - _ -

WHAT ARE THE BENEFITS OF TIITS STUDY?
You may not benefit personally from being in this study. However, we hope that, in the future, other people might benefit from this study and these benefits include but are not limited to 1) gaining a better understanding of the muscle activity in the back muscles with trunk rotation and 2) increasing the current level of knowledge of muscle activity and motion patterns of these muscles during this activity. This will begin to provide more information on how to design treatment programs that include these muscles.

WILL IT COST ME ANYTHING TO BE IN THIS STUDY?
You will not have any costs for being in this research study.

WILL I BE PAID FOR PARTICIPATING?
You will not be paid for being in this research study.

WHO IS FUNDING THE STUDY?
The University of North Dakota and the research team are receiving no payments from other agencies, organizations, or companies to conduct this research study.

CONFIDENTIALITY
The records of this study will be kept private to the extent permitted by law. In any report about this study that might be published, you will not be identified. Your study record may be reviewed by Government agencies, the UND Research Development and Compliance office, and the University of North Dakota Institutional Review Board.

Any information that is obtained in this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. Confidentiality will be maintained as each subject will be given a randomly selected identification number at the beginning of the study, which will be known by the researchers only. All information involving the research study, digital and hard copy, along with a hard copy of the statistically analyzed data, will be secured in a locked cabinet inside the Department of Physical Therapy at the University of North Dakota. Unless the data is required for future studies, the information will be destroyed via shredding three years after the study has been completed.

If we write a report or aiticle about this study, we will describe the study results in a summarized manner so that you cannot be identified.

EMG data and digital recordings of the motions performed as part of this research study will be coded in the same manner as the information form. Your name will not be associated with the digital file. All digital information will be stored separately form the consent forms in a secure location in the Department of Physical Therapy. After a period of 3 years from the completion of the study, the digital data will be deleted from all disks/drives. You are free to look at the digital recordings of your muscle activity at the conclusion of the data collection period.

Date____
Subject Initials: _ _

COMPENSATION FOR INJURY
In the event that this research activity results in an injury, treatment will be available including first aid, emergency treatment and follow-up care as needed. Payment for any such treatment is to be provided by you (you will be billed) or your third-party payer, if any (such as health insurance, Medicare, etc.) No funds have been set aside to compensate you in the event of injury. Also, the study staff cannot be responsible if you knowingly and willingly disregard the directions they give you.

IS THIS STUDY VOLUNTARY?
Your participation is voluntary. You may choose not to participate or you may discontinue your participation at any time without penalty or loss of benefits to which you are otherwise entitled. Your decision whether or not to participate will not affect your current or future relations with the University of North Dakota.

The investigators or you may stop the experiment at any time if you are experiencing discomfort, pain, fatigue, or any other symptoms that may be detrimental to your health. If you agree to participate , you will be allowed to stop your participation in this study at any time without prejudice or jeopardizing any future relationships with the UND Department of Physical Therapy.

CONTACTS AND QUESTIONS?
The researcher conducting this study is Susan H. N. Jeno, PT, PhD. You may ask any questions you have now. If you later have questions, concerns, or complaints about the research please contact Susan Jeno at 701 777-2831 during the day.

If you have questions regarding your rights as a research subject, you may contact The University of North Dakota Institutional Review Board at **(701) 777-4279.**

- You may also call this number about any problems, complaints, or concerns you have about this research study.
- You may also call this number if you cannot reach research staff, or you wish to talk with someone who is independent of the research team.
- General information about being a research subject can be found by clicking "Information for Research Participants" on the web site: http://und.edu/research/resources/human-sub jec ts/research -participants .cfm

I give consent to be videotaped during this study.

Please initial: **Yes** **No**

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Expiration Date: AUG 14 ffl
University of North Dakota IRB

Date
Subject Initials:

Your signature indicates that this research study has been explained to you, that your questions have been answered, and that you agree to take part in this study. You will receive a copy of this fo1m.

Subjects Name: -

Signature of Subject _____ Date _____

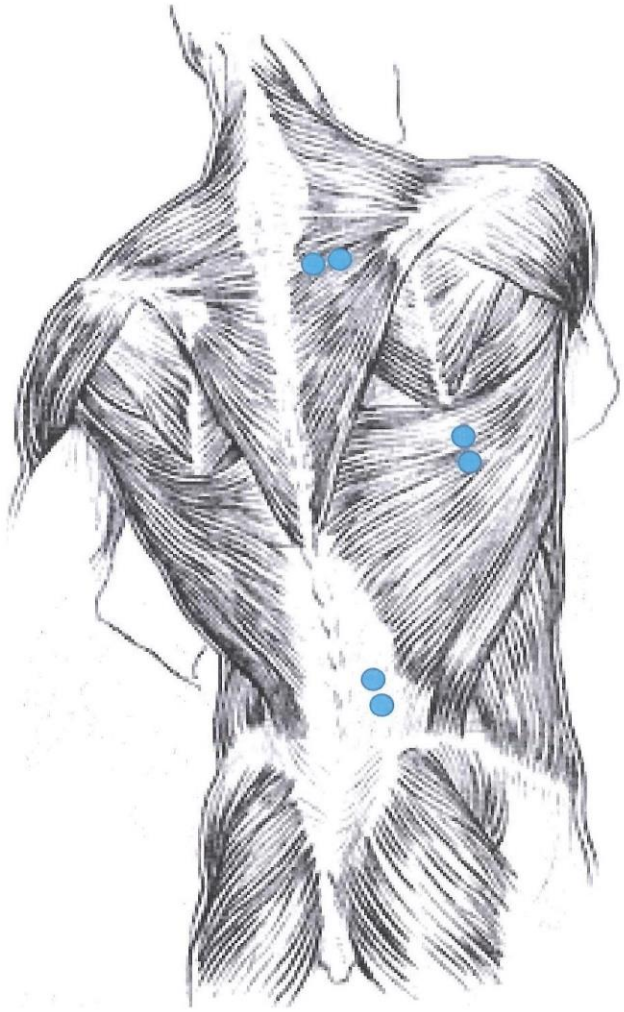
I have discussed the above points with the subject or, where appropriate, with the subject's legally authorized representative.

Signature of Person Who Obtained Consent _____ Date _____

Approval Date: AUG 15 2019
Expiration Date: AUG 14 2020
University of North Dakota IRB

Date_ _ _ _
Subject Initials: _ _ _

Location of electrodes on your back. Electrodes are placed on both sides of the back (small circles).



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Expiration Date: AUG 14 2(0)
University of North Dakota IRB

Date_
Subject Initials-:

APPENDIX C

University of North Dakota Human Subjects Review Form
January 2015 Version

All research with human participants conducted by faculty, staff, and students associated with the University of North Dakota, must be reviewed and approved as prescribed by the University's policies and procedures governing the use of human subjects. It is the intent of the University of North Dakota (UND), through the Institutional Review Board (IRB) and Research Development and Compliance (RD&C), to assist investigators engaged in human subject research to conduct their research along ethical guidelines reflecting professional as well as community standards. The University has an obligation to ensure that all research involving human subjects meets regulations established by the United States Code of Federal Regulations (CFR). When completing the Human Subjects Review Form, use the "IRB Checklist" for additional guidance.

Please provide the information requested below. Handwritten forms are not accepted – responses must be typed on the form.

Principal Investigator: Susan H N Jeno, PT, PhD

Telephone: 777-3662 E-mail Address: sue.jeno@med.und.edu

Complete Mailing Address: 501 North Columbia Road Stop 9037 Grand Forks, ND 58202-9037

School/College: SMHS Department: PT

Student Advisor (if applicable): _____

Telephone: _____ E-mail Address: _____

Address or Box #: _____

School/College: _____ Department: _____

*** ***All IRB applications must include a Key Personnel Listing.***

Project Title: EMG Analysis of Latissimus Dorsi, Erector Spinae and Middle Trapezius Muscle Activity During Trunk Rotation

Proposed Project Dates: Beginning Date: April 15, 2015 Completion Date: April 15, 2016 (Including data analysis)

Funding agencies supporting this research: N/A

Did the contract with the funding entity go through UND Grants and Contracts Administration? ☐ YES or ☐ NO
Attach a copy of the contract. Do not include any budgetary information. The IRB will not be able to review the study without a copy of the contract with the funding agency.

☐ YES or ☒ NO Does any researcher associated with this project have an economic interest in the research, or act as an officer or a director of any outside entity whose financial interests would reasonably appear to be affected by the research? If yes, submit on a separate piece of paper an additional explanation of the financial interest. The Principal Investigator and any researcher associated with this project should have a Financial Interests Disclosure Document on file with their department.

☐ YES or ☒ NO Will any research participants be obtained from another organization outside the University of North Dakota (e.g., hospitals, schools, public agencies, American Indian tribes/reservations)?

☐ YES or ☒ NO Will any data be collected at or obtained from another organization outside the University of North Dakota?

If yes to either of the previous two questions, list all organizations: _____

Letters from each organization must accompany this proposal. Each letter must illustrate that the organization understands its involvement and agrees to participate in the study. Letters must include the name and title of the individual signing the letter and should be printed on organizational letterhead.

Does any external site where the research will be conducted have its own IRB? ☐ YES ☐ NO ☐ N/A

If yes, does the external site plan to rely on UND's IRB for approval of this study? ☐ YES ☐ NO ☐ N/A
(If yes, contact the UND IRB at 701 777-4279 for additional requirements)

If your project has been or will be submitted to other IRBs, list those Boards below, along with the status of each proposal.

_____ Date submitted: _____ Status: ☐ Approved ☐ Pending

_____ Date submitted: _____ Status: ☐ Approved ☐ Pending

(include the name and address of the IRB, contact person at the IRB, and a phone number for that person)

Type of Project: Check "Yes" or "No" for each of the following.

☒ YES or ☐ NO	New Project	☐ YES or	☒ NO	Dissertation/Thesis/Independent Study
☐ YES or ☒ NO	Continuation/Renewal	☐ YES or	☒ NO	Student Research Project
☐ YES or ☒ NO	Is this a Protocol Change for previously approved project? If yes, submit a signed Protocol Change Form, along with a signed copy of this form with the changes bolded or highlighted.			
☐ YES or ☒ NO	Does your project involve abstracting medical record information? If yes, complete the HIPAA Compliance Application and submit it with this form.			
☐ YES or ☒ NO	Does your project include Genetic Research?			

Subject Classification: This study will involve subjects who are in the following special populations: Check all that apply.

- ☐ Children (< 18 years)
- ☐ Prisoners
- ☐ Cognitively impaired persons or persons unable to consent
- ☐ Other _____
- ☒ UND Students
- ☐ Pregnant Women/Fetuses

Please use appropriate checklist when children, prisoners, pregnant women, or people who are unable to consent will be involved in the research.

This study will involve: Check all that apply.

- ☐ Deception (Attach Waiver or Alteration of Informed Consent Requirements)
- ☐ Radiation
- ☐ New Drugs (IND) IND # _____Attach Approval
- ☐ Investigational Device Exemption (IDE) # _____Attach Approval
- ☐ Non-approved Use of Drug(s)
- ☒ None of the above will be involved in this study
- ☐ Stem Cells
- ☐ Discarded Tissue
- ☐ Fetal Tissue
- ☐ Human Blood or Fluids
- ☐ Other _____

I. Project Overview

Please provide a brief explanation (limit to 200 words or less) of the rationale and purpose of the study, introduction of any sponsor(s) of the study, and justification for use of human subjects and/or special populations (e.g., vulnerable populations such as children, prisoners, pregnant women/fetuses).

To date, the research concerning the activation of the latissimus dorsi muscle focuses on its contribution to upper extremity movement. With attachments on spinous processes, the latissimus dorsi as well as the middle trapezius has the potential to impact spinal rotation. Without proper identification of these muscles' contribution to spinal rotation, proper rehabilitation of a patient with upper extremity or spinal pathology would be impossible. This pilot project is intended to analyze the activation of the latissimus dorsi, middle trapezius and for comparison, the erector spinae muscles during spinal rotation to identify the muscles' contribution to this biomechanical movement.

II. Protocol Description

Please provide a thorough description of the procedures to be used by addressing the instructions under each of the following categories.

1. Subject Selection.

a) Describe recruitment procedures (i.e., how subjects will be recruited, who will recruit them, where and when they will be recruited and for how long) and include copies of any advertisements, fliers, etc., that will be used to recruit subjects.
Investigators will voluntarily recruit subjects through fliers posted throughout the SMHS during the months of April-June 2015. No incentives will be provided to participants in this study. See attached flier. (See attached)

b) Describe your subject selection procedures and criteria, paying special attention to the rationale for including subjects from any of the categories listed in the "Subject Classification" section above.
Subjects will be between the ages of 20-40, have no history of shoulder or spine pathology. They will also be able to lay in a prone position for a maximum of 20 minutes and maintain a 4-point quadruped position for approximately 15 minutes during the testing procedure. Subjects from the SMHS will be recruited as a sample of convenience.

c) Describe your exclusionary criteria and provide a rationale for excluding subject categories.
Exculsion criteria include pathology to the shoulder or spine that required medical attention, if the subject is pregnant, or has allergies to latex or isopropyl alcohol. Any of these criteria would pose a risk for the subject to participate in the research study.
Exclusion criteria for this study include: 1) history of shoulder or spine pathology - differences in electrical activity and functional movements associated with pathology could alter the patterns demonstrated during the testing procedure and subjects will be asked to perform an isometric contraction of the shoulder extensors, scapular retractors and trunk extensors which may exacerbate previous pathologies; 2) age of subjects less than 20 years or greater than 40 years. Differences in muscle physiology in younger and older individuals could enhance variability between subjects; 3) sensitivity to isopropyl alcohol or latex - electrodes used during the procedure may contain trace amounts of latex; skin is cleaned with isopropyl alcohol; in an effort to avoid adverse reactions, individuals with these sensitivities will be excluded from participation in this study.

d) Describe the estimated number of subjects that will participate and the rationale for using that number of subjects.
It is anticipated that a maximum of 50 healthy UND students will be recruited for this study to reduce the risk of research error associated with smaller sample sizes.

e) Specify the potential for valid results. If you have used a power analysis to determine the number of subjects, describe your method.
Valid results are anticipated with a sample size of up to 50 subjects and randomization of the order of the testing position during the data collection protocol to minimize the error associated with training effects or fatigue.

2. Description of Methodology.

a) Describe the procedures used to obtain informed consent.
Informed consent will be obtained from each subject through the information and consent form (see attached form). All individuals participating in this study will be capable of independent decision making and will sign a consent form stating their understanding and willingness to participate in this study. A copy of the consent form will be provided for each subject.

b) Describe where the research will be conducted. Document the resources and facilities to be used to carry out the proposed research. Please note staffing, funding, and space available to conduct this research.
All data collection will occur within a private room in the UND Department of Physical Therapy within the SMHS. EMG equipment owned by the Department will be utilized for all data collection.

c) Indicate who will carry out the research procedures.
Research will be carried out by Dr. Sue Jeno and Year 2 Graduate Physical Therapy Students.

d) Briefly describe the procedures and techniques to be used and the amount of time that is required by the subjects to complete them.

Electromyographic (EMG) activity of the muscles will be monitored during standing trunk rotation and trunk rotation in a 4-point quadruped position with the use of pre-gelled, self-adhesive electrodes placed over motor points of the relavent muscles in the back. Muscles to be monitored include the latissimus dorsi, middle trapezius, erector spinae muscles on both sides of the body. Precise electrode placement will be determined by standard electrode placement charts and previously published research. Female subjects will be asked to wear shorts and bathing suit top and male subjects will be asked to wear shorts to facilitate access to the muscles and protect modesty. Prior to electrode placement, the skin will be prepared in standardized fashion and skin impedance will be measured to ensure adequate electrical conduction at each site. Preparation of the skin includes removing excess hair in the area where the electrodes will be positioned will an electric razor, the skin slightly abraded with sandpaper and then cleaned with alcohol wipes. A goniometer attachment will be placed along the lumbar spinous processes to record trunk rotation. The electrodes and goniometer will be connected to a transmitter which will be placed in a belt around the subject's waist. The EMG signals will be transmitted to a receiver and then to a computer. Raw EMG data will be obtained for analysis.

Once the electrodes are in place, each subject will perform a maximal voluntary contraction (MVC) of each of the muscles on both sides of the body for muscle activity comparison. A hand-held device will be utilized to record the amount of force generated by each contraction in addition to the EMG data. Each exercise will be performed 3 times, held for 5 seconds with 30-60 sec rest between trials. The MVC testing position for all muscles is a prone position; latissimus dorsi (LD) - resistance to arm extension from a neutral position will be used to record the MVC; middle trapezius (MT) - the arm will be abducted to 90 degrees with the elbow bent to 90 degrees and scapular retraction will be resisted at the proximal humerus; erector spinae (ES) muscles - trunk extension with the arms at sides with resistance provided across the upper back. Subjects will be allowed to practice the testing and rotation activities prior to data collection to ensure understanding of the motions and appropriate speed of motion. Following the collection of the MVC data, you will be asked to perform a series of trunk rotations both to the right and to the left from a standing position with arms at your side, and holding a bar against a wall in 3 different positions of arm forward elevation (45 deg, 90 deg, 120 deg) and from a position on your hands and knees. The motions will be performed with the order randomized to avoid research bias or error. Each rotation will be timed with a metronome for a 3 count motion to obtain full rotation and a 3 count motion to return to a neutral position. Subjects will be asked to perform 5 continuous repetitions of each rotation paced by a metronome for each trial. A rest of 30-60 seconds will be provided between each trial. The rotational motions will be digitally video recorded for use in analyzing the EMG data.

e) Describe audio/visual procedures and proper disposal of tapes.
Video recording is directly linked to the computer and EMG data for analysis. No actual audio recordings are made of the subjects. Video recordings will be utilized in the data analysis process, saved and stored in similar fashion as the EMG data and destroyed simultaneously. No separate tapes are created in this process.

f) Describe the qualifications of the individuals conducting all procedures used in the study.
The primary investigator for this study is a faculty member in the Department of Physical Therapy who will be assisted by Year 2 Gradute Physical Therapy students all of whom are trained in the use of EMG equipment.

g) Describe compensation procedures (payment or class credit for the subjects, etc.).
There will be no compensation given to subjects involved in this study.

Attachments Necessary: Copies of all instruments (such as survey/interview questions, data collection forms completed by subjects, etc.) must be attached to this proposal.

3. Risk Identification.

a) Clearly describe the anticipated risks to the subject/others including any physical, emotional, and financial risks that might result from this study.

The potential physical risks associated with this study are minimal. The EMG electrode placement and analysis is a non-invasive procedure utilized in clinical practice. During the performance of the MVC contractions and trunk rotation activities, there is a slight chance the subject may lose balance or experience shoulder or back pain. This potential risk will be minimized by the presence of a spotter during the activity. Minor skin irritation from the skin preparation and EMG electrodes is possible. Subjects may experience slight fatigue or muscle soreness following participation in this study but it is anticipated that this would not be any worse than that experienced during minimal physical exercise. All subjects will be healthy with no history of shoulder or spine pathology so these risks are minimized by inclusion/exclusion criteria.

b) Indicate whether there will be a way to link subject responses and/or data sheets to consent forms, and if so, what the justification is for having that link.

Subject's names will not be used in any reports of the results of this study. Each participant will be assigned an identification number, known only by the investigators, which will be the only association between consent forms and data collected by EMG. Any information that is obtained in connection with this study and that can be identified with the subject will remain confidential and will be disclosed only with permission from the subject. At the completion of the study, the research data and the consent forms will be stored in separate locked locations in the Department of Physical Therapy for 3 years at which point the forms will be shredded and electronic data deleted. Data will be reported in aggregate form only to protect the confidentiality of all subjects.

c) Provide a description of the data monitoring plan for all research that involves greater than minimal risk.

d) If the PI will be the lead-investigator for a multi-center study, or if the PI's organization will be the lead site in a multi-center study, include information about the management of information obtained in multi-site research that might be relevant to the protection of research participants, such as unanticipated problems involving risks to participants or others, interim results, or protocol modifications.

4. Subject Protection.

a) Describe precautions you will take to minimize potential risks to the subjects (e.g., sterile conditions, informing subjects that some individuals may have strong emotional reactions to the procedures, debriefing, etc.).

Selection of the subject pool utilizing the exclusion criteria will minimize the risks associated with this study. Limiting the trunk rotation to what the subject can complete comfortably will also limit potential risks of back pain associated with trunk rotation. Muscle soreness will be minimized by limiting the number of repetitions in each position. The possibility of skin irritation will be minimized by proper skin preparation and subject screening prior to participation. To protect confidentiality and modesty, all data collection will occur in a private room. The investigators or participant may stop the experiment at any time if the participant is experiencing discomfort, pain, fatigue, or any other symptoms that may be detrimental to his/her health. All subjects will be allowed to terminate their participation in this study at any time without prejudice.

b) Describe procedures you will implement to protect confidentiality and privacy of participants (such as coding subject data, removing identifying information, reporting data in aggregate form, not violating a participants space, not intruding where one is not welcome or trusted, not observing or recording what people expect not to be public, etc.). If participants who are likely to be vulnerable to coercion and undue influence are to be included in the research, define provisions to protect the privacy and interests of these participants and additional safeguards implemented to protect the rights and welfare of these participants.

Subject and result information will not be linked to the consent form in order to protect the confidentiality of the subjects. Names will not be associated with data collection forms. Subjects will be assigned a confidential, unique number which will be used for identification purposes. To protect confidentiality and modesty, all data collection will occur in a private room.

c) Indicate that the subject will be provided with a copy of the consent form and how this will be done.

Prior to participation in this study, each subject will read and sign a consent form. Participants in this study will all be capable of independent decision making and will sign a consent form stating their understanding and willingness to participate in this study. Participants will be encouraged to ask any questions regarding the consent form to ensure their understanding of the document. Each participant will be given a copy of the signed consent form for their records.

d) Describe the protocol regarding record retention. Please indicate that research data from this study and consent forms will both be retained in separate locked locations for a minimum of three years following the completion of the study.
Describe: 1) the storage location of the research data (separate from consent forms and subject personal data)
2) who will have access to the data
3) how the data will be destroyed
4) the storage location of consent forms and personal data (separate from research data)
5) how the consent forms will be destroyed

Participant consent forms and data collection sheets/computerized files will be stored separately and secured in separate locked locations in the Department of Physical Therapy. Only the investigators will have access to this information. After a period of 3 years from the completion of the study, the consent forms and data collection sheets will be shredded for final disposition and computerized data will be deleted from all disks/drives.

e) Describe procedures to deal with adverse reactions (referrals to helping agencies, procedures for dealing with trauma, etc.).

The investigators or participant may stop the experiment at any time if the participant is experiencing discomfort, pain, fatigue, or any other symptoms that may be detrimental to his/her health. If subjects consent to participate they will be allowed to terminate their participation in this study at any time without prejudice or jeopardizing any future relationships with the UND Department of Physical Therapy. All investigators are CPR trained. Medical treatment will be provided to each subject as needed, including first aid, CPR, and follow-up care as that provided to a member of the general public in a similar circumstance.

f) Include an explanation of medical treatment available if injury or adverse reaction occurs and responsibility for costs involved.

In the event an adverse event occurs during participation in this study, the subject will be prompted to seek immediate medical attention. All incurred medical expenses will be the repsonsibility of the subject or the subject's third-party payer.

III. Benefits of the Study

Clearly describe the benefits to the subject and to society resulting from this study (such as learning experiences, services received, etc.). **Please note:** extra credit and/or payment are not benefits and should be listed in the Protocol Description section under Methodology.

Possible benefits of this study include but are not limited to: 1) gaining a better understanding of the muscle activity in the back muscles with trunk rotation and 2) increasing the current level of knowledge of muscle activity and motion patterns of these muscles during this activity; 3) further research may be stimulated; and 4) improved understanding of the kinematics of trunk rotation to aid in the teaching of this activity to students enrolled in the professional physical therapy curriculum. There will be neither cost associated with nor any compensation to any subject who participates in this study.

IV. Consent Form

Clearly describe the consent process below and be sure to include the following information in your description (Note: Simply stating 'see attached consent form' is not sufficient. The items listed below must be addressed on this form.):

1) The person who will conduct the consent interview
2) The person who will provide consent or permission
3) Any waiting period between informing the prospective participant and obtaining consent
4) Steps taken to minimize the possibility of coercion or undue influence
5) The language to be used by those obtaining consent
6) The language understood by the prospective participant or the legally authorized representative
7) The information to be communicated to the prospective participant or the legally authorized representative

1. The person who will conduct the consent interview will be the primary investigator or a second year PT graduate student. Consent interview will be done in a private location within the PT Department in the SMHS.
2. The person who will provide consent or permission will be the subject in the study. Only those subjects who understand written and verbal explanation of the test protocol in English and who are able to provide consent will be subjects in this study.
3. There will be no waiting period between informing the participant and obtaining consent.
4. All subjects will gain access to the study through voluntarily contacting the researcher for an opportunity to participate. During the consenting process, it will be explained to the potential subjects that the process is entirely voluntary and that they are free to withdraw at any point in the process. Withdrawal from the study will not alter their relationship with the Department of Physical Therapy in any way.
5. English will be the language used to obtain consent. Medical jargon will not be utilized to ensure subject understanding of the research protocol.
6. English will be the language understood by the participant.
7. All risks and benefits, test procedures, and consent document will be explained to each prospective subject.

See Attached form.

A copy of the consent form must be attached to this proposal. If no consent form is to be used, document the procedures to be used to protect human subjects, and complete the Application for Waiver or Alteration of Informed Consent Requirements. Refer to form IC 701-A, Informed Consent Checklist, and make sure that all the required elements are included. **Please note:** All records attained must be retained for a period of time sufficient to meet federal, state, and local regulations; sponsor requirements; and organizational policies. The consent form must be written in language that can easily be read by the subject population and any use of jargon or technical language should be avoided. **The consent form should be written at no higher than an 8th grade reading level**, and it is recommended that it be written in the third person (please see the example on the RD&C website). A two inch by two inch blank space must be left on the bottom of each page of the consent form for the IRB approval stamp.

Necessary attachments:

- ☐ Signed Student Consent to Release of Educational Record Form (students and medical residents only);
- ☐ Investigator Letter of Assurance of Compliance; (all researchers)
- ☐ Consent form, or Waiver or Alteration of Informed Consent Requirements (Form IC 702-B)
- ☐ Key Personnel Listing
- ☐ Surveys, interview questions, etc. (if applicable);
- ☐ Printed web screens (if survey is over the Internet); and
- ☐ Advertisements (flyer, social media postings, email/letters, etc.).

By signing below, you are verifying that the information provided in the Human Subjects Review Form and attached information is accurate and that the project will be completed as indicated.

Signatures:

(Principal Investigator)	Date:
(Student Advisor)	Date:

*****All students and medical residents must list a faculty member as a student advisor on the first page of the application and must have that person sign the application.*****

Requirements for submitting proposals:
Additional information can be found on the IRB website at: http://und.edu/research/resources/human-subjects/index.cfm

Original, signed proposals and all attachments, along with the necessary number of copies (see below), should be submitted to: Institutional Review Board, 264 Centennial Drive Stop 7134, Grand Forks, ND 58202-7134, or brought to Room 106, Twamley Hall.

Required Number of Copies:

- Expedited Review: Submit the signed original and 1 copy of the entire proposal.
- Full Board Review: Submit the signed original and 22 copies of the entire proposal by the deadline listed on the IRB website: http://und.edu/research/resources/human-subjects/meeting-schedule.cfm
- Clinical Medical Subcommittee and Full Board Review: Submit the signed original and 24 copies of the entire proposal by the deadline listed on the IRB website: http://und.edu/research/resources/human-subjects/meeting-schedule.cfm

Prior to receiving IRB approval, researchers must complete the required IRB human subjects' education. Please go to: http://und.edu/research/resources/human-subjects/human-subject-education.cfm

The criteria for determining what category your proposal will be reviewed under is listed on page 3 of the IRB Checklist. Your reviewer will assign a review category to your proposal. Should your protocol require full Board review, you will need to provide additional copies. Further information can be found on the IRB website regarding required copies and IRB review categories, or you may call the IRB office at 701 777-4279.

In cases where the proposed work is part of a proposal to a potential funding source, one copy of the completed proposal to the funding agency (agreement/contract if there is no proposal) must be attached to the completed Human Subjects Review Form if the proposal is non-clinical; 5 copies if the proposal is clinical-medical. If the proposed work is being conducted for a pharmaceutical company, 5 copies of the company's protocol must be provided.

INVESTIGATOR LETTER OF ASSURANCE OF COMPLIANCE WITH ALL APPLICABLE FEDERAL REGULATIONS FOR THE PROTECTION OF THE RIGHTS OF HUMAN SUBJECTS

I _Susan H. N. Jeno_____
(Name of Investigator)

agree that, in conducting research under the approval of the University of North Dakota Institutional Review Board, I will fully comply and assume responsibility for the enforcement of compliance with all applicable federal regulations and University policies for the protection of the rights of human subjects engaged in research. Specific regulations include the Federal Common Rule for Protection of the Rights of Human Subjects 45 CFR 46. I will also assure compliance to the ethical principles set forth in the National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research document, The Belmont Report.

I understand the University's policies concerning research involving human subjects and agree to the following:

1. Should I wish to make changes in the approved protocol for this project, I will submit them for review PRIOR to initiating the changes. (A proposal may be changed without prior IRB approval where necessary to eliminate apparent immediate hazards to the subjects or others. However, the IRB must be notified in writing within 72 hours of any change, and IRB review is required at the next regularly scheduled meeting of the full IRB.)

2. If any problems involving human subjects occur, I will immediately notify the Chair of the IRB, or the IRB Coordinator.

3. I will cooperate with the UND IRB by submitting Research Project Review and Progress Reports in a timely manner.

I understand the failure to do so may result in the suspension or termination of proposed research and possible reporting to federal agencies.

_____ _ _____
Investigator Signature Date

STUDENT RESEARCHERS: As of June 4, 1997 (based on the recommendation of UND Legal Counsel) the University of North Dakota IRB is unable to approve your project unless the following "Student Consent to Release of Educational Record" is signed and included with your IRB application.

STUDENT CONSENT TO RELEASE OF EDUCATIONAL RECORD[1]

Pursuant to the Family Educational Rights and Privacy Act of 1974, I hereby consent to the Institutional Review Board's access to those portions of my educational record which involve research that I wish to conduct under the Board's auspices. I understand that the Board may need to review my study data based on a question from a participant or under a random audit. The title of the study to which this release pertains is EMG analysis of Latissimus Dorsi, Erector Spinae and Middle Trapezius Muscle Activity During Trunk Rotation.

I understand that such information concerning my educational record will not be released except on the condition that the Institutional Review Board will not permit any other party to have access to such information without my written consent. I also understand that this policy will be explained to those persons requesting any educational information and that this release will be kept with the study documentation.

ID #	Printed Name
Date	Signature of Student Researcher

[1]Consent required by 20 U.S.C. 1232g.

References

1. Jeno SH, Varacallo M. Anatomy, Back, Latissimus Dorsi. [Updated 2019 Apr 5]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2019 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK448120/

2. Moore KL, Dalley AF, Agur AMR. *Clinically oriented anatomy*. 7th ed. Philadelphia, PA: Wolters Kluwer; 2013: 440-443, 464-465, 482-484, 485-486, 700-703, 991

3. Bell J, Burnett A. Exercise for the primary, secondary and tertiary prevention of low back pain in the workplace: A systematic review. *J Occup Rehabil*. 2009;19(1):8-24. https://www.ncbi.nlm.nih.gov/pubmed/19219537. doi: 10.1007/s10926-009-9164-5.

4. Krismer, M,|van Tulder, M. Low back pain (non-specific). *Best Pract & Res Cl Rh*. 2007;21(1):77-91. doi:10.1016/j.berh.2006.08.004

5. Donohue BF, Lubitz MG, Kremchek TE. Sports injuries to the latissimus dorsi and teres major. *Am J Sport Med*. 2017;45(10):2428-2435. doi: 10.1177/0363546516676062.

6. Weiner BK. Spine update: The biopsychosocial model and spine care. *Spine*. 2008;33(2):219-223. doi: 10.1097/BRS.0b013e3181604572.

7. Sugaya T, Sakamoto M, Nakazawa R, Wada N. Relationship between spinal range of motion and trunk muscle activity during trunk rotation. *J Phys Ther Sci*. 2016;28(2):589-595. doi: 10.1589/jpts.28.589.

8. Masaki M, Tateuchi H, Koyama Y, Sakuma K, Otsuka N, Ichihashi N. Back muscle activity and sagittal spinal alignment during quadruped upper and lower extremity lift in young men with low back pain history. *Gait & Posture*. 2018;66:221-227. doi: 10.1016/j.gaitpost.2018.09.002.

9. Vanti C, Conti C, Faresin F, Ferrari S, Piccarreta R.. The relationship between clinical instability and endurance tests, pain, and disability in nonspecific low back pain. *J Manipulative Physiol Ther*. 2016;39(5):359-368. doi: 10.1016/j.jmpt.2016.04.003.

10. Vasseljen O, Unsgaard-Tøndel M, Westad C, Mork PJ. Effect of core stability exercises on feed-forward activation of deep abdominal muscles in chronic low back pain: A randomized controlled trial. *Spine*. 2012;37(13):1101-1108. doi: 10.1097/BRS.0b013e318241377c.

11. Ehsani F, Arab AM, Jaberzadeh S. The effect of surface instability on the differential activation of muscle activity in low back pain patients as compared to healthy individuals: A systematic review of the literature and meta-analysis. *J Back Musculoskelet*. 2017;30(4):649-662. doi: 10.3233/BMR-150361.

12. Shamsi M, Sarrafzadeh J, Jamshidi A, Arjmand N, Ghezelbash F. Comparison of spinal stability following motor control and general exercises in nonspecific chronic low back pain patients. *Clin Biomech*. 2017;48:42-48. doi: 10.1016/j.clinbiomech.2017.07.006.

13. Fritz JM, Delitto A, Erhard RE. Comparison of classification-based physical therapy with therapy based on clinical practice guidelines for patients with acute low back pain: A randomized clinical trial. *Spine*. 2003;28(13):1363-1371. doi:

10.1097/01.BRS.0000067115.61673.FF.

14. Delitto A, George SZ, Van Dillen L, et al. Low back pain. *J Orthop Sports Phys Ther*. 2012;42(4):A1–A57. doi:10.2519/jospt.2012.42.4.A1

15. Geisser M, Haig A, Wallborn A, Wiggert E. Pain-related fear, lumbar flexion, and dynamic EMG among persons with chronic musculoskeletal low back pain. *Clin J Pain*. 2004:20:61-69.

16. Park S-Y, Yoo W-G. Comparison of exercises inducing maximum voluntary isometric contraction for the latissimus dorsi using surface electromyography. *J Electromyogra Kinesiol*. 2013;23(5):1106-1110. doi:10.1016/j.jelekin.2013.05.003.

17. Criswell E. Cram's Introduction to Surface Electromyography Guidelines. 2nd ed. Jones and Bartlett Publishers: 178-179, 266-268

18. Pozzi F, Plummer HA, Sanchez N, Lee Y, Michener LA. Electromyography activation of shoulder and trunk muscles is greater during closed chain compared to open chain exercises. *J Electromyogra and Kinesiol*. 2019. doi:10.1016/j.jelekin.2019.05.007.

19. Flint J, Linneman T, Pederson R, Storstad M. EMG analysis of latissimus dorsi, erector spinae, and middle trapezius activity during spinal rotation: A pilot study. 2015.

20. Bitter L, Erlandson S, Fedie A, Palmquist L, Peterson J. EMG analysis of latissimus dorsi, erector spinae, and middle trapezius activity during spinal rotation: A pilot study. 2016.

21. Huberty H, Klingbeil J, Miller M, Utt M. EMG analysis of latissimus dorsi, erector spinae, and middle trapezius activity during spinal rotation: A pilot study. 2017.

22. Wagner A, Forister B, Huot Z, Snellings T. EMG analysis of latissimus dorsi, erector spinae, and middle trapezius activity during spinal rotation: A pilot study. 2018.

23. Vera-Garcia FJ, Moreside JM, McGill SM. Abdominal muscle activation changes if the purpose is to control pelvis motion or thorax motion. *J Electromyogra Kinesiol*. 2011;21(6):893-903. doi: 10.1016/j.jelekin.2011.08.003.

24. Hunter SK. Sex differences in fatigability of dynamic contractions. *Exp Physiol*. 2016;101(2):250–255. doi:10.1113/EP085370

25. Pan F, Arshad R, Zander T, Reitmaier S, Schroll A, Schmidt H. The effect of age and sex on the cervical range of motion – A systematic review and meta-analysis. *J Biomech*. 2018;75:13-27. doi: 10.1016/j.jbiomech.2018.04.047.

26. De Luca CJ. Physiology and mathematics of myoelectric signals. *IEEE Trans Biomed Eng*. 1979;26(6):313–325. doi:10.1109/ TBME.1979.326534

27. Englehart K, Hudgins B, Parker P, Stevenson M. Classification of the myoelectric signal using time-frequency based representations. *Med Eng Phys*. 1999;21(6-7):431–438 doi:10.1016/S1350-4533(99)00066- 1.