

THE EFFECT OF KINESIO TAPE® APPLIED TO FORWARD SHOULDER POSTURE OBSERVED
AND QUANTIFIED WITH DIAGNOSTIC ULTRASOUND

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ABSTRACT

Allied health care professionals use Kinesio Tape® to reduce pain and increase performance without evidence of the impact on anatomical structures. The purpose of this research was to evaluate the effects of three Kinesio Taping Methods® on Forward Shoulder Posture (FSP). Thirty adults were randomized in a pre-/post-test study randomly assigned to one of the three Kinesio Tape® conditions: (1) inhibition of the pectoralis minor; (2) facilitation of the lower trapezius; and (3) a combination of both techniques. A baseline measurement of the location of the humerus was obtained using diagnostic ultrasound. Participants wore the respective taping technique for 24 hours and were re-measured without tape. The overall effect between each taping technique was not statistically significant ($P > .05$). Health care professionals should consider individual differences in anatomy as well as injury before arbitrarily applying Kinesio® Tape in hopes that it will alleviate pain or reduce injury.

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TABLE OF CONTENTS

ABSTRACT.....	iii
ACKNOWLEDGEMENTS.....	iv
LIST OF TABLES	viii
LIST OF FIGURES	ix
CHAPTER 1. INTRODUCTION.....	1
1.1. Overview of the Problem	1
1.2. Statement of Purpose	2
1.3. Research Questions	2
1.4. Definitions	2
1.5. Limitations	3
1.6. Delimitations	4
1.7. Assumptions	4
1.8. Variables.....	5
1.9. Significance of the Current Study	5
CHAPTER 2. LITERATURE REVIEW.....	6
2.1. Forward Shoulder Posture.....	6
2.1.1. Definition	6
2.1.2. Causes.....	7
2.1.2.1. Pectoralis Minor	7
2.1.2.2 Posterior Back Musculature	8
2.1.3. Measurement	9
2.1.3.1. Postural Assessment Involving the Use of Digitizing Systems.....	9

2.1.3.2. Observational Postural Assessment Involving the Use of a Plumb Line	10
2.1.3.3. Quantitative Methods for Forward Shoulder Posture.....	11
2.1.4. Treatment.....	17
2.2. Kinesio Tape®	18
2.2.1. Definition	18
2.2.2. Implications	19
2.2.3. Application	21
2.2.4. Inhibition and Facilitation	21
2.3. Diagnostic Ultrasound.....	26
2.3.1. Definition	26
2.3.2. Application	27
2.3.3. Diagnostic Ultrasound on Shoulders.....	29
2.4. Conclusion	31
CHAPTER 3. METHODOLOGY	32
3.1. Participants.....	32
3.2. Setting.....	33
3.3. Equipment	33
3.4. Procedures.....	34
3.5. Data Analysis	38
3.6. Conclusion	38
CHAPTER 4. MANUSCRIPT.....	39
4.1. Abstract.....	39
4.2. Introduction.....	40

4.3. Methods	41
4.3.1. Participants	41
4.3.2. Procedures.....	41
4.3.3. Statistical Analysis	44
4.4. Results	44
4.5. Discussion.....	45
4.6. Conclusions.....	47
CHAPTER 5. DISCUSSION.....	48
5.1. Research Findings	48
5.2. Limitations	52
5.3. Future Research	53
5.4. Conclusions.....	55
REFERENCES	57
APPENDIX A. NORTH DAKOTA STATE UNIVERSITY INSTITUTIONAL REVIEW BOARD APPROVAL	63
APPENDIX B. TAKE HOME INSTRUCTIONS	64
APPENDIX C. PHYSICAL ACTIVITY READINESS QUESTIONNAIRE (PAR-Q)	66

LIST OF TABLES

<u>Table</u>	<u>Page</u>
1. Reliability and Validity for Four Objective Techniques to Measure Forward Shoulder Posture	15
2. Descriptive Statistics for Repeated Measures ANOVA.....	45
3. Descriptive Statistics for Repeated Measures ANOVA.....	49
4. Tests Between-Subjects Effects	51

LIST OF FIGURES

<u>Figure</u>	<u>Page</u>
1. Double Square and Measuring the Distance from the Wall to the Anterior Tip of the Left Acromion Using the Double Square Method	12
2. Baylor Square and Measuring the Distance from the C7 Spinous Process to the Anterior Tip of the Left Acromion Using the Baylor Square.....	13
3. Anterior View of the Sahrman Technique and Lateral View of the Sahrman Technique Depicting the Goniometric Measuring of Shoulder Flexion with Full External Rotation	14
4. Forward Shoulder Posture Measurement of Posterior Border of Acromion to Table Surface with the Patient Supine	16
5. Application of Kinesio Tape® Inhibiting Pectoralis Minor	36
6. Application of Kinesio Tape® Facilitating Lower Trapezius.....	37
7. Application of Kinesio Tape® Inhibiting Pectoralis Minor	43
8. Application of Kinesio Tape® Facilitating Lower Trapezius.....	44

CHAPTER 1. INTRODUCTION

1.1. Overview of the Problem

Forward shoulder posture is a common postural alteration of scapular kinematics and produces scapular muscle imbalances, which predispose an individual to injury.¹⁻³ Posture alterations are associated with modifications in muscular actions which change joint alignment and cause movement impairment. These impairments can affect functional activities and restrict an active, healthy life. Sahrman⁴ states that evaluation of posture leads to an understanding of the impact of muscle imbalance on the observed posture alterations. Forward shoulder posture, also known as rounded shoulders is characterized by a protracted, downwardly rotated, and anteriorly tipped scapular position with increased cervical lordosis and upper thoracic kyphosis.¹ Forward scapular posture alters scapular kinematics and produces scapular muscle imbalances that are reported in shoulder impingement syndrome and rotator cuff injuries.^{5,6} Research shows that forward shoulder posture is linked with pectoralis minor length and lower trapezius weakness.⁷⁻⁹ Therefore, clinicians must work with patients to reduce these imbalances in order to protect functional movement.

To date, an extensive literature review revealed few published studies that specifically examined the quantitative research of the application of the inhibition and facilitation Kinesio Tape® methods. Kinesio Tape® is a widely used modality that has limited research to support the claims of developer Dr. Kenzo Kase. Kinesio Tape® is a product that has elastic properties similar to the epidermis to limit the body's perception of weight and avoid sensory stimuli when properly applied.¹⁰ Kinesio Tape® claims to have the ability to "re-educate the neuromuscular system, reduce pain, optimize performance, prevent injury, and promote improved circulation and healing."^{11(p23)} Understanding if the inhibition and facilitation Kinesio Tape Method® can be used as a treatment intervention for forward shoulder posture could benefit clinicians in treating the resting position of scapular protraction which limits scapular posterior tilt or external arm motion potentially predisposing patients to injuries.³

Diagnostic ultrasound is a non-invasive technique to observe and analyze musculoskeletal structures, bony prominences and fluid within the structure in real time. While there are common anatomical landmarks referenced in the literature, there appears to be no exact measurements for forward shoulder posture in literature. Therefore, using diagnostic ultrasound to observe forward shoulder posture can provide a quantifiable measurement of the effectiveness of Kinesio Tape® on forward shoulder posture.

1.2. Statement of Purpose

The purpose of this study was to determine if Kinesio Tape® Methods of inhibition of the pectoralis minor, facilitation of the lower trapezius, or combination of both taping techniques decreases forward shoulder posture when measured and quantified by diagnostic ultrasound.

1.3. Research Questions

This study was guided by the following research questions:

Q₁: Does the Kinesio Tape® inhibition of the pectoralis minor create a statistically significant measurement of the lesser tubercle of the glenohumeral head in relation to the coracoid process in individuals who suffers from forward shoulder posture?

Q₂: Will the facilitation method of the lower fibers of the trapezius create a statistically significant measurement of the lesser tubercle of the glenohumeral head in relation to the coracoid process in individuals who suffer from forward shoulder posture?

Q₃: Will the combination of the inhibition of the pectoralis minor and facilitation of the lower fibers of the trapezius produce a statistically significant decrease in forward shoulder posture in individuals who suffer from forward shoulder posture?

1.4. Definitions

Forward shoulder posture (FSP): also known as “rounded shoulders” is a posture characterized by a protracted, downwardly rotated, and anteriorly tipped scapular position with increased cervical lordosis and upper thoracic kyphosis.¹

Kinesio Tex Tape®: is polymer elastic strand wrapped by 100% cotton fibers that is approximately the same thickness as the epidermis of the skin, which purports to limit the body's perception of weight and avoid sensory stimuli when properly applied.¹¹ The tape absorbs moisture from the body and therefore can be left on the skin for up to 72 hours.¹¹ The heat activated adhesive tape is also latex- free and similar to that of human fingerprints in a wave pattern to help with its designed effects.¹¹

Diagnostic ultrasound: a non-invasive imaging technique that uses a transducer that contains a crystal sound head that creates sound waves that interact with soft tissues to produce an image.¹²

Echogenicity: the ability of tissues to reflect ultrasound waves.¹²

Hyperechoic: a bright echo on the image when an interface between tissues produces a large difference in impedance and the sound beam is strongly reflected such as interfaces between bone and soft tissues.¹²

Plumb line: a line to which is attached a plumb bob (a small lead weight). When suspended, it represents a vertical line. When used for analyzing standing posture, it must be suspended in line with fixed points.¹³

1.5. Limitations

This research study contained limitations as a result of numerous variables. One limitation of the current study was the degree of forward shoulder posture was measured only on the dominant arm. The prevalence of participants' forward shoulder posture could vary between their dominant arm compared to the non-dominant arm. An additional limitation was participants for this study will include those between the ages of 18 and 50 years old. Therefore, research will not be applicable to those outside of the age range such as individuals classified in the pediatric, adolescent, or geriatric categories. Furthermore, the precise tension of the Kinesio Tape application was not measured. Although the application was applied by a Certified Kinesio Tape Practitioner, a varying amount of tension could affect the musculature and alter the measurement of forward shoulder posture. Finally, only 30 participants were utilized in the

following study resulting in a small sample size. Future research should consider these limitations and develop appropriate methodologies to include these variables.

1.6. Delimitations

Due to lack of time and relevance to the purpose of this study, a few related variables will not be accounted for throughout the data collection. This study will use the dominant shoulder to measure forward shoulder posture. In addition, the measurement of forward shoulder posture will only be taken initially and after 24 hours even though Kinesio Tape® claims its effects can last up to 72 hours.^{11,14,15} Furthermore, activity level of patients and the usage of the shoulder complex during activities will not be considered. Therefore, the Kinesio Tape® could have different effects on the degree of forward shoulder posture based on the usage of the shoulder joint. The last delimitation of this study is Dr. Kenzo Kase suggests in his manual that the facilitation of the upper trapezius should be used in order to correct forward shoulder posture. However, Dr. Kase does not provide any research or clinical rationale as to why he suggests this particular taping application for the upper trapezius. Therefore, this study facilitated the lower trapezius due to the results of the extensive literature review. Moreover, the application for the facilitation of the lower trapezius administered in the study will be different from published recommendations. The facilitation will occur from the origin of the muscle, spinous processes of the T6 to T12 vertebrae, to the insertion of the lower trapezius, the tubercles of the apex of the scapular spine.¹³ These factors are outside the scope of the current study and should be considered for future research. The researchers of the current study have considered numerous variables and have chosen the methodology based on a thorough literature review of Kinesio Tape®, forward shoulder posture, and musculoskeletal diagnostic ultrasound.

1.7. Assumptions

There are a few assumptions that will be made throughout this research study. Since participants will be continuing with their normal daily routine, it will be assumed that subjects will honestly and

accurately report any vigorous activity (e.g. weight lifting). It is also to be assumed that the participants will remove the Kinesio Tape® if they are feeling any discomfort or irritation.

1.8. Variables

The dependent variable in this study was the measurement of the humeral head in relation to the acromion process following application of the Kinesio Tape® inhibition and facilitation method. The independent variable in this study was the Kinesio Tape® application.

1.9. Significance of the Study

Kinesio Tape® is a modality that is used by athletic trainers, physical therapists, massage therapists, and others in the medical field. However, the use of Kinesio Tape® continues to be a controversial treatment option due to a lack of published evidence. While there are a few peer-reviewed articles investigating the effects of facilitating and inhibiting musculature, most published articles complete a methodology that is not following Dr. Kenzo Kase's directed applications of Kinesio Tape®.¹⁶⁻

²⁰ Overall there have been no publications examining the effects of Kinesio Tape® on forward shoulder posture (FSP) as measured and quantified by diagnostic ultrasound.

CHAPTER 2. LITERATURE REVIEW

There is limited research on quantitative measurements for specific treatment interventions for forward shoulder posture. Kinesio Tape® can be used to decrease pain levels and increase range of motion or strength in individuals who may have shoulder issues such as postural abnormalities.^{10,21-23} However, the use of Kinesio Tape® methods of facilitation and inhibition application techniques on forward shoulder posture is not well researched. Furthermore, the ability to quantify the success of a treatment intervention on forward shoulder posture is inadequate. Diagnostic ultrasound can be used to observe the positional angle of a bony prominence within the shoulder joint to establish the degree of forward shoulder posture present. To date, there have been no published articles utilizing diagnostic ultrasound to examine the quantitative measurements of the effects of Kinesio Tape® on forward shoulder posture. This literature review was organized into the following areas: forward shoulder posture, Kinesio Tape®, and diagnostic ultrasound.

2.1. Forward Shoulder Posture

2.1.1. Definition

Forward shoulder posture, also known as rounded shoulders, is a posture characterized by a protracted, downwardly rotated, and anteriorly tipped scapular position with increased cervical lordosis and upper thoracic kyphosis.¹ As the scapula is pulled into an anterior tilt, the coracoid process is also pulled anteriorly causing the scapula to elevate and have an increased internal rotation of the humerus. The internally rotated humerus is typically what clinicians observe as forward shoulder posture. This altered mechanism causes an increased area of contact pressure of the humerus with the posterior-superior glenoid. Forward posture alters scapular kinematics and produces muscle imbalances that result in a resting position of scapular protraction. This position may limit scapular posterior tilt and external arm motion, which predisposes injuries that occur secondary to this scapular dyskinesia.^{3,7,24} Examples of

these injuries can include shoulder impingement, rotator cuff injuries, acromioclavicular joint arthrosis or separation, and glenohumeral labral abnormalities.^{5,6}

There are numerous musculoskeletal factors of forward shoulder posture including repetitive overhand movement and habitual slouched posture in everyday tasks.^{5,25} Sahrman⁴ states that evaluation of posture leads to understanding of the impact of muscle imbalance on the observed posture alterations. Thus, medical providers must work on reducing these imbalances in order to improve posture and potentially prevent injuries associated with musculoskeletal imbalances. According to the literature, two of the primary muscular elements of predisposing forward shoulder posture are pectoralis minor length and the posterior musculature weakness of the lower trapezius.

2.1.2. Causes

2.1.2.1. Pectoralis Minor. Pectoralis minor tightness and length may be a predictor for an increased forward shoulder position.^{3,7,26} The pectoralis minor originates on the superior margins of the outer surfaces of the third, fourth and fifth ribs near the cartilage. It inserts on the superior surface of the coracoid process of the scapula. The pectoralis minor is innervated by the medial pectoral nerve with fibers from a communicating branch of the lateral pectoral nerve. Its actions include tilting the scapula anteriorly while supporting ribs during inspiration.¹³ Tightness of this muscle has been shown to increase scapular anterior tilt and internal rotation.^{3,26}

Several studies relate shortened pectoralis minor muscle length as the cause of scapular biomechanical alterations that are associated with forward shoulder posture. The pectoralis minor is lengthened during glenohumeral external rotation, scapular upward rotation, and posterior tilting.⁸ Tightness of the pectoralis minor is common among overhead athletes such as baseball players.^{7,27} Laudner et al⁷ observed baseball players to determine if forward scapular posture was more prevalent in the dominant arm compared to the non-dominant arm. Results suggest that the pull placed on the scapula during the follow-through phase of a throwing motion makes the humerus adaptively pull the

scapula forward. The athlete's dominant shoulder demonstrated a statically significant forward scapular position compared to the non-dominant shoulder ($P < .004$).⁷

J. H. Lee et al²⁴ determined the relationships between the degree of forward scapular posture and the pectoralis minor by its relation with thoracic spine angle, posterior shoulder tightness, and strength of the serratus anterior. Researchers recruited 18 participants with forward scapular posture and objectively measured the acromion distance by the Sahrman technique, the pectoralis minor, and the strength of the serratus anterior muscle of each participant. The total explained variance in the forward scapular posture was 93%. The pectoralis minor accounted for 78% of the variance in this forward scapular posture.²⁴ Clinical application of measuring the pectoralis minor can help clinicians determine a need for and effectiveness of interventions for lengthening this muscle and inhibiting its action.^{3,26,2}

2.1.2.2. Posterior Back Musculature. In addition to pectoralis minor tightness, posterior back musculature weakness can be associated with the predisposition of forward shoulder posture. As pectoralis minor tightness translates the scapula into a forward tilt, the back musculature needs to be strong enough to hold the scapula in correct alignment. This is due to the position of the humerus being dependent on the skeletal relationships of the components of the shoulder girdle complex and on soft tissue support.²⁸ Posterior muscular weakness is a common characteristic among upper-hand athletes such as baseball, rugby, volleyball, and tennis.²⁹ This weakness can be the result of tissue shortening of soft tissue attachments of the posterior deltoid, infraspinatus, teres minor, and latissimus dorsi on the scapula.^{7,30} Moreover, the tightness of the pectoralis minor and weakness of the lower trapezius create a muscular imbalance.³ The lower trapezius originates on spinous processes of T6 to T12. The muscle inserts on the tubercles of the apex of the scapular spine. The lower fibers of the trapezius are responsible for upper rotation and depression of the scapula. The muscle is innervated by the spinal accessory nerve.¹³

Pectoralis minor tightness and lower trapezius weakness contributes to forward shoulder posture as supported by the Upper Crossed Syndrome (UCS).⁹ Upper Crossed Syndrome is characterized as

facilitation of the upper trapezius, levator scapulae, sternocleidomastoid, and pectoralis muscles, as well as inhibition of the deep cervical flexors, lower trapezius, and serratus anterior.⁹ Janda noted that these changes in muscular tone create a muscle imbalance, which leads to movement dysfunction. Muscles prone to tightness generally have a lowered irritability threshold and are readily activated with any movement, thus creating abnormal movement patterns.⁹ Specific postural changes are seen in UCS including forward shoulder posture, cervical lordosis and thoracic kyphosis, elevated and protracted shoulders, and rotation or abduction of the scapula.⁹ By using Janda's classification, clinicians can begin to predict patterns of tightness and weakness in the musculoskeletal system in attempt to prevent and treat postural abnormalities.

2.1.3. Measurement

2.1.3.1. Postural Assessment Involving the Use of Digitizing Systems. Clinical assessment of posture tends to be subjective in nature. Various authors have described methods for evaluation of muscle action in relation to posture alterations to establish standards for this technique.^{31,32} Although the gold standard to identify the scapular position is radiography, there are several other objective measurements being used in the medical field. Most of the quantifiable research on postural assessment for shoulders involves a computerized program that assesses the reflective markers placed on anatomical locations in relation to a plumb line or other landmarks.^{31,32}

The reliability of a computer assisted slide digitizing system called the Postural Analysis Digitizing System (PADS) was investigated by Braun, B., & Amundson.³¹ The purpose of the study was to assess the within-day and between-day reliability of the PADS system to measure three aspects of head and shoulder posture and aimed to quantify the postural assessment model. Twenty male subjects were photographed in a neutral position, maximally protracted position, and maximally retracted position of the humeral head and scapula. The slide photograph was analyzed using PADS. The reliability of the system was tested by calculating an intra-class correlation coefficient (ICC), student t-test, and the percent error for each position. The ICC values demonstrated a significant correlation between the measurements from

the sessions for all positions (0.71 to 0.87). Overall, it was concluded that the three head positions were both reproducible and reliable making the PADS system accurate for posture assessment. However, the application of the PADS system into a clinical setting requires further investigation.³¹ The equipment needed to take slide photographs is not readily available in the clinical setting and requires additional technical training for the PADS system.³¹

Likewise, Normand et al³² used a photographic digitizer (Posture Print® system) to conduct research on postural assessment. The authors state "in today's evidence based care arena, it is unacceptable to evaluate patients with non-objective measures."^{32(p2)} In the study, three examiners performed repeated postural measurements on 40 subjects over two days. Each examiner palpated anatomical locations and placed 13 markers on the subjects before photography. The digital photographs were then examined using the Posture Print® internet computer system and calculated postures as rotations in degrees and translations in millimeters. For reliability, two different types (liberal and conservative) of inter- and intra-examiner correlation coefficients (ICC) were calculated. All the "liberal" ICCs were in the excellent range (>0.84). For the more "conservative" type ICCs, four inter-examiner ICCs were in the interval (0.5-0.6), 10 ICCs were in the interval (0.61-0.74), and the remainder were greater than 0.75. The authors concluded that this method of evaluating posture is reliable but using this system in a clinical setting has to be called into question due the availability of the equipment.³²

2.1.3.2. Observational Postural Assessment Involving the Use of a Plumb Line. Despite the literature support of performing objective measurements of forward shoulder posture with computerized software, a large quantity of certified athletic trainers will resort to using visual analysis of forward shoulder posture by using a plumb line in a clinical setting. A plumb line is a reference of alignment for the body to detect abnormalities.¹³ In a lateral view plumb line analysis, the acromion process lies anterior to the plumb line, which is referenced by aligning it with the lobe of the ear. Theoretically, this posture may produce or result from soft tissue tightness anteriorly of the pectoralis minor, serratus anterior, and lower trapezius as well as posterior muscular weakness.¹³

To try and find a correlation of observational posture, fifty physical therapists and two experts trained in global postural re-education assessed the standing posture from photographs of five youths with idiopathic scoliosis using a plumb line with 23 posture indices representing six body regions (head and neck, shoulders and scapula, thoracic region, lumbar region, pelvis and lower limbs).³³ Fortin et al³³ used Kappa coefficients (κ) and the percentage of agreement to assess inter-rater reliability and intra-class coefficients (ICC) for determining agreement between the physical therapists and experts. For shoulder posture assessment, inter-rater reliability was poor for protraction and rounded shoulders. Protracted shoulders had a high percentage of agreement was 88%; κ : 0.17-0.50; good to excellent ICC: 0.66 – 0.99. Rounded shoulders had a moderate percentage of agreement was 50%; κ : 0.65 to 1.00, and ICC -0.42 to 0.94. Therefore, clinicians need to be aware of the limitations of visual assessment, and it should be used in combination with other quantitative measurements to improve the quality of posture examination.

2.1.3.3. Quantitative Methods for Forward Shoulder Posture. Aside from using plumb line and computerized posture assessments, there are several other methods to quantify forward shoulder posture. The research performed by Peterson et al³⁴ compared intra-rater reliability for four objective techniques to measure forward shoulder posture. Subjects consisted of 25 males and 24 females who began by having an x-ray taken of the lateral cervical spine. After the radiograph films were completed, the horizontal distance from the C7 spinous process to the anterior tip of the left acromion process was measured. Subjects then proceeded to complete the four measurements in random order. The tests included: the Baylor square, the double square, the Sahrman technique, and scapular position. These measurements were then repeated to determine the intra-rater reliability. To help ensure blinded data on repeat measures, the evaluation of forward shoulder posture was done in large groups. All subjects were instructed to stand in the natural, relaxed posture with arms at their sides. The results were then compared with the radiographic measurement to establish criterion validity. The ICC for intra-rater

reliability for each technique was relatively high: Baylor square 0.91, double square 0.89, Sahramann technique 0.89 and scapular position 0.91.

One method to determine forward scapular posture is described by Peterson et al³⁴ as the double square method. For this measurement each participant was asked to stand against a wall. Meanwhile, the examiner placed a 12-inch carpenters square over the shoulder being tested parallel with the wall. Then the second square extended along the 12-inch ruler and positioned at the tip of the anterior portion of the acromion process. The distance is then measured between the wall and the acromion to determine the amount of forward scapular posture.^{7,24,34} By placing the patient in an upright position, a clinically relevant and realistic view on scapular positioning is provided. Reliability of the double square method was measured on 20 shoulders without previous injury or surgery using an intra-class correlation coefficient (ICC) formula. Each participant's postural scapular position was measured and reassessed a minimum of 24 hours later. Respectively, the ICC and standard error of measurement values for this method were moderately high with 0.84 and 4.6mm.³⁵

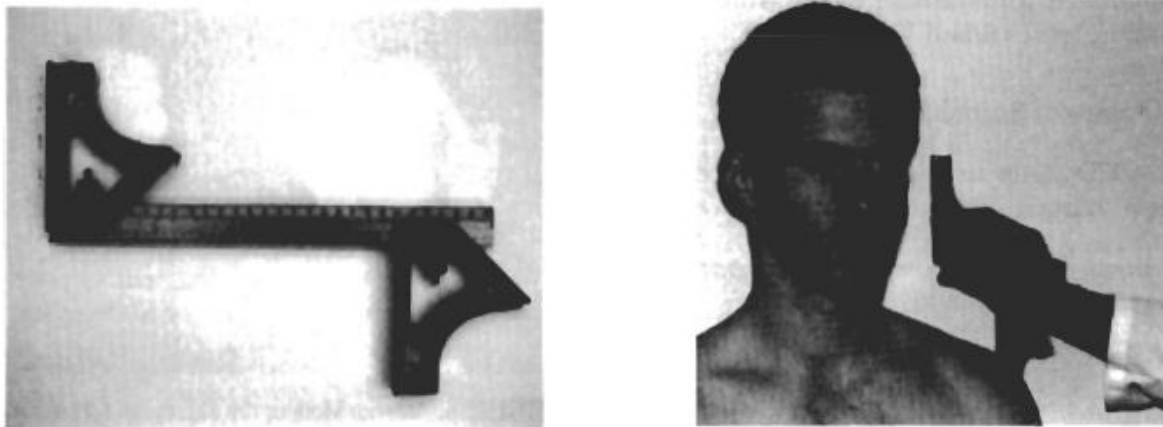


Figure 1. Double Square (Left) and Measuring the Distance from the Wall to the Anterior Tip of the Left Acromion Using the Double Square Method (Right).³⁴

The Baylor Square is another method for measuring FSSP and was incorporated into the Peterson et al³⁴ research. This device consists of a carpenter square having a 24-inch long arm and a 16-inch arm.

This tool is mounted on an intravenous pole using a clamp so that the vertical distance can be adjusted for subject heights. The tester uses this tool to measure the distance from the C7 spinous process to the anterior tip of the acromion process in a sagittal plane.³⁴ The intra-rater reliability was high with ICC = 0.91; however, the techniques' ability to detect postural changes over time requires further research.³⁴

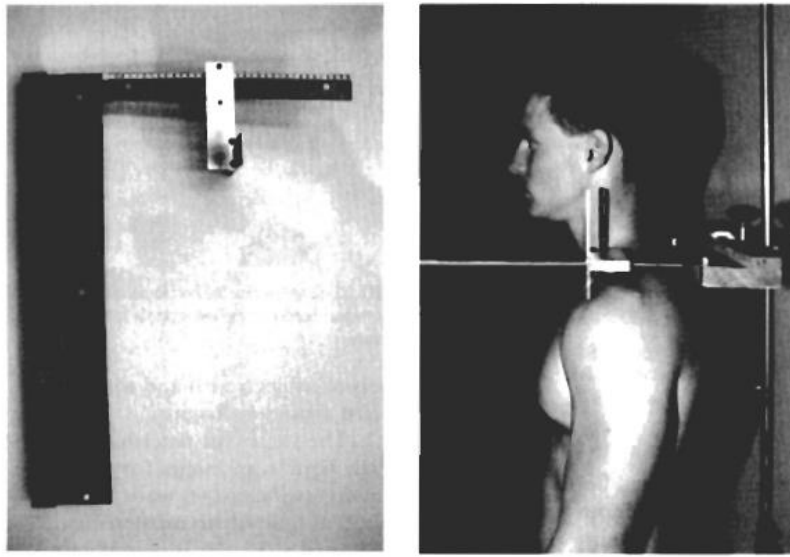


Figure 2. Baylor Square (Left) and Measuring the Distance from the C7 Spinous Process to the Anterior Tip of the Left Acromion Using the Baylor Square (Right).³⁴

An additional method to objectively measure scapular position is the Sahrman technique.^{34,36} The Sahrman technique consists of each subject standing with their back touching the wall. Knees are slightly flexed and abdominal muscles are activated to flatten the low back against the wall. The tester uses the index fingers and thumbs pinched together to place the radial borders of the index finger against the wall at ear level. The researcher then instructs the subjects to slide both hands as high as possible without losing contact between the wall. The tester uses their index fingers along the scapula radial borders to ensure the elbows are pointed straight out to keep the shoulder in flexion and external rotation. The final position is judged to be reached when the subject is unable to continue to slide their

hands without deviation from this position. When subjects reach their final test position a goniometer is used to measure the shoulder flexion angle between the subjects arm and midline of the trunk (Figure 3).



Figure 3. Anterior View of the Sahrman Technique (Left) and Lateral View of the Sahrman Technique Depicting the Goniometric Measuring of Shoulder Flexion with Full External Rotation (Right).³⁴

Measurement of scapular position is an additional assessment of forward shoulder posture examined by Peterson et al.³⁴ In this quantifiable measurement, the tester used a cloth tape measure to obtain the horizontal distance from the vertebral border of the left scapula to the spinous process of the third thoracic vertebrae in centimeters. Host³⁷ describes a similar method measuring the distance from the medial scapular border to the fourth thoracic spinous processes. The distance was measured while the patient was in a relaxed neutral state, and was repeated with the patient actively retracting both shoulders. The ICC values for this measurement was moderate to good with an ICC = 0.50-0.70.³⁸ Host also indicated that the typical distance from the medial scapular border to the thoracic spinous processes is believed to be 5.08cm.³⁷

Peterson et al³⁴ demonstrated good clinical reliability for each technique; validity could not be established when compared with the radiographic measurements. Validity was assessed based on a radiographic representation of a modified plumb line description of forward shoulder posture. Most of the correlations between the radiographs were moderate or good, but the validity of these techniques was not established as the validity for the radiographic measurements is limited. A radiograph is a two

dimensional plane representation of a three dimensional object. As such, magnification distortion and true distortion could provide incorrect distance measurements. Radiograph also provided a vertical cassette support that alters a patient's posture. Finally only the Baylor square technique used the same bony landmarks as the radiographic measurement.³⁴ The Baylor square was found to have the strongest correlation ($r=0.77$) with the radiographic measurements. Both the double square and scapular measure techniques had moderate correlation coefficients of 0.65 and 0.57. The Sahrman technique had a negative correlation (-0.33). Therefore, these techniques may have a clinical value in objectively measuring the change in a patients shoulder posture. However, future research is necessary to establish inter-rater reliability and assess each techniques' ability to detect postural changes over time.³⁴

Table 1. Reliability and Validity for Four Objective Techniques to Measure Forward Shoulder Posture *

Objective measurement	Intra-rater reliability (ICC = #)	Validity (r = #)
Baylor square	0.91	0.77
Double square	0.89	0.65
Sahramann technique	0.89	-0.33
Scapular Position	0.91	0.57

*Adapted from Peterson et al³⁴

A more prominent method of forward shoulder posture is used after Sahrman later modified his technique in 2002.³⁹ To perform this measurement the patient lied supine on an examination table with their arms by their sides and elbows flexed and rested against the lateral wall of the abdomen. The investigator palpated the posterior aspect of the lateral acromion process. Then the investigator positioned a tape measure perpendicular to the examination table to mark the height from the examination table to the palpated area and the distance was measured in centimeters (Figure 4).^{1,13,39-42} During this technique, a measurement of greater than or equal to 2.54 cm was defined as rounded shoulder posture by Sahrman.^{39(p211)} The intra-rater reliability of the supine rounded shoulder measure

was moderate to high with an ICC = 0.80 and a CI= 0.68-0.88,⁴¹ Nijs et al³⁸ confirmed the findings of Sahrman and found a high ICC of this measurement to be 0.88-0.94. It has been noted that the supine rounded shoulder posture measure is an effective diagnostic predictor but does not correlate well with an index of pectoralis minor length.^{40,41} This measurement technique is the most common technique utilized by clinicians in the literature.^{1,13,39-42}



Figure 4. Forward shoulder posture measurement of posterior border of acromion to table surface with the patient supine³⁸

A quantitative assessment may have considerable diagnostic and therapeutic utility in medical practice as it guides the understanding of muscular impairment associated with abnormal forward shoulder posture patterns. Accurate posture assessment tools in the laboratory and in the clinical setting produce numerical indices, which allow for quantification of observed posture alterations. However, many techniques do not provide guidance in determining a numerical value that defines forward shoulder posture. While there are many documented techniques that use a variety of equipment to determine the degree of forward shoulder posture, the modified Sahrman³⁹ technique is the only clinically applicable

technique to establish the presence of forward shoulder posture with quantification. Professionals in the health field should use the modified Sahrman technique due to a lack of quantification of other methods to evaluate patients ascertain appropriate treatment.

2.1.4. Treatment

There are various treatment interventions for rehabilitating rounded shoulder posture including stretching tight musculature, strengthening weak musculature, and using a shoulder brace or taping to correct the altered posture. Exercises that promote scapular retraction have been shown to aid in the correction of rounded shoulder posture.²⁰ Cole et al⁵ have concluded that scapular stabilization with a brace accurately alters posture and scapular muscle activity in athletes with forward-head and rounded shoulder posture. Ninety-three participants were assigned randomly to two groups: compression shirt with no brace tension and compression shirt with brace straps fully tensioned. Posture was measured using lateral-view photography with retroreflective markers. Electromyography of the upper trapezius, middle trapezius, lower trapezius, and serratus anterior in the dominant upper extremity was measured during four exercises and two glenohumeral motions. Posture and exercise EMG measurements were taken with and without the brace applied. Before a brace, the forward shoulder angle with a 95% confidence interval was $61.0^{\circ} \pm 8.2$ and after the brace was applied it decreased to $56.6^{\circ} \pm 10.0$. After a brace was applied with tension, the forward shoulder angle decreased from a $63.3^{\circ} \pm 8.6$ to a $57.2^{\circ} \pm 7.3$ after application.⁵ Although a brace can decrease the amount of degrees of forward shoulder posture, it is not practical for those who perform overhead scapula movements such as athletes who participate in baseball and softball.

Lee et al²⁰ investigated three different intervention effectiveness in decreasing forward shoulder posture. Treatment interventions included scapular posterior tilting exercises alone, scapular posterior tilting exercises after pectoralis minor stretching, and the scapular posterior tilting exercises with use of shoulder brace. Rounded shoulder posture was confirmed using a caliper measure of the pectoralis minor length. Surface electromyography data was collected during all interventions and were expressed as a

percentage of the maximal voluntary isometric contraction. The test-retest reliability for EMG measurements was substantial in the three interventions: scapular posterior tilting exercises alone (ICC = 0.86, CI = 0.61-0.96), scapular posterior tilting exercises after pectoralis minor stretching (ICC = 0.87, CI = 0.63-0.96) and scapular posterior tilting exercises with the use of a brace (ICC = 0.95, CI = 0.84-0.98). Each intervention provided statically significant differences ($P < .05$). There were also statistically significant differences in lower trapezius muscle activity ($P = .009$) between the three interventions. The researchers concluded that rounded shoulder posture was highest in scapular posterior tilting exercises alone. The pectoralis minor length and scapular posterior tilting exercises elicited the greatest lower trapezius muscle activation among the compared interventions. They concluded that rounded shoulder posture had the highest correlation following scapular posterior tilting exercises. Therefore, pectoralis minor stretching and application of a shoulder brace may help correct rounded shoulder posture and restore the length of the pectoralis minor.^{20,24}

2.2. Kinesio Tape®

2.2.1. Definition

Kinesio Tape ® is an adhesive therapeutic tape for injury prevention, rehabilitation, and performance enhancement that is utilized by various medical professionals such as certified athletic trainers and physical therapists.^{10,43} Kinesio Tape® was a technique developed by Japanese chiropractor, Dr. Kenzo Kase, in the 1970s.¹¹ The profile of Kinesio Tape® became increasingly popular amongst athletes and clinicians after it was observed on athletes at the 2008 Olympic Games.⁴⁴ Kinesio Tape® is polymer elastic strand wrapped by 100% cotton fibers which are approximately the same thickness as the epidermis of the skin which purports to limit the body's perception of weight and avoid sensory stimuli when properly applied.¹¹ The tape absorbs moisture from the body and, therefore, can be left on the skin for up to 72 hours.^{11,14,15} The heat activated adhesive tape is similar to that of human fingerprints in a wave pattern to help with its designed effects. Kinesio Tape® can be applied to any muscle or joint in the body which attracts many athletes and practitioners in both recreational and

competitive sports realm. Although Kinesio Tape® is widely used in the sports medicine field; it is not well researched with objective measurements. Furthermore, most research that is available does not follow the published guidelines of Kinesio Tape® as determined by Dr. Kase, and are implemented incorrectly with inappropriate factors, such as tension percentage. Therefore, researchers are making false conclusions about Kinesio Tape®. To date, an exhaustive literature review did not reveal many published studies with correct application and objective measurements that examine the use of the inhibition and facilitation Kinesio Tape® methods on forward shoulder posture as measured by diagnostic ultrasound.

2.2.2. Implications

Kase et al^{10,11} have proposed several benefits of Kinesio Tape®, depending on the percentage of stretch applied to the tape as well as direction of pull during application. These benefits include providing sensory stimuli to: (1) provide positional stimulus, (2) creating more space by lifting soft tissues, fascia and cutaneous structures, (3) assisting or limiting range of motion, (4) align fascial tissues to reduce adhesions, and (5) decrease swelling and edema by direct inflammation towards a lymph duct.^{11,21} Investigators have demonstrated that Kinesio Taping® effectively improves postural alignment, increases the shoulder range of motion, and reduces pain and discomfort of the glenohumeral joint.^{11,21,23}

When examining the effects of Kinesio Tape® on range of motion, Thelen et al²¹ examined college students with shoulder pain to determine the short-term clinical efficacy of Kinesio Tape® when compared to a sham tape application. Subjects included in the study had pain onset prior to 150° of active shoulder elevation in any plane, a positive empty can test suggesting possible supraspinatus involvement, positive Hawkins-Kennedy indicating possible external impingement, and complained of difficulty performing activities of daily living. Subjects were randomly assigned to one of two taping groups: therapeutic Kinesio Tape® application and a sham Kinesio Tape® group. For the therapeutic Kinesio Tape®, the first strip involved the facilitation of the supraspinatus with a Y-strip applied origin to insertion with paper-off tension. The subject was positioned in cervical flexion to the contralateral side

and with their arm reaching to the back pocket on the contralateral side as the tape was applied. The second strip was a Y-strip applied from insertion to origin with paper-off tension of the deltoid. The first tail of the anterior deltoid was applied while the arm was externally rotated and horizontally abducted. The tail for the posterior deltoid was applied with the arm horizontally adducted and internally rotated. The third strip was an I-strip that was applied with a downward pressure tension of 50-75% from the coracoid process to the posterior deltoid. For the sham Kinesio Tape® group, two I-strips were applied with no tension following different parameters as the therapeutic tape. The first strip was over the acromion-clavicular joint in the sagittal plane and the other strip was on the distal deltoid in the transverse plane. Researchers then utilized three primary outcome measures of the Shoulder Pain and Disability Index, pain free active range of motion, and the visual analogue scale to assess pain. The Kinesio Tape® application showed immediate improvement in pain free abduction with a mean \pm SD increase of $16.9^{\circ} \pm 23.2^{\circ}$. Thelen et al²¹ concluded that Kinesio Tape® may assist clinicians to obtain immediate improvement in pain-free shoulder abduction range of motion. No other differences between groups regarding range of motion, pain, or disability scores at any time interval were found.

Simsek et al²² investigated the effectiveness of Kinesio Taping® when combined with exercise treatment of subacromial impingement syndrome. Researchers examined 38 participants with shoulder impingement syndrome. Participants were randomly assigned to two groups: therapeutic Kinesio Tape® and sham Kinesio Tape®. The application of the tape was performed as described by Thelen et al^{21, 22}. An I-strip was applied from insertion to origin over the deltoid and supraspinatus with a 50-75% stretch to allow the mechanical correction technique. For the sham Kinesio Tape®, the application mimicked the mechanical correction technique but was applied with no tension. The application of the tape was repeated for 12 days with a three day application. All participants received an exercise therapy program in addition to the taping. There was significant ($P < .05$) improvement in night pain, pain with movement, DASH score, shoulder external range of motion, muscle strength, and pain free abduction

range of motion with therapeutic Kinesio Tape® at the 12th day. Therefore, Kinesio tape® can be effective in the rehabilitation of subacromial impingement syndrome when administrated with exercises.

Similarly, Kaya et al²³ compared the efficacy of Kinesio Tape® and physical therapy modalities in patients with shoulder impingement syndrome. Out of 55 participants, 30 participants were treated with Kinesio Tape® while the remaining 25 were treated with local modalities. The Kinesio Tape® group had tape applied a total of three times to the supraspinatus, deltoid, and teres minor during two consecutive, three day intervals. The 25 participants who received local modalities had treatments daily for two weeks using ultrasound, transcutaneous electrical nerve stimulation, and hot packs. Response to treatment was evaluated with the Disability of Arm, Shoulder, and Hand scale. Outcome measures were assessed at baseline, first, and second weeks of treatment. They found that the Kinesio Tape® group outcome measurement was statistically significantly lower ($P = .001$) when compared to the physical activity group. Therefore, Kinesio Tape® has been found to be more effective in treatment of pain and discomfort of shoulder impingement syndrome as the tape application successfully provides proximal scapular stability.

2.2.3. Application

There are six primary application techniques for the administration of Kinesio Tape®. These techniques include: (1) mechanical correction or recoiling, (2) fascia correction or holding, (3) space correction or lifting, (4) ligament/tendon correction or pressure, (5) functional correction or spring-assist correction, and (6) channeling or lymphatic correction.¹⁰ The mechanical correction or recoiling is used by clinicians to facilitate or inhibit muscles. When facilitating a muscle, the tape is applied from origin to insertion with 15-35% tension on the tape. When inhibiting a muscle, the tape is applied insertion to origin with a 15-25% tension on the tape.¹¹

2.2.4. Inhibition and Facilitation

Kinesio Tape® has two basic mechanical application directions for the treatment of tissue. To inhibit muscle function for over-used or stretched muscles, the tape is applied from insertion to origin.

For weak muscles or where increased contraction is desired, the tape is applied from origin to insertion to facilitate muscle function.¹¹ The inhibition and facilitation methods of Kinesio Tape® are designed to allow a recoil effect to pull the tape back toward the anchor thus facilitating or inhibiting a muscle.¹⁰ Although Kinesio Tape® is not designed to increase strength, most of the studies hypothesized the facilitation of a muscle would provide a small, immediate increase in muscle strength by producing a concentric pull on the fascia, which may stimulate increased muscle contraction.^{16-19,45} In a commentary published in the *Journal of Bodywork and Movement Therapies*, Morrissey proposed that tape applied under tension in the direction of the muscle fibers is thought to facilitate the underlying muscle. Morrissey's proposal is supported in theory that muscle shortening optimizes the length-tension relationship of a muscle, enhancing its ability to generate force.⁴⁶

Other theorized explanations for the effects of inhibition and facilitation include the skin's sensory input from the application of tape, which alters the motor-neuron output that innervates the skeletal muscle's activation.⁴³ Alexander et al⁴³ investigated whether or not tape affects trapezius reflexes to determine if tape can facilitate the muscle. They assessed the effect of tape applied to the skin overlying and aligned with the lower fibers of the trapezius by testing the monosynaptic reflex of the sensory nerve of the trapezius using electrical stimulation. The electrical stimulation upon the H-reflex provides an index of trapezius motor-neuron pool excitability. Researchers reported statistical significance for the two-way ANOVA ($P < .001$) and Tukey HSD ($P < .05$), although all relevant statistical data was not provided. Overall, the results of this study indicate that taping the skin overlying the muscle inhibits its H-reflexes although it does not last with removal of the tape.⁴³

One research study evaluated the change in muscle function with Kinesio Tape® application to the dominant and non-dominant arms and assessed strength before the taping intervention, after 30 minutes, 24 hours, and 48 hours of taping the flexor digitorum superficialis.⁴⁷ This study recruited 75 healthy women and randomly subdivided into three groups ($n = 25$): Kinesio Tape® (25% to 35% tension), Kinesio Tape® without tension (no tension), and the control group (no taping application). The

tape was applied origin to insertion. The handgrip strength dynamometry measured the Kinesio Tape® group having an increase in handgrip strength after 30 minutes, 24 hours, and 48 hours of tape application compared to control. A statistically significant increase ($P < .05$) in strength was observed in the Kinesio group comparison to the control group after 24 hours and 48 hours for the right hand, and after 48 hours for the left hand. This study confirmed the hypothesis that Kinesio Taping® can increase handgrip strength when applied with facilitation of flexor digitorum superficialis muscles.⁴⁷

Researchers have reported increase in electromyography activity with the use of Kinesio Tape®. Hsu et al¹⁶ concluded that lower trapezius isometric strength increased significantly after Kinesio Tex™ application on 17 baseball players with shoulder impingement. All subjects received two types of taping, a placebo taping and lower trapezius Kinesio Tex™ in a randomly assigned order. The two taping sessions were separated by at least three days to avoid accumulation of the taping effects. The Kinesio Tex™ was cut into a Y-shape and applied to envelope the lower trapezius muscle with minimal tension according to the recommendation of Kase. Although the researcher did not mention the direction of pull with the tape, their figure illustrates the anchor being placed on the insertion of the tape, therefore, inhibiting the lower trapezius. The placebo tape was a same-sized Y-shaped, 3 M Micropore tape applied over the same position without any stretch force. Muscle strength and muscle activity was measured with an 8-channel FM/FM Telematic EMG system and a hand-held dynamometer. The lower trapezius strength with Kinesio Tex™ increased 38.3 ± 9.9 lbs. ($P < .05$) when compared to the placebo taping group.¹⁶ Therefore, the lower trapezius isometric strength increased significantly after Kinesio Tex™ application.

Slupik et al¹⁷ examined 27 healthy individuals effect of Kinesio Taping® on changes in the tone of the vastus medialis muscle during isometric contraction after 10 minutes, 24 hours, 72 hours, and 94 hours of application. This study used a Y-shaped Kinesio Tape® by starting at the origin of the vastus medialis muscle, with the two tails following along the muscle border to end at the muscles insertion: patella, patella ligament, and medial retinacula of the patella. Once researchers applied active electrodes, the participant completed five repetitions of a cycle of tightening the muscle for three seconds followed

by three seconds of relaxation. They found significant effects ($P < .05$) in the increase of bioelectrical activity of the muscle after 24 hours and 48 hours.¹⁷

In contrast to Slupik et al¹⁷, Fu et al¹⁸ applied Kinesio Tape® to the anterior thigh in a Y-shape to examine the possible immediate and delayed effect of Kinesio Taping® on muscle strength in the hamstring and quadriceps by an isokinetic dynamometer. Fourteen healthy, young athletes were recruited and were assessed by an isokinetic dynamometer under three conditions: (1) without taping, (2) immediately after taping, and (3) 12 hours after taping with the tape. The results of the comparison of peak torque and total work revealed no significant interaction effect existed between conditions and assessments ($P > 0.05$). Discrepancies were observed in the results presented as the tape application did not follow Dr. Kase's guidelines when the tape was applied the portion between the origin and attachment was stretched to 120%.¹⁸ Therefore, it cannot be concluded that Kinesio Tape® does not have the ability to alter peak torque and total work.

Isokinetic quadriceps strength and functional performance with facilitation and inhibition Kinesio Tape® in 36 healthy adults was examined by Vercelli et al¹⁹ The researchers' had three different taping conditions: (1) Kinesio tape® method to facilitate, (2) Kinesio tape® method to inhibit, and (3) sham Kinesio Tape® application on the anterior thigh. The facilitation was reported as applied with 25%-50%, whereas the inhibition application was reported as applied with 15-25% tension of the Kinesio Tape®. However, the amount of tension during facilitation is incorrect according to Dr. Kase. Both facilitation taping and inhibition taping were applied in a Y-shape strip. The Sham application consisted of one I-shaped strip with no tension. Although the tape did not have tension, the Kinesio Tape® still provides sensory input.^{10,48} Researchers concluded that Kinesio Tape® had short-term effects on maximal muscle strength, but the results revealed there were no significant changes ($P > .05$) related to the type of Kinesio Tape® application.¹⁹ Although Vercelli et al¹⁹ determined Kinesio Tape® does not illicit an increase in muscle strength when the facilitation application is applied, the research was done with

improper tension. Moreover, the results of this study do not provide accurate conclusions on Kinesio Tape's® effect on muscle strength.

Chang et al⁴⁵ aimed to determine the effects of applied Kinesio taping on maximal grip strength of 21 healthy male athletes. They assessed maximal grip strength of the dominant hand wrist flexor muscles with a hand-held dynamometer with three conditions: (1) without taping, (2) with placebo taping, and (3) with Kinesio taping. The three taping conditions were assigned by using a random-number allocation with an interval of one week for each of the conditions. The Kinesio Tape® application was consistent with the protocol for medial epicondylitis of the elbow as suggested by Dr. Kase. Kinesio tape® was applied to the wrist flexor muscle, in a Y-strip applied from insertion to origin with a 15-20% tension. Results revealed no significant differences between the three conditions ($P = .936$).⁴⁵ However, the inhibition application of Kinesio Tape® is not suggested to increase strength because it produces a recoil in the opposite direction.¹⁰

The methodology and results of these studies have raised questions regarding the effect of the application direction of Kinesio Tape® as described by Kase et al¹¹ A systematic review evaluated the inhibition and facilitation Kinesio Tape® techniques. The review concluded that there were inconsistent studies reporting positive outcomes for muscle strength.⁴⁴ Websites discussing Kinesio Tape® are predominantly of poor quality and inappropriately highlight only positive results without any mention of negative data.⁴⁹ A systematic review of the existing literature by Mostafavifar et al⁵⁰ reported that there are few articles of good quality investigating Kinesio Tape® but overall there is insufficient evidence to support its use for treating musculoskeletal injuries. Other meta-analyses reached similar conclusions stating that there is no clear evidence for the effectiveness on the use of Kinesio Tape® on a variety of movement disorders or as an alternative instead of other therapeutic modalities.⁵¹⁻⁵³ The articles concluded that the number of high-quality, consistent studies available is limited, and warrants further research with higher levels of evidence, larger sample sizes, control groups, randomized control trials, and longer follow-up times to show the effect of Kinesio Tape®.⁵⁰⁻⁵³

The lack of consistency of Kinesio Tape® applications seems to be due to various research models, taping methods, subject samples, and testing procedures throughout the studies. Some authors evaluated the influence of Kinesio Taping® immediately after its application^{18,19,45}, as well as after 12 hours up to 72 hours of taping.^{17,47} In addition, most of the studies applied the tape to only one of the following muscles: the upper trapezius, the lower trapezius, the supraspinatus, the deltoid, or the pectoralis minor. Other studies used two or three taping application techniques applied to various groupings of muscles without consistency. Furthermore, some authors do not specify the tension as it was applied to the various muscles, so the Kinesio Tapes® tension cannot be factored into the final analysis. This is an omission of a key consideration because even without tension, the Kinesio Tape® will elicit stimulus and some effects might be apparent.^{43,46} The amount of variables and designs does not allow data to be compared. Most studies simply do not follow the general standards recommended by the Kinesio Taping Association International⁴⁸ and by Dr. Kase.^{10,11} Further, no research was found using diagnostic ultrasound to provide additional objective, quantitative data of the usage of the Kinesio Tape Method® of facilitation and inhibition.

2.3. Diagnostic Ultrasound

2.3.1. Definition

Diagnostic ultrasound is an imaging method which uses a transducer that contains a crystal sound head. This transducer creates sound waves that interact with soft tissues to produce an image.¹² A transducer determines the imaging plane and structures that are imaged by being placed on the skin surface. When the diagnostic ultrasound conducts electrical signals to the transducer, it produces sound waves. With an aid of a water-based gel, the sound waves penetrate into soft tissues where they interact with musculoskeletal and bone interferences. Some of the waves are absorbed by the tissues, and the extent to which the ultrasound is absorbed or is reflected gives information about the structures scanned.^{12,54}

Depending on what structure the clinician is trying to observe, the most useful frequency ranges for the diagnostic ultrasound transducer is between 7 MHz and 12 MHz.⁵⁴ The choice of transducer depends on the size and location of the desired image structure. Linear transducers are used with high-frequency settings that have a higher resolution imaging but poor tissue penetrance making them ideal for small, superficial structures. On the other hand, low-frequency transducers (<7.5 MHz) have poor resolution but high tissue penetrance that are preferable for larger, deeper structures. Interpretation of ultrasound images depends on the echogenicity, or the brightness of the picture. The echogenicity is dependent on the degree of reflection of the ultrasound waves.⁵⁴ When the surface of bone is shown by ultrasound it appears smooth and hyperechoic showing a high reflective pattern and appearing brighter than the surrounding tissue.⁵⁴⁻⁵⁶

2.3.2. Application

Compared to other imaging modalities, diagnostic ultrasound has the unique advantage to allow for a dynamic evaluation of musculoskeletal structures.⁵⁷ This imaging technique is attractive regarding its noninvasiveness, lack of radiation, readiness of use, cost-effectiveness, side by side comparison, and production of images in real time.^{54,57} The possibility of measuring joint space with diagnostic ultrasound is high because of its ability to assess bone circumference.⁵⁸ Diagnostic ultrasound is primarily used to assist physicians with injections into a joint.¹² In addition to measuring joint space, diagnostic ultrasound is also useful in differentiating full thickness from partial thickness tendon tears, muscle tears, and tendon and nerve subluxations or dislocations.⁵⁴ With diagnostic ultrasound, small structures and superficial structures can easily be identified and abnormalities can be diagnosed with confidence.⁵⁶

De Jesus et al⁵⁹ conducted a meta-analysis that provided a comparison of the diagnostic accuracy of MRI, MR arthrography, and ultrasound for the diagnosis of rotator cuff tears. Summary statistics were generated from 65 articles and two approaches were utilized for the analysis of the diagnostic tests. Researchers pooled data from the studies to obtain overall sensitivities and specificities then compared the two using the chi-square test. They also used the approach using regression to construct receiver

operating characteristics (ROC) curves for each technique and then computed a z-test to compare the points of the curve where sensitivity equals specificity. This demonstrated that the area under the ROC curve is greatest for MR arthrography (0.935), followed by ultrasound (0.889) and then MRI (0.878). However, pairwise comparisons of these curves show no significant differences between MRI and ultrasound ($P > .05$). Therefore, while MR arthrography is the most sensitive and specific technique for diagnosing both full and partial thickness rotator cuff tears, diagnostic ultrasound and MRI are comparable in both sensitivity and specificity and less invasive.⁵⁹

Diagnostic ultrasound has research and clinical practice limitations. One limitation is the inability of the beam to penetrate beyond bone cortex. Although ultrasound can evaluate some aspects of joint cartilage, MRI offers a more comprehensive evaluation of those structures. In addition, MRI is considered the best imaging test of choice for other intra-articular structures such as an anterior (ACL) and posterior (PCL) cruciate ligament in the knee.⁵⁵ This diagnostic tool lacks uniformity because of the dynamic nature of musculoskeletal examinations. The mobile nature of joints gives rise to unlimited permutations in image variations. This is best illustrated by ultrasound examination of the rotator cuff in the shoulder, where clinical accuracy is highly dependent on the scanning technique and ability.⁵⁴

Two radiologists independently and prospectively scanned 65 patients with clinical suspicion of rotator cuff lesion and then used an MRI for a reference standard.⁶⁰ The two sonographic operators were in agreement about full-thickness rotator cuff tears ($\kappa = 0.90$), supraspinatus tendinosis ($\kappa = 0.80$), abnormalities of the long head of biceps tendon ($\kappa = 0.84$), subacromial bursa abnormalities ($\kappa = 0.89$), and acromioclavicular osteoarthritis ($\kappa = 0.81$). The agreement was only moderate for partial-thickness tears ($\kappa = 0.63$) and intratendinous tears ($\kappa = 0.57$). Their results support that in moderately experienced professionals, the usage of sonography has a high to moderate level of inter-observer variability for full-thickness rotator cuff tears. Considering partial-thickness and intratendinous rotator cuff tears, their data suggests that inter-observer variability is higher.⁶⁰

2.3.3. Diagnostic Ultrasound on Shoulders

There is little research using diagnostic ultrasound as an evaluative tool to measure bony prominence locations in the shoulder as a majority of the studies are focused on the soft tissue structures in the shoulder.⁵⁴ The most common shoulder disorders assessed by diagnostic ultrasound are represented by abnormalities of rotator cuff and long head biceps tendon, lesions of glenohumeral and acromioclavicular joints, and pathological conditions of other soft-tissue structures of the shoulder girdle. The implementation of ultrasound guided interventional procedures and monitoring of therapeutic response are of significant importance and usefulness.⁶¹

To assess the intra-rater and inter-rater reliability of real time ultrasound scanning Bdaiwi et al⁶² measured static humeral head positions. Twenty healthy subjects were examined with the Mylab 60 Esaote diagnostic ultrasound model while positioned in five different positions. The examiner standardized the ultrasound probe on the anterior, posterior, and superior aspects of the shoulder to capture images of the most anterior aspect of the humerus and coracoid process, the most posterior aspect of the humerus and posterior glenoid, and the most superior aspect of the humerus and acromion process for each position. Images were captured in one session by one rater to assess test-retest reliability and image analyses were done by two raters to assess inter-tester reliability of image analysis. Intra-rater and inter-rater reliability were quantified by using the intra-class correlation coefficient and standard error of measurement. The intra-rater reliability for all positions was found to be excellent for all tests ranged from 0.83 to 0.99 respectively. The inter-rater reliability between examiners was found to be good to excellent for all test positions ranging from 0.66 to 0.98. There were no differences between measurements for the dominant and non-dominant side in anterior, posterior, or superior ultrasound views in various arm positions. Therefore, this study demonstrates that real-time ultrasound scanning is a reliable method of assessing the location of the humeral head in a number of glenohumeral joint positions in healthy subjects when measured by the same examiner.⁶²

Diagnostic ultrasound is not typically used for the evaluation of patients with glenohumeral joint instability. However, a scanning technique for documenting the presence, direction, and extent of glenohumeral translation has been described in patients with posterior shoulder subluxation or dislocation.^{63,64} With the examiner standing behind the patient, transverse scans are obtained over the posterior glenohumeral joint to measure the distance between the dorsal rim of the bony glenoid and the tip of the humeral head. The measured glenohumeral distances were compared with the affected shoulder and asymptomatic shoulder indicating that differences greater than 20mm indicate dislocation, whereas differences of 12 mm to 18 mm indicate subluxation.⁶³

Kumar et al⁶⁴ determined portable diagnostic ultrasound is a quick and reliable method of assessing acromion to greater tuberosity distance in healthy individuals when measured by the same examiner. Inferior shoulder subluxation is assessed by a palpable increase in the distance between the acromion and the head of the humerus but has been criticized for its subjectivity and insensitivity and requires a more objective clinical assessment tool to diagnose shoulder subluxation. Researchers used a portable diagnostic ultrasound machine to measure the distance between the acromion and greater tuberosity and tested the intra-rater reliability in healthy individuals. Thirty-two healthy participants aged 51-85 years were recruited. Each participant was asked to perform a few arm movements to establish the range of motion was equal bilaterally and pain free within normal parameters. Participants then sat upright in a chair in neutral rotation with the elbow at 90° of flexion and forearm in pronation. A portable diagnostic ultrasound TITAL model with a 10-5MHz linear array transducer was used for scanning the shoulder. Seated participants were scanned by a physiotherapist trained in shoulder ultrasound. The lateral border of the acromion was palpated and the ultra-sonographic transducer head was placed on the acromion and along the longitudinal axis of the humerus. The reference points were identified and image was frozen to measure the distance of the lateral edge of the acromion process to the superior part of the greater tuberosity of the humerus. The researcher repeated the measurement five to ten minutes later and then switched to the contralateral side, performing four measurements on each

participant at a time. Measurements were recorded on day one and again within two weeks with the same procedure. Reliability was assessed by intra-class correlation coefficients. The mean distance was 1.68 ± 0.41 cm for the left and 1.78 ± 0.40 cm for the right shoulder. There was excellent within-day (ICC = 0.97-0.99) and day-to-day intra-class correlation (ICC = 0.96-0.97) between repeated shoulder measurements. Therefore, portable diagnostic ultrasound provides a reliable method of assessing the acromion to the greater tuberosity distance in healthy individuals.⁶⁴

Diagnostic ultrasound is most commonly used for guided injections but the uses to observe bony abnormalities, analyzing the structure of a musculoskeletal tissue, and analyzing the fluid within the structure continue to be explored. If clinicians were able to have a quantifiable measurement of the bony prominence of the glenohumeral head in relation to the acromion, the understanding of the occurrence of forward scapular positioning may be more accurate and possibly better treated.

2.4. Conclusion

Based on the literature reviewed, there are published articles regarding the clinical use of Kinesio Tape® to facilitate and inhibit a muscle. Though few researchers have examined a different tape application on shoulders and posture, there has been no published research on Kinesio Tape® inhibition and facilitation usage on forward shoulder posture. Future research is warranted to determine if a correlation between Kinesio Tape's® effects on forward shoulder posture is observed and quantified by diagnostic ultrasound. Due to the nature of the indications of Kinesio Tape® and growing usage of diagnostic ultrasound, many professionals in the health field overlook the combination of the two in the treatment and correction of forward shoulder posture. Therefore, it is necessary for research to be continued in order to advance the quantitative measurements of Kinesio Tape® to help support research of the usage of diagnostic ultrasound specific to Kinesio Tape® techniques.

CHAPTER 3. METHODOLOGY

The purpose of this study was to determine if Kinesio Tape® Methods of inhibition of the pectoralis minor, facilitation of the lower trapezius, or combination of both taping techniques decreased forward shoulder posture when measured and quantified by diagnostic ultrasound. This study was guided by the following research questions:

Q₁: Does the Kinesio Tape® inhibition of the pectoralis minor create a statistically significant measurement of the lesser tubercle of the glenohumeral head in relation to the coracoid process in individuals who suffers from forward shoulder posture?

Q₂: Will the facilitation method of the lower fibers of the trapezius create a statistically significant measurement of the lesser tubercle of the glenohumeral head in relation to the coracoid process in individuals who suffer from forward shoulder posture?

Q₃: Will the combination of the inhibition of the pectoralis minor and facilitation of the lower fibers of the trapezius produce a statistically significant decrease in forward shoulder posture in individuals who suffer from forward shoulder posture?

3.1. Participants

Participants for this study included 15 males and 15 females (n=30) between the ages of 18 and 50. Each participant must have had forward shoulder posture as determined by two certified athletic trainers each with no less than five years of clinical experience. Participants were recruited from a convenience sample via email listserv and word-of-mouth at North Dakota State University and the local Fargo-Moorhead regions. Exclusion criteria for this study included: (1) past shoulder surgery on the dominant arm; (2) non-surgical shoulder injury in the past 12 months on the dominant arm; (3) prior history of general medical conditions involving joints, muscles, bones or connective tissue such as fibromyalgia, osteoporosis, etc., (4) reported allergies to Kinesio Tex Tape® or any other adhesive material, and (5) any contraindications for the usage of Kinesio Tape®. All participants were

compensated for their participation and time. Each participant received \$20 for the successful completion of the study. If a participant had to be dismissed due to not fulfilling the inclusion criteria of having forward shoulder posture, they were entered into a raffle for a compensation of \$5. Informed written and verbal consent were obtained from each participant before enrollment and baseline demographic and clinical data was collected by the PAR-Q.

3.2. Setting

This study took place in a dedicated Athletic Training Laboratory in the Bentson Bunker Fieldhouse on the North Dakota State University Campus, room 14, 1301 Centennial Blvd. Fargo, ND 58108. The Athletic Training Laboratory is the best place for the study to occur because the equipment necessary for this study was stored in this location. Participants also had easy access to the building as they are recruited from the local surrounding area.

3.3. Equipment

Diagnostic ultrasound is primarily used as a noninvasive production of images of skeletal and soft tissue structures.^{54,57} The diagnostic ultrasound unit for this study was the Terason 3200. The Terason 3200 has three different frequency settings (high to low) but does not specify the amount of MHz with each setting. Depending on the musculoskeletal depth of the individual, a high or medium frequency was used to produce the clearest image. The Terason 3200 unit is readily available for research at North Dakota State University.

The original Kinesio Tex Classic Tape® was used to either facilitate and/or inhibit a muscle depending on a random-number allocation grouping. This tape is a polymer elastic strand wrapped by 100% cotton fibers that is approximately the same thickness as the epidermis of the skin. It is latex-free tape and is heat activated.¹¹ Depending on the percentage of stretch applied to the tape during the application, Kase et al^{10,11} has proposed several benefits of Kinesio Tape® including providing positional stimulus, creating more space, assisting or limiting range of motion, aligning fascial tissues, and decreasing edema. There are six primary application techniques for the administration of Kinesio Tape®.

For the purpose of this research, the method of muscle facilitation and inhibition will be used.^{11,21} Kinesio Tape's® elastic qualities allow for optimal recoiling to allow for facilitation and inhibition of a muscle.^{10,11} To inhibit muscle function, the tape is applied from insertion to origin with a 15-25% tension. To facilitate muscle function, the tape is applied origin to insertion with a 15-35% stretch.¹¹

3.4. Procedures

Prior to data collection, this research project was approved by the North Dakota State University Institutional Review Board (IRB). Research was conducted in the summer of 2016 in room 14 of the Bentson Bunker Fieldhouse on the NDSU campus. Upon arrival of the participants to the lab, each individual signed necessary paperwork including the Informed Consent and PAR-Q.

To determine a participant's inclusion in the study, each participant must have had forward shoulder posture as determined by two certified athletic trainers, each with more than five years of clinical experience. While there are many documented techniques, the modified Sahrman technique is the only clinically applicable technique to establish the presence of forward shoulder posture with quantitative data.^{1,25,39-42} The participant was positioned supine on an examination table with their arms by their sides and elbow flexed and rested against the lateral wall of the abdomen. The investigator measured the height from the examination table to the posterior aspect of the lateral acromion process. According to Sahrman, a measurement of greater than or equal to 2.54 cm indicates forward shoulder posture. Therefore, if the certified athletic trainer found this measurement they determined the participant has forward shoulder posture.³⁹

Determination of a participant's forward shoulder posture was blinded as each athletic trainer was not allowed to converse their findings with one another. One at a time, each athletic trainer documented a "yes" or a "no" corresponding to each participants' assigned number. The findings from both certified athletic trainers had to be similar with respect to each participants' forward shoulder posture, and consequently, be included in the study. If either one of the certified athletic trainers

documented a “no” finding, an individual was not included for further participation in this study. At this point, a participant was dismissed from the study and entered into a raffle to receive \$5 compensation.

Following determination of forward shoulder posture confirmed by two certified athletic trainers, the primary investigator for this project trained in diagnostic ultrasound, obtained baseline data of humeral head location. Participants were instructed to sit on the edge of a treatment table with the arm hanging at the side. The most superior aspect of the humeral head was palpated. Then marks were placed where the ultrasound probe should be placed so that the humeral head location can be premeasured with greater ease and accuracy. The ultrasound transducer was placed in a sagittal position over the anterior shoulder specifically over the lesser tubercle of the glenohumeral head bony prominence of the dominant shoulder. Once the humeral head was observed, the screen was frozen and the distance between the coracoid process and the lesser tubercle of the humeral head was measured.^{54,62} To evaluate the inter-rater reliability of the ultrasound measurement prior to and post Kinesio Tape® application, an examiner with six years of training and experience in diagnostic ultrasound confirmed the measurements.

The Kinesio Tape® facilitation and inhibition mechanical correction, as described in published Kinesio Tape® manuals^{10,11,48}, was applied to the clean skin of the patient by a Certified Kinesio Tape® Practitioner (CKTP). Skin was cleaned using an alcohol preparation pad and excess hair was trimmed. The participants (n=30) were given random-number allocations into one of three groups for the application of the Kinesio Tape®: (1) inhibition of the pectoralis minor; (2) facilitation of the lower trapezius; or (3) application of both the inhibition of the pectoralis minor and the facilitation of the lower trapezius. Each group had the same number of males and females (n=5 of each gender).

The Kinesio tape® paper will be torn back from the tape to create an anchor and was applied without tension. For the application of the inhibition of the pectoralis minor, the tape was anchored in a Y-strip without tension on the insertion site of the anterior surface of the coracoid process of the scapula.^{13,48} The patient was positioned in 90° shoulder flexion, horizontal abduction and external

rotation with slight elbow flexion for the application of the superior tail. For the inferior tail, the patient was repositioned with 110-135° shoulder flexion with external rotation and full horizontal abduction. Then the Kinesio Tape® was pulled with a tension of 15-25% and ending without tension on the origin of pectoralis minor, the superior margins of the outer surfaces of the third, fourth, and fifth ribs near the cartilage (Figure 5).¹³ Once the tape was applied, the tape was rubbed vigorously to activate the adhesive with friction heat.^{10,11}



Figure 5. Application of Kinesio Tape® Inhibiting Pectoralis Minor

For the facilitation of the lower trapezius, the tape was in a Y-strip with the tails splayed with no tension on the origin of the muscle, spinous processes of the T6 to T12 vertebrae.¹³ The participant then was positioned into scapular decompression, external rotation and trunk lateral flexion by having the participant hug themselves and then bend forward to the side to place the tissue on a stretch.⁴⁸ The Kinesio Tape® was pulled with a 15-35% tension, and the tails will be anchored to tubercles of the apex of the scapular spine where the lower fibers of the trapezius insert (Figure 6).¹³ Once the tape was applied, the tape should be rubbed vigorously to activate the adhesive with friction heat.^{10,11}



Figure 6. Application of Kinesio Tape® Facilitating Lower Trapezius.

All 30 participants were asked to wear the Kinesio Tape® application assigned to them for a time frame of 24 hours as they perform at normal activity levels. Participants were asked to refrain from vigorous activity (e.g. weight lifting); however, participants were encouraged to perform all activities of daily living. The participants were given an instruction sheet that informed them on the contraindications and precautions of wearing the tape (Appendix A). If any discomfort or skin irritation occurs, participants removed the tape immediately.⁴⁸ Moreover, if the tape application needed to be removed due to a contraindication or negative reaction, that participant was excluded from the remainder of the assessment. Any complications from the tape were immediately reported to Dr. Katie Lyman as outlined by the Informed Consent and take-home instructions. Dr. Katie Lyman reported any issues to the NDSU IRB.

All remaining participants returned to the laboratory 24 hours later to have the tape application removed and have the humeral head location re-measured using diagnostic ultrasound. The Kinesio Tape® application was removed before re-measuring the humeral head relation to the acromion process to determine if after 24 hours the tape had a lasting effect on the shoulder posture. Each participant had the tape removed for exactly two minutes prior to the post measurements. In addition, the participants

were re-evaluated for forward shoulder posture using a modified Sahrmann following the same procedure as before. Both certified athletic trainers who determined forward shoulder posture for the inclusion were utilized for the follow up assessment as well. If the two certified athletic trainers disagreed on determining if a participant still has forward shoulder posture, another experienced certified athletic trainer was utilized to evaluate forward shoulder posture to resolve incongruity.

3.5. Data Analysis

Statistical analysis for the approved research was computed using SPSS software (Version 23.0). Two-way repeated measures ANOVA with a significance of $P < .05$ was conducted in order to compare the mean differences between the type of tape application and the inclusion of gender. Post hoc statistical significance was determined by Tukey's honestly significant difference (HSD) test.

3.6. Conclusion

The purpose of this study was to analyze the relationship between Kinesio tape® application and forward shoulder posture. Diagnostic ultrasound was used to measure bony landmarks to quantify the forward shoulder posture before and after application of the Kinesio Tape®. This prospective research was used to determine the effect of Kinesio Tape® on forward shoulder posture in order to improve treatment and decrease pathologic injuries that occurs secondary to forward shoulder posture.

CHAPTER 4. MANUSCRIPT

4.1. Abstract

Allied health care professionals are faced with numerous options when attempting to care for athletic injuries. Since the bright, colorful tape, Kinesio® Tape, made its international debut, athletic trainers and health care professionals have been applying it in order to reduce pain and increase performance without evidence it makes a positive impact on anatomical structures. The purpose of this research was to evaluate the effects of three Kinesio Taping Methods® on postural alterations common in overhead athletes. A randomized pre-/post-test study included thirty adults who were determined to have Forward Shoulder Posture (FSP). A baseline measurement of the humeral head location was obtained using diagnostic ultrasound. Based on randomized group assignment, participants were taped following Kinesio® Tape guidelines in one of three conditions: (1) inhibition of the pectoralis minor; (2) facilitation of the lower trapezius; and (3) a combination of both techniques resulting in the inhibition of the pectoralis minor and facilitation of the lower trapezius. Participants wore the respective taping technique for 24 hours and were re-measured without tape, each participant serving as his/her control. The position of the anterior humerus did not change after Kinesio® Tape had been worn for 24 hours. The overall effect between each taping technique was not statistically significant ($P > .05$). Participants who met the inclusion criteria of FSP did not have a statistically significant effect after wearing the respective Kinesio® Tape application. Health care professionals should consider individual differences in anatomy as well as injury before arbitrarily applying Kinesio® Tape in hopes that it will alleviate pain or reduce injury.

Key words: posture; shoulder injuries; Kinesio® Tape; diagnostic ultrasound

4.2. Introduction

Athletic trainers have long relied on various types of athletic tape to protect athletes' injuries and keep them in competition. Nevertheless, it has been debated by experts on the benefits of applying traditional athletic tape to injured muscles.⁵¹ Kinesio® Tape made its international debut during the 2008 Olympics and continues to make headlines as many high-profile athletes showcase the tape for various musculoskeletal conditions.⁶⁵ Kinesio® Tape, unlike traditional white tape, allows joints to perform full range of motion.^{10,11} Thus, Kinesio Taping® methods have increased in popularity because athletes report an increased capacity to perform functional, overhead movements.

Athletes who participate in overhead sporting events typically perform motions which cause muscles in the front of the shoulder to contract. Frontal, overhead activities, such as throwing, cause muscles on the anterior aspect of the shoulder complex to pull on the scapula causing humeral head rotation and ultimately a postural condition known as Forward Shoulder Posture (FSP). This posture is characterized by a protracted, downwardly rotated, and anteriorly tipped scapular position with increased cervical lordosis and upper thoracic kyphosis.^{1,11} FSP is a common postural alteration which can alter shoulder movements and can produce shoulder and back muscle imbalances.^{1,3} The chronic postural alteration has been linked to secondary shoulder injuries such as subacromial impingement, bicep tendonitis, rotator cuff pathology, and glenohumeral joint instability.⁶⁶ As health care professionals are aware, athletes who suffer from chronic shoulder injuries are at risk for pain and decreased performance potentially removing the athlete from competition.

Past research confirms that FSP is associated with a tight pectoralis minor and weakness of the lower trapezius.⁷⁻⁹ The associated pathomechanics of the muscle imbalance can lead to alterations in throwing, swimming, spiking, and other overhead activity mechanics. Although a few Kinesio® Tape studies have been shown to inhibit tight muscles¹⁶ and facilitate weak muscles¹⁷, no research has been conducted studying the effects of the tape on individuals suffering from FSP. Furthermore, little to no research has been directed on the usage of diagnostic ultrasound to determine the effectiveness of

Kinesio Tape®. Diagnostic ultrasound is a non-invasive technique to observe and analyze musculoskeletal structures, bony prominences and fluid within the structure in real time.^{54,62} While there are common anatomical landmarks referenced in the literature, there appears to be no exact measurements for forward shoulder posture. Therefore, using diagnostic ultrasound to observe FSP can provide a quantifiable measurement of the effectiveness of Kinesio Tape® on forward shoulder posture.

The primary purpose of this project was to investigate the effects of Kinesio® Tape on Forward Shoulder Posture (FSP). In order to measure the potential changes in FSP, 30 individuals were randomized into one of three groups: (1) inhibition of the pectoralis minor; (2) facilitation of the lower trapezius; and (3) combination of the two techniques. This research is one of the few existing pieces of original research utilizing Kinesio® Tape which required an inclusion criteria of unhealthy tissue^{22,23,37}, i.e., FSP, as determined by two allied health care practitioners. Researching quantifiable evidence about the effectiveness of Kinesio Taping Methods® will allow athletic trainers to make informed decisions regarding the use of tape for their overhead athletes.

4.3. Methods

4.3.1. Participants

Volunteer participants were recruited from a large United States university whose Institutional Review Board approved the research protocol. The sample consisted of 30 participants (15 males, 15 females) who ranged in age from 18 to 50 ($M=23.5$, $SD=5.036$). Inclusion criteria for this study were that participants had FSP as determined by two certified athletic trainers (ATC) with more than 10 years of clinical experience. Participants were excluded from the study if they had past shoulder surgery on their non-dominant arm, a non-surgical shoulder injury within the last year, or any contraindication to Kinesio Tape®.

4.3.2. Procedures

Because of muscle contraction requirements of overhead athletes, clinical evaluation of FSP is crucial to minimizing potential secondary shoulder injuries.⁴ FSP was diagnosed by two certified athletic

trainers, each with more than 10 years of clinical experience. While there are many documented techniques using a variety of equipment for determining the degree of forward shoulder posture, the modified Sahrman technique is the only clinically applicable technique to establish the presence of forward shoulder posture with quantitative data.^{1,25,39-42} The participant was positioned supine on an examination table with their arms by their sides and elbow flexed and rested against the lateral wall of the abdomen. The investigator measured the height from the examination table to the posterior aspect of the lateral acromion process. According to Sahrman, a measurement of greater than or equal to 2.54 cm indicates forward shoulder posture. Therefore, if the certified athletic trainer obtained a measurement greater than or equal to 2.54cm, the athletic trainer documented the findings and participants were included in the research protocol.³⁹

Following clinical determination of FSP, the primary investigator for this project obtained objective data of humeral head location through the use of a diagnostic ultrasound unit called the Terason 3200. Participants were instructed to sit on the edge of a treatment table with the arm hanging at the side. The most superior aspect of the humeral head was palpated. The ultrasound transducer was placed in a sagittal position over the anterior shoulder specifically over the lesser tubercle of the glenohumeral head bony prominence of the dominant shoulder. Once the humeral head was observed, the screen was frozen and the distance between the coracoid process and the lesser tubercle of the humeral head was measured.^{54,62} To evaluate the inter-rater reliability of the ultrasound measurement prior to and post Kinesio Tape® application, an examiner with six years of training and experience in diagnostic ultrasound confirmed the measurements.

Participants (n=30) were given random-number allocations into one of three groups for the application of the Kinesio® Tape: (1) inhibition of the pectoralis minor; (2) facilitation of the lower trapezius; or (3) application of both the inhibition of the pectoralis minor and the facilitation of the lower trapezius. Each group had the same number of males and females.

The Kinesio® Tape paper was torn back from the tape to create an anchor and was applied without tension. For the application of the inhibition of the pectoralis minor, the tape was anchored in a Y-strip without tension on the insertion site of the anterior surface of the coracoid process of the scapula.^{13,48} The patient was positioned in 90° shoulder flexion, horizontal abduction and external rotation with slight elbow flexion for the application of the superior tail. For the inferior tail, the patient was repositioned with 110-135° shoulder flexion with external rotation and full horizontal abduction. Kinesio® Tape was pulled with a tension of 15-25%¹¹ and ending without tension on the origin of pectoralis minor: superior margins of the outer surfaces of the third, fourth, and fifth ribs near the cartilage¹³ (Figure 7).



Figure 7. Application of Kinesio Tape® Inhibiting Pectoralis Minor

For the facilitation of the lower trapezius, the tape was in a Y-strip with the tails splayed with no tension on the origin of the muscle, spinous processes of the T6 to T12 vertebrae.¹³ The participants were positioned into scapular decompression, external rotation and trunk lateral flexion by having the participant hug themselves and then bend forward to the side to place the tissue on a stretch. Kinesio® Tape was pulled with a 15-35% tension¹¹, and the tails were anchored to tubercles of the apex of the scapular spine where the lower fibers of the trapezius insert (Figure 8).



Figure 8. Application of Kinesio Tape® Facilitating Lower Trapezius.

All participants were asked to wear the Kinesio® Tape application assigned to them for 24 hours as they performed normal activities. Participants were asked to refrain from vigorous activity (e.g. weight lifting); however, participants were encouraged to perform all activities of daily living (ADL). All participants (n=30) returned to the laboratory 24 hours later to have the tape application removed. In nine cases, there were concerns regarding peeling of the tape. Following tape removal, participants waited two minutes and then were re-measured using diagnostic ultrasound.

4.3.3. Statistical Analysis

The data were analyzed using a two-way repeated measure ANOVA in order to compare the mean differences between the type of tape application and the inclusion of gender. Post hoc statistical significance was determined by Tukey's honestly significant difference (HSD) test.

4.4. Results

Descriptive statistics for the current research are displayed in Table 2. Descriptive statistics indicate that the greatest decrease in forward shoulder posture occurred when both taping techniques were employed, with a mean difference of 0.237 cm (SD=0.493). The decrease of the forward shoulder posture for the facilitation taping method was 0.054 cm (SD=0.401) and the inhibition taping technique

was 0.045 cm (SD=0.530). The overall effect between each taping technique was not statistically significant ($P > .05$). Furthermore, the main effect due to each taping technique was also not statistically significant ($P > .05$).

Table 2. Descriptive Statistics for Repeated Measures ANOVA

Tape	Gender	Mean	Std. Deviation	N
Facilitate	Female	-.1080	.29012	5
	Male	.0000	.73485	5
	Total	-.0540	.52976	10
Inhibit	Female	-.0660	.56756	5
	Male	-.0240	.24131	5
	Total	-.0450	.41175	10
Both	Female	-.0500	.41298	5
	Male	-.4240	.40765	5
	Total	-.2370	.43418	10
Total	Female	-.0747	.40676	15
	Male	-.1493	.50884	15
	Total	-.1120	.45422	30

* Dependent Variable: Outcome of pre and post DUS measurements

Tukey's HSD tests also revealed no statistically significant differences between genders. While wearing the tape application, males consistently had a decreased shoulder posture with inhibition of the pectoralis minor ($P = .412$), facilitation of the lower trapezius ($P = .436$) at a higher capacity than females. However, females had more increased shoulder posture when both taping techniques were combined ($P = 0.386$) when compared to males. For each taping application gender differences was not statistically significant. These results were similar to the conclusions made in past reports.

4.5. Discussion

Forward Shoulder Posture (FSP) predisposes overhead athletes to secondary shoulder pathomechanics and potential injury due to unique musculoskeletal contraction to execute sport-specific demands.^{4,66} Though quantitative research is limited regarding the use of Kinesio® Tape, specifically with

the facilitation and inhibition application methods, the findings of this study do not support the use of Kinesio® Tape to decrease FSP. Therefore, athletic trainers should be cautious of incorporating Kinesio® Tape techniques for athletes who suffer from FSP without a full assessment of the individual cause of the postural alteration.

Although the anatomical area differs, similar results by Fu et al,¹⁸ indicate that a facilitation of the quadriceps muscles do not change immediate or delayed muscle strength. Fourteen healthy athletes were recruited and assessed by an isokinetic dynamometer under three conditions: (1) without taping; (2) immediately after taping; and (3) 12 hours after taping with the tape. The results of the comparison of peak torque and total work revealed no significant interaction effect between conditions and assessments ($P > 0.05$). Correspondingly, Vercelli et al,¹⁹ investigated isokinetic quadriceps strength and functional performance with facilitation and inhibition with Kinesio® Tape applications in 36 healthy adults. The researchers' incorporated three different taping conditions: (1) facilitation; (2) inhibition; and (3) no-tension sham application on the anterior thigh. Researchers concluded Kinesio® Tape had short-term effects on maximal muscle strength, but the results revealed there were no significant differences ($P > .05$) related to the type of Kinesio® Tape application.¹⁹ Thus, the concept of direction of tape application, i.e., facilitation and inhibition, remains controversial and may not produce a clinical or true performance effect.

Health care professionals should be cognizant of the issue of poor methodology in research when considering the utilization of Kinesio® Tape for athletes. The previously mentioned studies both report findings that Kinesio Taping® facilitation and inhibition applications did not positively affect performance. However, there were discrepancies in the tape application. Previously mentioned studies did not follow the Kinesio Tape Association International (KTAI) taping guidelines.¹¹ For example, Fu et al,¹⁸ applied the tape application with 120% stretch rather than the correct tension of 15-35% for facilitation.¹¹ Similarly, Vercelli et al¹⁹ reported a facilitation with 25-50% tension. Likewise, Shakeri et al⁶⁷ applied a Y-strip facilitation with approximately 50% tension. Another study implemented 75% tension for muscle

facilitation.⁶⁸ Additionally, other research implemented the incorrect direction of Kinesio Tape® for the desired goal. Chang et al⁴⁵ found no significant differences of Kinesio Tape® being applied to wrist flexors to determine the effects on maximal grip strength. Too often coaches, athletes, and parents rely on internet searches as the source for medical advice. Approved Kinesio Tape Methods® require an appropriate, individualized assessment by an allied health care professional followed by specific application procedures such as tension and direction of pull.

Although the results of this project suggest Kinesio® Tape does not significantly decrease FSP, every individual's musculoskeletal system is different and responds differently to treatment interventions. The inclusion criteria for the current study involved participants who clinically suffered from FSP; however, none of the participants reported pain due to the postural alteration. The skin's sensory input from the application of tape alters the motor-neuron output that innervates the skeletal muscle's activation allowing an alteration of pain receptors.⁴³ Therefore, future research should be conducted on athletes who suffer from FSP and also have corresponding shoulder or back pain.

4.6. Conclusion

Health care professionals aim to provide and employ evidence-based material regarding interventions which could provide treatment strategies for musculoskeletal injuries. Forward Shoulder Posture (FSP) is a common postural alteration which can alter the mechanics of overhead activities. The findings of the current research should be viewed as a pilot study and can guide other researchers to investigate taping options for overhead athletes. Athletic trainers and other allied health care professionals with training and certification in Kinesio® Tape should continue to expand their knowledge about pathomechanics and associated treatment interventions.

CHAPTER 5. DISCUSSION

The purpose of this study was to determine if Kinesio Tape® Methods of inhibition of the pectoralis minor, facilitation of the lower trapezius, or combination of both taping techniques decreases forward shoulder posture when measured and quantified by diagnostic ultrasound. Researchers used the following questions to guide the study:

Q₁: Does the Kinesio Tape® inhibition of the pectoralis minor create a statistically significant measurement of the lesser tubercle of the glenohumeral head in relation to the coracoid process in individuals who suffers from forward shoulder posture?

Q₂: Will the facilitation method of the lower fibers of the trapezius create a statistically significant measurement of the lesser tubercle of the glenohumeral head in relation to the coracoid process in individuals who suffer from forward shoulder posture?

Q₃: Will the combination of the inhibition of the pectoralis minor and facilitation of the lower fibers of the trapezius produce a statistically significant decrease in forward shoulder posture in individuals who suffer from forward shoulder posture?

Though quantitative research is limited regarding the use of Kinesio® Tape, specifically the facilitation and inhibition Kinesio Tape Method®, the statically insignificant findings of this research ($P > .05$) does not support the use of the facilitation and inhibition Kinesio Tape Method® to decrease forward shoulder posture.

5.1. Research Findings

The results were conducted on thirty participants with a mean age of 23.50 (SD=5.036). Descriptive statistics for the current research are displayed in Table 3. Descriptive statistics indicate that the greatest decrease in forward shoulder posture occurred when both taping techniques were employed, with a mean difference of 0.237 cm (SD=0.434). The overall effect between each taping technique was not statistically significant ($P > .05$). Furthermore, the main effect due to each taping technique was also

not statistically significant ($P > .05$). The decrease of the forward shoulder posture for the inhibition taping method was 0.045 cm (SD=0.412) and the facilitation taping technique was 0.054 cm (SD=0.530). Therefore, conclusion of research questions 1, 2 and 3 indicated no statistically significant findings.

Table 3. Descriptive Statistics for Repeated Measures ANOVA

Tape	Gender	Mean	Std. Deviation	N
Facilitate	Female	-.1080	.29012	5
	Male	.0000	.73485	5
	Total	-.0540	.52976	10
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Both	Female	-.0500	.41298	5
	Male	-.4240	.40765	5
	Total	-.2370	.43418	10
Total	Female	-.0747	.40676	15
	Male	-.1493	.50884	15
	Total	-.1120	.45422	30

* Dependent Variable: Outcome of pre and post DUS measurements

Tukey's HSD tests also revealed no statistically significant differences between genders. While wearing the tape application, males consistently had a decreased shoulder posture with inhibition of the pectoralis minor ($P = .412$), facilitation of the lower trapezius ($P = .436$) at a higher capacity than females. However, females had more increased shoulder posture when both taping techniques were combined ($P = 0.386$) when compared to males. For each taping application gender differences was not statistically significant. These results were similar to the conclusions made in past reports.

Although the anatomical area differs, similar results by Fu et al¹⁸ indicate that a facilitation of the quadriceps muscles do not change immediate or delayed muscle strength. Fourteen healthy athletes were recruited and assessed by an isokinetic dynamometer under three conditions: (1) without taping; (2)

immediately after taping; and (3) 12 hours after taping with the tape. The results of the comparison of peak torque and total work revealed no significant interaction effect between conditions and assessments ($P > 0.05$). Correspondingly, Vercelli et al¹⁹ investigated isokinetic quadriceps strength and functional performance with facilitation and inhibition with Kinesio® Tape applications in 36 healthy adults. The researchers' incorporated three different taping conditions: (1) facilitation; (2) inhibition; and (3) no-tension sham application on the anterior thigh. Researchers concluded Kinesio® Tape had short-term effects on maximal muscle strength, but the results revealed there were no significant differences ($P > .05$) related to the type of Kinesio® Tape application.¹⁹ Similarly, Chang et al⁴⁵ aimed to determine the effects of applied Kinesio taping on maximal grip strength of 21 healthy male athletes by assessing grip strength of the dominant hand wrist flexor with three conditions: (1) without taping, (2) with placebo taping, and (3) with Kinesio taping. The three taping conditions were assigned by using a random-number allocation with an interval of one week for each of the conditions. The Kinesio Tape® application was consistent with the protocol for medial epicondylitis of the elbow as suggested by Dr. Kase. Kinesio tape® was applied to the wrist flexor muscle, in a Y-strip applied from insertion to origin with a 15-20% tension. Results revealed no significant differences between the three conditions ($P = .936$).⁴⁵ In addition, Firth et al⁶⁹ investigated the effect of Kinesio Tape® on hop distance, pain and motoneuronal excitability in 48 healthy participants and 24 participants with Achilles tendinopathy. Participants were taped with a continuous strip of Kinesio Tape® for the Achilles tendon that transitioned into facilitation over the gastrocnemius. The participant was placed in active dorsiflexion while the tape was tensioned at 50-75% over the Achilles tendon. At the musculotendinous junction between the Achilles tendon and gastrocnemius the tape was then applied with 15-25% tension. Researchers found no significant changes in hop distance ($P = .55$) and pain ($P = .74$) when tape was applied.⁶⁹ Thus, the concept of direction of tape application, i.e., facilitation and inhibition, remains controversial and may not produce a clinical or true performance effect.

The data analyzed using a repeated measure ANOVA with differences between the pre-and-post diagnostic ultrasound measurements as the between-subjects factor appears in Table 4. In nine cases, there were concerns regarding peeling tape. Therefore, the analysis was repeated with those cases removed. In no case did these additional tests alter the conclusions or implications of the study. Furthermore the smaller sample would possess less statistical power. Therefore, all results represented here utilize the full sample.

Table 4. Tests Between-Subjects Effects

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	.618 ^a	5	.124	.553	.735
Intercept	.376	1	.376	1.683	.207
Tape	.235	2	.117	.525	.598
Gender	.042	1	.042	.187	.669
Tape * Gender	.341	2	.171	.764	.477
Error	5.365	24	.224		
Total	6.359	30			
Corrected Total	5.983	29			

a. R Squared = .103 (Adjusted R Squared = -.084)

After an exhaustive review of the current literature, this is the first study to analyze a quantifiable effect of Kinesio Tape® on forward shoulder posture. Previous research has correlated the cause of forward shoulder posture being linked to a tight pectoralis minor and weak lower trapezius.⁷⁻⁹ Other research found a link between skeletal muscle strength and Kinesio Tape® application.^{18,19,45,47,65} However, no protocol was previous initiated to combine the two areas of research. The current study

revealed no significant findings that occur as a result of Kinesio Tape® being applied to an individual who suffers from forward shoulder posture. Therefore, the effect of Kinesio Tape® on shoulder posture to decrease predisposition of injury remains unclear. It is possible that the measurements observed during this study was caused by recruiting participants who had varying levels of forward shoulder posture and exhibited no pain or previous shoulder injuries; however, until research analyzes Kinesio Tape® on unhealthy tissue, the effect of the significant decrease in shoulder posture over an active lifestyle remains unknown.

5.2. Limitations

The limitations of this research study may affect the power of the results. First, there are variables associated with the application of Kinesio Tape® that may have caused unpredictable outcomes. The precise tension of the Kinesio Tape application was not measured. Although the application was applied by a Certified Kinesio Tape Practitioner, a varying amount of tension could affect the musculature and alter the measurement of forward shoulder posture. In addition, nine taping applications reported skewed data due to the tape peeling or causing skin irritation. Although the skin was prepared for the placement of the Kinesio Tape®, epidermis varies slightly between each individual. Therefore, without repeating each tape application on each individual, slight alteration in application can cause drastic changes in results.

Also, the Kinesio Tape® application was only worn for twenty-four hours between a pre- and post- measurement even though Kinesio Tape® claims its effects can last up to 72 hours.^{11,14,15} Without conducting several measurements over varying time periods, it was unclear if the insignificant changes in the degree of forward shoulder posture were due to the time period selected or if there would have been a decrease in forward shoulder posture had the tape been worn longer or shorter in duration.

In addition, this study relied on self-reported activity levels during the wearing of the Kinesio Tape®. Participants were instructed to refrain from vigorous activity (e.g. weight lifting); although, participants were encouraged to perform all activities of daily living. However, the normal activities of

their shoulder joint were not accounted for and each person may have interpreted no vigorous activity in different ways. Therefore, there may have been slight variability in reports of activity while wearing the Kinesio Tape® application.

Furthermore, Dr. Kenzo Kase suggests the proper taping technique for the treatment of forward shoulder posture needs to incorporate the facilitation of the upper trapezius.¹⁰ However, this study facilitated the lower trapezius rather than the upper trapezius due to the results of the literature review indicating more decompression and adduction of the scapula. Although the application direction differed between previous researches, all studies utilized a Kinesio Tape® in a Y shaped tape. Moreover, the origin remained the spinous process of the T6 to T12 vertebrae and the insertion was the tubercles of the apex of the scapular spine.¹³ Moreover, the participant position was consistent with Kase's recommendations to allow the Kinesio Tape® to be applied to lower trapezius tissue on a stretch.

Finally, to measure the amount of forward shoulder posture that was present, the distance between the humeral head and lesser tubercle was taken using musculoskeletal diagnostic ultrasound. However, there is no research which specifies these anatomical landmarks will accurately measure forward shoulder posture. Therefore, a future line of research should compare multiple types of diagnostic tools in order to accurately diagnose forward shoulder posture.

5.3. Future Research

Some individuals suffer from forward shoulder posture but do not report negative symptoms such as pain. Therefore, future research is needed to continue exploring the many factors associated with shoulder posture to prevent future injuries. In addition, the findings of this research could act as a catalyst for future research endeavors to create a protocol for measuring bony structural distances with diagnostic ultrasound, as well as standardize a measurement of forward shoulder posture. The limitations of this study, such as small sample size, should be addressed and modified for future research studies.

The most important aspect of this study that should be considered in future research is the inclusion criteria. While there are many documented techniques that use a variety of equipment to

determine the degree of forward shoulder posture, the modified Sahrman³⁹ technique is the only clinically applicable technique to establish the presence of forward shoulder posture with quantification. Every recruited individual was classified with forward shoulder posture due to this technique. However, clinically using non-quantifiable measurements such as a plumb line, would not have qualified this individual for this study. The large varying amount of forward shoulder posture between participants could have affected the outcome results. Future researchers should continue to standardize a measurement of forward shoulder posture. In addition, the inclusion criteria for study participants were those between the ages of 18 and 50 years old creating a large gap in population. Therefore, this study is not applicable to those outside of the age range such as individuals classified in the pediatric, adolescent, or geriatric categories. Furthermore, the inclusion criteria for the current study involved participants who clinically suffered from FSP; however, none of the participants reported pain due to the postural alteration. The skin's sensory input from the application of tape alters the motor-neuron output that innervates the skeletal muscle's activation allowing an alteration of pain receptors.⁴³ Therefore, future research should be conducted on athletes who suffer from FSP and also have corresponding shoulder or back pain.

In addition, despite the extensive literature review on Kinesio Tape®, there are varying discrepancies in the tape application that should continue to be examined. The previously mentioned studies conducted by Fu et al¹⁸, and Vercelli et al¹⁹ both report findings that Kinesio Taping® facilitation and inhibition applications did not positively affect performance. However, neither study followed the Kinesio Tape Association International (KTAI) taping guidelines.¹¹ For example, Fu et al¹⁸ applied the tape application with 120% stretch rather than the correct tension of 15-35% for facilitation.¹¹ Similarly, Vercelli et al¹⁹ reported facilitation with 25-50% tension. Likewise, Shakeri et al⁶⁷ applied a Y-strip facilitation with approximately 50% tension. Another study implemented 75% tension for muscle facilitation.⁶⁸ Additionally, other research implements the incorrect direction of Kinesio Tape® for the desired goal. Chang et al⁴⁵ found no significant differences of Kinesio Tape® being applied to wrist

flexors to determine the effects on maximal grip strength. However, the researchers utilized the direction of inhibition which does not improve strength because it causes a recoil in the opposite direction.¹⁰ Too often coaches, athletes, and parents rely on internet searches as the source for medical advice. Approved Kinesio Tape Methods® require an appropriate, individualized assessment by an allied health care professional followed by specific application procedures such as tension and direction of pull.

Finally, other predictor variables for forward scapular posture consist of serratus anterior and trapezius strength were not taken into account. The serratus anterior is a primary muscle involved in biomechanical scapular movements, specifically stabilizing the medial border and inferior angle of the scapula which prevents scapular anterior tilting.^{28,70} Weakness of the serratus anterior is often related to improper scapular anterior tilting and protraction.^{24,71,72} J. H. Lee et al²⁴ found a negative correlation ($r = -0.89, p = .000$) between the degree of forward scapular posture due to the pectoralis minor length, thoracic spine angle measurement, posterior shoulder tightness, and serratus anterior muscle strength when measured on 18 subjects with forward shoulder posture. There were high intra-rater reliabilities in all measurements: amount of forward scapular posture ($ICC_{3,2} = .90$), pectoralis minor length ($ICC_{3,2} = .96$), strength of the serratus anterior ($ICC_{3,2} = .90$), thoracic kyphosis angle ($ICC_{3,2} = .91$), glenohumeral horizontal adduction ($ICC_{3,2} = .90$), and glenohumeral internal rotation ($ICC_{3,2} = .95$). The adjusted coefficient of determination was 0.93. Thus with this experiment, the total explained variance in the forward scapular posture was 93% ($F = 29.42, p = .000$).²⁴ Therefore, the relationship between the amount of forward scapular posture is related to all predictor variables because of its high degree of concordance among researchers. The pectoralis minor length, glenohumeral horizontal adduction and glenohumeral internal rotation should be further considered while assessing, managing, and preventing forward scapular posture.

5.4. Conclusions

There are many complex factors associated with forward shoulder posture and Kinesio Tape®. Based on the results of this study, in conjunction with previous research, it is evident that Kinesio Tape®

on shoulder posture is complex and needs to be conducted in a thorough manner to provide accurate recommendations. Various studies have provided evidence on the leading cause to forward shoulder posture and the potential harm that could arise.^{2,4,6,36,40} Other studies have provided extensive amounts of Kinesio Tape® on various musculoskeletal conditions.^{8,16,37} In order for health care professionals to best treat the impacted functional activities associated with shoulder postural alteration, quantifiable research will need to continue.

The current research was an important addition to the evidence-based treatment intervention of Kinesio Tape®. To date, an extensive literature review revealed few published studies that specifically examined the quantitative research of the application of the inhibition and facilitation Kinesio Tape® methods. Understanding if the inhibition and facilitation Kinesio Tape Method® can be used as a treatment intervention for forward shoulder posture could benefit clinicians in treating the resting position of scapular protraction which limits scapular posterior tilt or external arm motion potentially predisposing patients to injuries.³ Furthermore, while there are common anatomical landmarks referenced in the literature, there appears to be no exact measurements for forward shoulder posture in literature. Therefore, this study's usage of diagnostic ultrasound to observe forward shoulder posture provided a quantifiable measurement of the effectiveness of Kinesio Tape® on forward shoulder posture.

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APPENDIX A. NORTH DAKOTA STATE UNIVERSITY INSTITUTIONAL REVIEW BOARD

APPROVAL



May 24, 2016

Dr. Katie Lyman
Department of Health, Nutrition & Exercise Sciences

IRB Approval of Protocol #HE16283, "The Effects of Kinesio Tape® on Forward Shoulder Posture as Observed and Quantified with Diagnostic Ultrasound"
Co-investigator(s) and research team: Taylor Ashcraft, Kara Gange, Mike Kjellerson

Approval period: 5/24/2016 to 5/23/2017
Continuing Review Report Due: 4/1/2017

Research site(s): NDSU Funding Agency: n/a
Review Type: Expedited category # 4
IRB approval is based on the revised protocol materials (received 5/23/2016).

Additional approval from the IRB is required:

- o Prior to implementation of any changes to the protocol (Protocol Amendment Request Form).
- o For continuation of the project beyond the approval period (Continuing Review/Completion Report Form). A reminder is typically sent approximately 4 weeks prior to the expiration date; timely submission of the report the responsibility of the PI. To avoid a lapse in approval, suspension of recruitment, and/or data collection, a report must be received, and the protocol reviewed and approved prior to the expiration date.

A report is required for:

- o Any research-related injuries, adverse events, or other unanticipated problems involving risks to participants or others within 72 hours of known occurrence (Report of Unanticipated Problem or Serious Adverse Event Form).
- o Any significant new findings that may affect risks to participants.
- o Closure of the project (Continuing Review/Completion Report Form).

Research records are subject to random or directed audits at any time to verify compliance with human subjects protection regulations and NDSU policies.

Thank you for cooperating with NDSU IRB procedures, and best wishes for a successful study.

Sincerely,

Digitally signed by Kristy Shirley
DN: cn=Kristy Shirley, o=NDSU,
ou=Institutional Review Board,
email=kristy.shirley@ndsu.edu, c=US
Date: 2016.05.24 14:24:08 -0500

Kristy Shirley, CIP, Research Compliance Administrator

For more information regarding IRB Office submissions and guidelines, please consult www.ndsu.edu/irb. This Institution has an approved FederalWide Assurance with the Department of Health and Human Services: FWA00002439.

INSTITUTIONAL REVIEW BOARD

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APPENDIX B. TAKE HOME INSTRUCTIONS

Kinesio Tape®

What is Kinesio Tape

Kinesio Tape® is a specific type of tape that is applied to an area of the body to:

- Increase circulation to the tissues under the taped area
- Decrease swelling by raising the tissue and relieving the pressures beneath the skin surface.

Depending on the direction it is applied, Kinesio Tape® will also:

- Help strengthen a weakened muscle by providing information from the skin and muscles to the brain to **increase** muscle activity; **or**
- Help decrease pain and muscle spasm by providing information from the skin and muscles to the brain to **decrease** muscle activity

The tape is waterproof and has holes to allow air circulation. It is hypoallergenic and does not contain latex, reducing the chances of allergic reaction.

How is Kinesio Tape® used?

The tape is applied to the area by a trained rehabilitation therapist. It works best if it is left on for three days.

Some individuals are bothered by the tape. It might feel itchy or uncomfortable at first. Try to keep the tape on for at least 24 hours before removing. Each time the tape is applied, try to increase the wearing time until it stays on for three days. Once the tape is removed, it will not stick to the skin again.

Removing the tape

- The tape comes off easiest when wet.

- You can also apply olive oil or abby oil on the tape and let it soak in.
- Remove tape in the direction the hair grows.
- As you pull the tape with one hand, use the fingers of your other hand to press against the skin.
- Rub the skin as you remove the tape to help reduce sensitivity.

How do I care for myself?

Watch for skin problems around the taped area. Redness under and around the tape may be normal, as the tape increases circulation. It should go away within 24 hours. Remove the tape right away and call your Certified Kinesio Tape® Practitioner if:

- Redness lasts more than 24 hours.
- Blisters appear on the skin.
- Itching occurs under the tape.

You can shower or bathe. The cotton fabric over the adhesive will absorb water, but will dry in about 20 minutes.

- **Blot** the tape's wet areas dry with a towel. **Do not rub** the tape, as this will cause the edges to loosen.
- **Do not** use a hairdryer to dry the tape. The heat will harden the acrylic glue making it very hard and uncomfortable to remove.

If the tape gets loose edges, carefully trim the loose edges with scissors. Do not get too close to the skin.

Questions?

This home program is to be used only under the guidance of your Certified Kinesio Tape® Practitioner. If you have any problems with this home program, or any questions, please call Dr. Katie Lyman

APPENDIX C. PHYSICAL ACTIVITY READINESS QUESTIONNAIRE (PAR-Q)

Physical Activity Readiness Questionnaire (PAR-Q) and You

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly:

YES	NO	
<input type="checkbox"/>	<input type="checkbox"/>	1. Has your doctor ever said that you have a heart condition <u>and</u> that you should only do physical activity recommended by a doctor?
<input type="checkbox"/>	<input type="checkbox"/>	2. Do you feel pain in your chest when you do physical activity?
<input type="checkbox"/>	<input type="checkbox"/>	3. In the past month, have you had chest pain when you were not doing physical activity?
<input type="checkbox"/>	<input type="checkbox"/>	4. Do you lose your balance because of dizziness or do you ever lose consciousness?
<input type="checkbox"/>	<input type="checkbox"/>	5. Do you have a bone or joint problem that could be made worse by a change in your physical activity?
<input type="checkbox"/>	<input type="checkbox"/>	6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?
<input type="checkbox"/>	<input type="checkbox"/>	7. Do you know of <u>any other reason</u> why you should not do physical activity?

If you answered:	YES to one or more questions
	<p>Talk to your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.</p> <ul style="list-style-type: none"> You may be able to do any activity you want – as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice. Find out which community programs are safe and helpful for you.
	NO to all questions
	<p>If you answered NO honestly to <u>all</u> PAR-Q questions, you can be reasonably sure that you can:</p> <ul style="list-style-type: none"> Start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go. Take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively.
	<p>Delay becoming much more active:</p> <ul style="list-style-type: none"> If you are not feeling well because of a temporary illness such as a cold or a fever – wait until you feel better; or If you are or may be pregnant – talk to your doctor before you start becoming more active.
	<p>Please note: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.</p>

Informed use of the PAR-Q: Reprinted from ACSM's Health/Fitness Facility Standards and Guidelines, 1997 by American College of Sports Medicine