

THE EFFECTS OF KINESIO® TAPE ON ACROMIOHUMERAL DISTANCE IN PATIENTS  
WITH SUBACROMIAL IMPINGEMENT

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**Title**

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Subacromial Impingement

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**MASTER OF SCIENCE**

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## **ABSTRACT**

Kinesio® Tape has the potential to optimize the treatment of subacromial impingement syndrome. This research project investigated the effect Kinesio® Tape has on patient-reported outcome measures and acromiohumeral distance in patients with subacromial impingement syndrome. Twenty volunteers exhibiting subacromial impingement syndrome symptoms were divided into two groups, one receiving Kinesio® Tape inhibition technique of the supraspinatus and deltoid muscles and the other receiving a sham Kinesio® Tape. Patient-reported SPADI scores and acromiohumeral distance measured by diagnostic ultrasound were recorded at 24- and 48-hour intervals. SPADI scores of both groups were statistically significantly lower at the 48-hour interval. No statistically significant change in acromiohumeral distance was found at any interval. Therefore, Kinesio® Tape on the supraspinatus and deltoid muscles alleviated symptoms related to subacromial impingement syndrome as reported by patient-outcome data but did not alter the subacromial space according to diagnostic ultrasound scanning.

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## LIST OF ABBREVIATIONS

AHD .....	Acromiohumeral Distance
SPADI .....	Shoulder Pain and Disability Index
KTAI .....	Kinesio Taping Association International®
US .....	Diagnostic Ultrasound
SC.....	Sternoclavicular
AC.....	Acromioclavicular
GH .....	Glenohumeral
ROM.....	Range of Motion
MMT .....	Manual Muscle Test
PPV .....	Positive Predictive Value
NPV .....	Negative Predictive Value
SIT .....	Subacromial injection test
VAS.....	Visual Analog Scale
DASH .....	Disabilities of the Arm, Shoulder, and Hand
MRI.....	Magnetic Resonance Imaging
CT.....	Computed Tomography
HHQ.....	Health History Questionare
CKTP.....	Certified Kinesio Tape® Practitioner
BLV .....	Baseline Value
PIV1.....	Post-Intervention Value 1
PIV2.....	Post-Intervention Value 2
PTRV.....	Post-Tape Removal Value
ANOVA .....	Analysis of Variance

## LIST OF SYMBOLS

®	.....Registered Trademark
™	.....Trademark
°	.....Degrees
±	.....Plus/Minus
<	.....Less Than
>	.....Greater Than
=	.....Equals

## **CHAPTER 1. INTRODUCTION**

### ***1.1. Overview of the Problem***

Subacromial impingement syndrome is the most commonly diagnosed shoulder condition in the general population, accounting for 44-65% of all shoulder complaints.<sup>1-6</sup> This diagnosis is often used as a broad term that encompasses multiple specific pathologies including supraspinatus tendinopathy, subacromial bursitis, and biceps tendinopathy.<sup>1,3-5,7</sup> Even with the high prevalence of this condition, the etiology and proper course of treatment is unclear. Once diagnosed, treatment often consists of stretching and/or rehabilitation exercises to correct any imbalances. In addition, modalities such as ice, electrical stimulation, soft tissue mobilization, therapeutic ultrasound, and Kinesio® Tape may be used to alleviate symptoms related to subacromial impingement syndrome.<sup>6,8-11</sup> Unfortunately, there is no specific treatment that has been proven to be the best for patients with subacromial impingement syndrome. Clinicians must use a holistic approach to evaluate this condition and knowledge of the treatment options available is vital to positive patient outcomes.

Kinesio® Tape is a widely used modality first created in the 1970s by Dr. Kenzo Kase.<sup>12,13</sup> With a multitude of theorized benefits, but minimal evidence supporting or refuting them, it is understandable that the use remains controversial. Among these theorized applications is the regulation of muscle activity.<sup>14-17</sup> When applied from a muscle's insertion to its origin, Kinesio® Tape is thought to inhibit the targeted muscle, which can be beneficial if symptoms are due to overactive musculature.<sup>13</sup> With subacromial impingement syndrome, the deltoid and supraspinatus muscles are often overactive and pull the humeral head superiorly, decreasing the subacromial space.<sup>5,7,18,19</sup> Kinesio® Tape, applied using the inhibition method, may decrease activity of these muscles therefore increasing the subacromial space and lessening symptoms related to subacromial impingement syndrome.

To quantify the subacromial space, diagnostic ultrasound has been shown to be a valid and reliable imaging technique.<sup>20-24</sup> Diagnostic ultrasound is a noninvasive, inexpensive imaging technique that can be used to visualize musculoskeletal structures in real time.<sup>22,25</sup> The subacromial space has been quantified in the literature with various landmarks, but the most common and representative

measurement involves the inferior aspect of the acromion and the superior aspect of the humerus<sup>20,24,26</sup> and will be the method used in this study.

### ***1.2. Statement of Purpose***

The purpose of this study was to determine if application of Kinesio® Tape for inhibiting the supraspinatus and deltoid has an effect on acromiohumeral distance (AHD) as well as pain measures for patients suffering from subacromial impingement.

### ***1.3. Research Questions***

- 1) What are the differences in AHD when Kinesio® Tape is applied on individuals who are diagnosed with subacromial impingement?
- 2) What are the differences on participants' perceived shoulder disability and pain levels with and without Kinesio® Tape applications?

### ***1.4. Dependent Variable***

The focal dependent variable in this study was the AHD measured with diagnostic ultrasound before and after Kinesio® Tape application. In addition, Shoulder Pain and Disability Index (SPADI) scores were recorded to quantify outcome measures.

### ***1.5. Independent Variable***

The independent variable in this study was the application of Kinesio® Tape.

### ***1.6. Limitations***

This research study was not without limitations due to the numerous variables present. First, this study was limited to participants between the ages of 18 and 55; therefore, the results are not generalizable to populations outside of this age range including pediatric and geriatric patients. Additionally, participants presented with varying severity of subacromial impingement. Parameters for differentiating severities of this condition have not been clearly outlined in previous literature, but the Kinesio® Tape may impact them differently. These limitations were outside of the current study's scope and future research should focus on developing methodologies to reduce these factors.

### ***1.7. Delimitations***

This study was delimited to the Fargo-Moorhead area of North Dakota and Minnesota, United States. To be included in the study, participants must have had symptomatic shoulder pain that was diagnosed as subacromial impingement syndrome by the researcher using the clinical prediction rule given by Park et al.<sup>27</sup> Participants had to be symptomatic at the start of the study, which occurred in the spring and fall of 2017. Due to time and resource constraints, this study was conducted over the course of 48 hours and did not include any long-term progression. Additionally, activity levels of the participants as well as shoulder complex usage were not accounted for outside of instructing the participants to continue their typical daily activities. The final delimitation for this study involved the application of Kinesio® Tape. Dr. Kenzo Kase and Kinesio Taping Association International® (KTAI) recommend using three strips to improve symptoms related to rotator cuff impingement or dysfunction: supraspinatus inhibition, deltoid inhibition, and glenohumeral joint mechanical correction. In this study, the glenohumeral joint mechanical correction strip was not used as this would interfere with the diagnostic ultrasound transducer placement on the shoulder joint. These factors are outside the scope of the current study and should be the focus of future research. The researchers of the current study considered numerous variables and reviewed the available literature on subacromial impingement, Kinesio® Tape, and diagnostic ultrasound in order to formulate an appropriate methodology.

### ***1.8. Assumptions***

There were a few assumptions that were made throughout this research study. Since participants were instructed to continue with their normal daily routine, it was assumed that subjects honestly and accurately reported any vigorous activity (e.g. weight lifting). It was also assumed that the participants would remove the Kinesio® Tape if they felt any discomfort or irritation.

### ***1.9. Significance of Study***

Kinesio® Tape is a modality used by many members of the medical community including athletic trainers and physical therapists. However, use of Kinesio® Tape continues to be a controversial treatment option due to lack of consistent evidence. While the effects of Kinesio® Tape on shoulders is a popular topic, no previous research design had investigated the effect this modality has on the objective

measure of AHD in individuals with symptomatic subacromial impingement syndrome. Overall, this study aids clinicians in determining if Kinesio® Tape is a viable treatment option in patients with subacromial impingement syndrome.

### **1.10 Definitions**

Subacromial impingement syndrome: The symptomatic irritation of structures between the superior aspect of the humerus and the inferior aspect of the acromion.<sup>3,4</sup>

Acromiohumeral Distance (AHD): The distance between acromion and the superior humeral head.<sup>28</sup> For this study, the AHD will be measured under diagnostic ultrasound as a perpendicular line from the hyperechoic lateral acromion to the hyperechoic humeral head to represent the distance between the cortical layer of the acromion and cortical layer of the superior humeral head.

Kinesio® Tape: A kinesthetic tape composed of a polymer elastic strand wrapped by cotton fibers that mimics the thickness and flexibility of skin. Able to stretch approximately 55-60% of its resting length, Kinesio® Tape is used to alter muscle activation, increase proprioception, decrease pain, increase lymphatic drainage, and provide mechanical support.<sup>13</sup>

Kinesio® Tape inhibition method: A Kinesio Taping® Methods technique used to decrease muscle activity. The tape is applied from the target muscle's insertion to its origin with 15-25% of available tension.<sup>13</sup>

Diagnostic ultrasound: a non-invasive imaging technique that uses a transducer containing a crystal sound head. This transducer creates sound waves which interact with soft tissues to produce an image.<sup>29</sup>

## **CHAPTER 2. LITERATURE REVIEW**

Shoulder pain is the most common musculoskeletal complaint across all ages.<sup>1-3,30</sup> Of all shoulder pain, subacromial impingement syndrome is the most commonly diagnosed disorder, accounting for 44-65% of all shoulder pathologies.<sup>1-6</sup> Subacromial impingement syndrome is a term that can be used for a variety of specific pathologies, but most commonly involves supraspinatus tendinopathy or subacromial bursitis.<sup>4,7</sup> For this literature review, subacromial impingement syndrome is broadly defined as the symptomatic irritation of structures between the superior aspect of the humerus and the inferior aspect of the acromion. Due to the common nature of this condition, various treatments are constantly being investigated. One of these treatments is Kinesio® Tape, which has been theorized to decrease symptoms of subacromial impingement syndrome by increasing the acromiohumeral distance (AHD), thus increasing the space available for structures in the area.<sup>13</sup> The purpose of this literature review is to give background information on subacromial impingement syndrome with regards to anatomy, diagnosis, treatment, Kinesio® Tape, and Diagnostic Ultrasound (US).

### ***2.1. Shoulder Anatomy***

An understanding of the musculoskeletal anatomy present at any specific area is vital to comprehend the epidemiology behind an injury. The shoulder complex is an intricate structure; with multiple motions, muscular attachments, bony articulations, nerves, and ligamentous attachments, the anatomy of the shoulder is often not well understood. Of particular importance to this research study is how the bony and muscular anatomy of the shoulder relates to subacromial impingement syndrome.

#### ***2.1.1 Bony Anatomy***

There are four main bones that comprise the shoulder complex: sternum, clavicle, scapula, and humerus.<sup>31,32</sup> The sternum is the flat bone centered over the chest and allows for the attachment of the 12 rib bones as well as the clavicle.<sup>33</sup> The clavicle, known as a collarbone to the lay person, is the s-shaped bone that runs from the sternum to the tip of the shoulder.<sup>31</sup> This bone serves to attach the upper extremity to the trunk through the sternoclavicular (SC) joint.<sup>31,33,34</sup> The distal end of the clavicle articulates with the scapula to form the acromioclavicular (AC) joint.<sup>31,34,35</sup> The scapula (also known as the shoulder blade) is the irregularly shaped bone that lays primarily on the upper, lateral thorax and



includes the glenoid fossa in which the humeral head is positioned, forming the glenohumeral (GH) joint.<sup>36</sup> This bone is responsible for accessory motions that allow the glenohumeral joint to have a vast range of motion.<sup>36</sup> This literature review will focus on the AC and GH joints, as these are typically the most important when discussing subacromial impingement. However, the SC joint as well as the scapulothoracic articulation, due to its role in scapular dyskinesia, should be considered by clinicians when evaluating a shoulder injury.

The AC joint is imperative when discussing subacromial impingement syndrome as it is directly related to the superior border of the subacromial space. As the name implies, the subacromial space is located beneath the acromion of the scapula. At the AC joint, the acromion and coracoid process of the scapula articulate with the distal end of the clavicle.<sup>35</sup> Reinforced by the acromioclavicular, coracoacromial, and coracoclavicular ligaments, there are three degrees of freedom available at the AC joint: internal/external rotation, upward/downward rotation, and anterior/posterior scapular tipping.<sup>30-32,34,35</sup> This large amount of motion available contributes significantly to subacromial impingement syndrome as any abnormalities or pathologies involving the AC joint impact the area as a whole.

The glenohumeral (GH) joint, is the articulation between the glenoid fossa of the scapula and the head of the humerus and is often regarded as more important than the AC joint when discussing subacromial impingement syndrome.<sup>32,36,37</sup> Frequently described as "a golf ball on a tee," this joint is responsible for the largest range of motion in the human body.<sup>37</sup> As a ball-and-socket joint, the motions available include flexion/extension, vertical and horizontal abduction/adduction, internal/external rotation, and circumduction.<sup>9,32,36</sup> The stability at the GH joint is almost entirely due to ligamentous support of the superior, middle, and inferior GH ligaments and muscular support of the rotator cuff, deltoids, and trapezius.<sup>30,38</sup> The GH joint is of particular importance to subacromial impingement syndrome due to the vast majority of shoulder motion that is accomplished at this joint. Located directly below the acromion, the subacromial space utilizes the head of the humerus as the inferior border.<sup>5</sup> In essence, any motion at the shoulder that results in humeral head motion will affect the subacromial space.

With two bony borders of the acromion and the humeral head, the subacromial space is a delicate area susceptible to many pathologies. In this space, the supraspinatus tendon passes and inserts

on the head of the humerus and is the second most often injured structure of the shoulder, behind only the acromioclavicular ligament.<sup>39,40</sup> Other tissues present in the subacromial area include the subacromial bursa and long head of the biceps tendon.<sup>5,41</sup> Subacromial impingement syndrome can encompass pathology to any of these structures, including but not limited to partial thickness rotator cuff tears, rotator cuff and biceps tendinopathy, and subacromial bursitis.<sup>4,7</sup>

### ***2.1.2. Muscular Anatomy***

There are 19 muscles that allow for movement of the scapula or the humerus in every plane of motion.<sup>31,32,34</sup> While all of these muscles are imperative to movement, this portion of the literature review will focus on specific musculature that directly affects motion at the glenohumeral joint related to subacromial impingement syndrome. The supraspinatus, subscapularis, infraspinatus, teres minor, deltoids, trapezius, and biceps brachii are muscles of particular importance when discussing this diagnosis.

With the rotator cuff musculature accounting for a large amount of motion available at the shoulder as well as the stabilization of the humerus, it may be the most important group of muscles when investigating shoulder pathologies.<sup>5,7</sup> Originating on the posterior scapula above the spine, the supraspinatus is arguably the most important muscle to consider when discussing subacromial impingement as it is the most often inflamed muscle of the rotator cuff.<sup>2,3,5,7,42</sup> The supraspinatus is a muscle of interest when considering the subacromial space because it passes directly through this space and inserts on the apex of the humeral head.<sup>43-45</sup> The supraspinatus functions primarily to abduct the humerus and stabilize the humeral head, although there is a component that is responsible for external rotation of the humerus as well.<sup>43,44</sup> While the supraspinatus contributes a small amount of external rotation, this motion is primarily achieved by the teres minor and infraspinatus working in tandem.<sup>43</sup> These muscles also aid in horizontal abduction and humeral head stabilization and the teres minor plays a small role in glenohumeral extension.<sup>31,43</sup> Both the teres minor and infraspinatus originate on the posterior aspect of the scapula, with the infraspinatus directly below the scapular spine and the teres minor immediately beneath the infraspinatus.<sup>45</sup> The insertions of the infraspinatus and teres minor on the posterosuperior and posterolateral humeral head respectively allow these muscles to take a large role in

external rotation.<sup>45,46</sup> The final rotator cuff muscle, the subscapularis, is the primary muscle credited for internal rotation of the humerus, as well as GH stabilization.<sup>43</sup> Unlike the other rotator cuff muscles, the subscapularis originates on the anterior aspect of the scapula and inserts on the anterior aspect of the humeral head.<sup>45,46</sup> Similar to the rest of the rotator cuff, the subscapularis plays a large role in humeral head stabilization.<sup>31,32,34</sup> While certainly an important and arguably the most important component to the shoulder complex, the rotator cuff musculature cannot stand alone and other muscle groups must be considered as well.

Outside of the rotator cuff, the deltoid has been shown to have the largest impact on subacromial impingement.<sup>5,7,19</sup> There are three components to the deltoids: posterior, middle, and anterior, and while they have a common insertion on the deltoid tubercle of the proximal humerus; their differing origins allow for unique actions in each.<sup>47</sup> The anterior deltoid originates on the lateral clavicle and is the prime flexor of the shoulder.<sup>32,43</sup> The anterior deltoid also aids in abduction, horizontal adduction, and internal rotation.<sup>43</sup> The origin of the middle third of the deltoid on the acromion process allows primarily for abduction while also aiding in shoulder flexion.<sup>43,47</sup> Notably, this portion of the deltoid also provides the lateral border for the subacromial space. Finally, the posterior deltoid, initiating on the spine of the scapula, is primarily responsible for shoulder extension and horizontal abduction, while also contributing to shoulder abduction and external rotation.<sup>43,47</sup> If the rotator cuff musculature, particularly the internal and/or external rotators, of an individual is weak due to pathology, decreased strength, or lack of neuromuscular control, the deltoid may become overactive to assist these movements.<sup>7</sup> An overactive deltoid is often a factor in subacromial impingement as it leads to a narrowing of the subacromial space as it pulls the humeral head into a resting state of elevation that is unopposed by the diminished inferior forces of the internal and external rotator.<sup>5,7,18,19</sup>

While not having an attachment on the humerus, the trapezius is an important muscle to consider when evaluating subacromial impingement.<sup>18,48,49</sup> Similar to the deltoid, the trapezius has three sections: upper, middle, and lower. The upper and lower segments primarily function to rotate the scapula upward and downward respectively, while the middle trapezius primarily retracts the scapula.<sup>31,50</sup> With insertions on the lateral clavicle and acromion process, the trapezius also aids with acromion

elevation. A weak trapezius may lead to depression in this area, preceding a smaller subacromial space and higher likelihood of impingement.<sup>18,48</sup>

Lastly, the biceps brachii muscle often plays a multifactorial role in subacromial shoulder impingement.<sup>51</sup> Primarily tasked with elbow flexion, this muscle is composed of two heads, the long head and short head, although the former is often viewed as the more intricate structure due to its origin on the supraglenoid tuberosity and superior aspect of the glenoid labrum.<sup>52</sup> With this origin, the biceps brachii provides assistance with shoulder flexion.<sup>53</sup> Similar to the aforementioned muscles, the long head of the biceps tendon is another structure that runs directly through the subacromial space and is often damaged due to subacromial impingement.<sup>51</sup>

The preceding is by no means a comprehensive overview of the musculature involved at the shoulder, and certain factors must be considered on a case-by-case basis. However, the musculature highlighted in this section tend to play the most prominent role in subacromial impingement syndrome. The deltoid and supraspinatus particularly are often viewed as the most significant muscles with this pathology as these muscles directly contribute to superior translation of the humeral head, thus narrowing the subacromial space.

A thorough knowledge of the musculoskeletal anatomy present at the shoulder complex is essential in order to fully understand any pathology at the shoulder. The anatomy related to subacromial impingement syndrome is of particular importance as this condition has the highest prevalence of all shoulder pathologies. In terms of bony anatomy, the scapula, clavicle, and humerus, as well as the articulations that these bones share, have the highest influence on the subacromial space. From a muscular anatomy viewpoint, the most important muscles are the deltoid, trapezius, and rotator cuff as these contribute the most to movement and stability at the GH joint. With knowledge of the anatomy, the possible etiologies of the condition can be better understood and discussed.

## ***2.2. Subacromial Impingement Syndrome***

Subacromial impingement syndrome is a complex and poorly understood pathology.<sup>1-6</sup> In addition, it is the most commonly diagnosed shoulder disorder in the general population, accounting for 44-65% of all shoulder complaints.<sup>1-6</sup> Subacromial impingement syndrome is typically defined as the

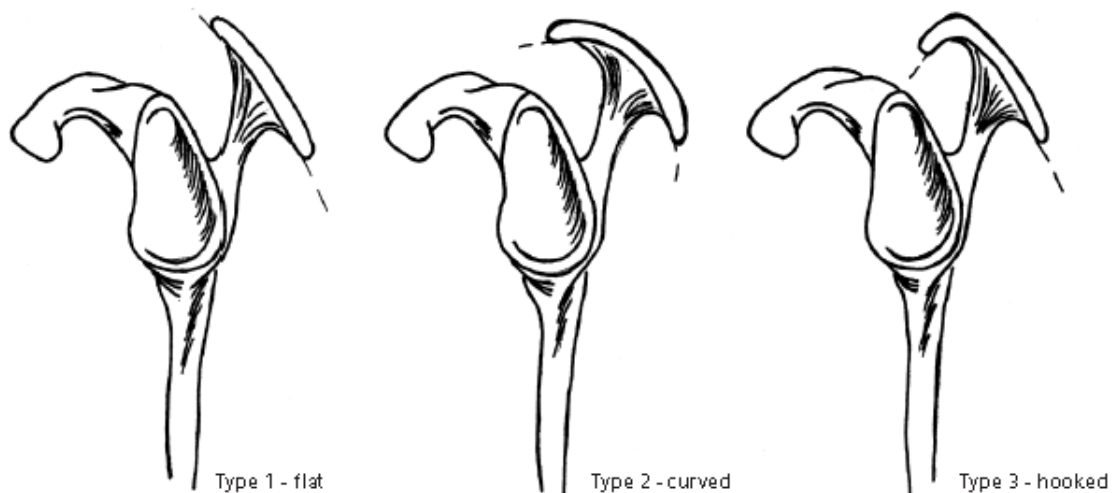
symptomatic irritation of structures between the superior aspect of the humerus and the inferior aspect of the acromion. This diagnosis is often used as a catch-all term for more specific pathologies which may occur in the subacromial space including supraspinatus tendinopathy, subacromial bursitis, and long head of the biceps tendinopathy.<sup>1,3-5,7</sup> Any one or combination of these structures may be damaged in subacromial impingement syndrome and differentiation is difficult without the use of advanced imaging or arthroscopic surgery.<sup>4</sup> Many causes of subacromial impingement syndrome have been theorized, but there is no universal constant in all cases and specific factors contributing to subacromial impingement syndrome must be examined on an individual basis.

### ***2.2.1. Etiology***

The theorized etiology of subacromial impingement syndrome has changed drastically in the past decades. In 1972, Neer proposed that 100% of subacromial impingement syndrome pathologies could be attributed to the acromion.<sup>35</sup> In the years since, various causes of subacromial impingement syndrome have been described and are accepted in the medical community. These causes may be broken down into six categories: anatomical/mechanical, rotator cuff dysfunction, hypermobility, restrictive movement, scapular instability, and posture.<sup>5,7</sup> This literature review will examine each of these, as a thorough understanding of the different possible causes of subacromial impingement syndrome is imperative when discussing the pathology.

One of the oldest and most well-known etiologies of subacromial impingement syndrome, the anatomical/mechanical group, has been examined thoroughly in the literature.<sup>7,35,39</sup> This is an extension of Neer's hypothesis about subacromial impingement syndrome and encompasses any morphological abnormalities of the acromion including acromion shape, acromion bone spurs, and os acromiale.<sup>5,7,35</sup> Figure 1 illustrates the three different acromion shapes which have been described in the literature: flat, curved, and hooked.<sup>7,35,39</sup> While results are controversial, it seems that the shape, as well as the angle, plays an important role in subacromial impingement syndrome. Hooked acromions, lower angles, and bone spurs have been found more often in patients with subacromial impingement syndrome and rotator cuff tears.<sup>39,54</sup> In cases without acromion abnormalities, Neer<sup>35</sup> hypothesized that subacromial impingement syndrome was caused by the shape of the coracoclavicular ligament, as the length of this

ligament was thought to partially dictate the size of the subacromial space, and the thickness of the ligament places an added pressure on structures in the area.<sup>5,7</sup> The final specific pathology related to this group is posterosuperior glenohumeral impingement, also known as internal impingement.<sup>7,55</sup> While the previous causes have been based on morphological differences in the acromion, this classification occurs when the anatomical variance originates from the superior surface of the humerus, which is the inferior border of the subacromial space.<sup>5,7,55</sup> This pathology most often causes damage during overhead motions, as elevation of the humerus decreases the subacromial space.<sup>7,55</sup> Any outgrowth of bone on the superior aspect of the humerus thus narrows this space further.<sup>7,55</sup> While anatomical and mechanical variances play a significant role in subacromial impingement syndrome, other factors must be examined.



**Figure 1.** The Three Types of Acromions<sup>7</sup>

The second category that has been theorized to be a contributor of subacromial impingement syndrome is rotator cuff dysfunction. Rotator cuff dysfunction can contribute to subacromial impingement syndrome through one of two pathways: degenerative tendinopathy or overuse injuries.<sup>7</sup> Degenerative tendinopathy occurs most often in later years of life and can be symptomatic or asymptomatic.<sup>56</sup> It has been reported that as high as 54% of asymptomatic patients over the age of sixty have some form of degenerative tendinopathy.<sup>56</sup> Overuse injuries occur often in sports, particularly in repetitive overhead sports such as baseball and volleyball.<sup>7,40,57</sup> Both degenerative and overuse tendinopathies lead to weakness in the rotator cuff musculature, which may compromise stability of the glenohumeral joint.<sup>5,7,43</sup>

Specifically, the teres minor, infraspinatus, and subscapularis play a large role in stability during shoulder elevation.<sup>5,7</sup> The insertions of these muscles aid in pulling the humeral head inferiorly to counteract the superior pull of the deltoid.<sup>5,7,45</sup> With a weakness in these muscles or tendons, the forces from the deltoid cannot be overcome and the humeral head shifts superiorly, narrowing the subacromial space and contributing to subacromial impingement syndrome.<sup>5,7</sup>

Similar to a lack of stability associated with rotator cuff dysfunctions, the mobility of the GH joint may play a large role in subacromial impingement syndrome. A hypermobile GH joint leads to an increase in humeral head translation on the glenoid fossa in various directions during normal kinematics.<sup>5,7</sup> This is of particular importance in GH flexion and elevation as a superior translation of one to three mm has been demonstrated in the first 30-60° of motion.<sup>58</sup> An increase in this translation is likely due to the inability of stabilizing factors including anatomical morphology, rotator cuff, and GH ligaments to overcome the pull of the deltoid.<sup>5,7,45</sup> The mean distance between the superior humeral head and the acromion has been described to be between 9 and 15 mm in healthy individuals in studies using radiographs and/or diagnostic ultrasound.<sup>22,25,59,60</sup> Any measurement less than nine mm can increase the risk of patients of developing symptoms of subacromial impingement syndrome.<sup>25,60</sup> Therefore, any increase in superior translation beyond normal could decrease the subacromial space and be a causative factor of subacromial impingement syndrome<sup>5,7</sup>.

In direct opposition to hypermobility, restrictive processes can also play a role in subacromial impingement syndrome.<sup>5,7,61</sup> Restrictive motion at the GH joint most often occurs due to tightness in the posterior capsule associated with adhesive capsulitis or surgical procedures.<sup>7</sup> These restrictions cause glenohumeral pathomechanics similar to hypermobile shoulders. For the shoulder to obtain full range of motion (ROM) and stability, the humeral head must undergo arthrokinematic movements including rolling and gliding, which may be hampered with posterior capsule tightness. One study specifically examined the translation of the humeral head after posterior capsule tightening in cadavers and an increase in both superior and anterior translation was found during passive shoulder flexion.<sup>61</sup> This increase in translation can cause subacromial impingement syndrome as the subacromial space is further compressed in these

cases.<sup>5,7,59</sup> When evaluating a case of subacromial impingement syndrome, both hyper- or hypomobility of the joint must be addressed as either one of these factors can be the causative factor<sup>5,7</sup>.

Recently receiving increased attention, the etiology of subacromial impingement syndrome in some cases can be traced to scapular instability.<sup>5,7,9,36</sup> During GH elevation, the scapula should undergo upward rotation, allowing the humerus to achieve the full ROM.<sup>9</sup> In patients with scapular instability or scapular dyskinesis, the scapula does not properly rotate and excessive humeral head rotation or translation occurs as compensation.<sup>5,7,9</sup> Scapular dyskinesis may be due to multiple factors, although muscular abnormalities seem to be the leading cause.<sup>9</sup> Several muscles directly attach to the scapula and provide scapular movement; these include but are not limited to: the rhomboids, trapezius, levator scapulae, and serratus anterior.<sup>31,32</sup> An imbalance or weakness in any of the muscles often leads to scapular instability.<sup>5,7,9,36</sup> Excessive restrictions at the scapulothoracic articulation can also lead to scapular dysfunction and a restriction in free movement.<sup>7,31</sup> The clear relation between the scapula and the humerus is an important factor to investigate in subacromial impingement syndrome cases as the true etiology may come from either of these components.

The final collectively accepted theory behind subacromial impingement syndrome is rooted in posture. The term "slouched posture" refers to a combination of three pathological postures: forward head, forward shoulder, and thoracic spine flexion.<sup>5</sup> While any one of these may cause pathomechanics, the combination of all three is the most concerning when discussing subacromial impingement syndrome. This postural abnormality relates a tightness of the anterior musculature and weakness of posterior musculature, which, in turn, places the scapula in an increased anterior tilt and decreases the subacromial space.<sup>5,7</sup> In addition, cervical spine flexion has been correlated to abnormal scapular position.<sup>5,62</sup> Cervical spine flexion of 25° has been demonstrated to decrease scapular posterior tilting as well as increase scapular upward rotation in shoulder elevation, both of which decrease the subacromial space.<sup>62</sup> While conducting a postural examination from the sagittal plane, clinicians are able to objectively visualize posture which has been shown to have a significant effect on subacromial impingement syndrome and treatment focusing on such is growing in the clinical setting.



As evidenced, subacromial impingement syndrome is a complicated pathology which may include a variety of structures and the etiology of which is difficult to find and varies by case. The more recognized and accepted etiologies include anatomical/mechanical abnormalities, rotator cuff dysfunction, hypermobility, restrictive movement, scapular instability, and posture.<sup>5,7</sup> In order to find the true cause of subacromial impingement syndrome, a detailed evaluation must be performed by a trained professional who understands the biomechanics involved in the shoulder complex.

### ***2.2.2. Diagnosis and Treatment***

The prominence of shoulder pain surpasses any other musculoskeletal condition and the complexity of the joint can make accurate diagnosis challenging.<sup>1-3,30</sup> The difficulty of diagnosing subacromial impingement syndrome is prevalent primarily due to the multifactorial etiology behind the condition and lack of consensus on diagnosis technique. Typically, subacromial impingement syndrome is diagnosed through a detailed clinical examination including history, manual muscle tests, and diagnostic tests. There is little consensus on a gold standard for diagnosis, with studies using MRI, diagnostic US or surgery as a reference standard. Therefore, the accuracy of special tests must be understood by the clinician<sup>1,2,27,63-65</sup>

While there is an extensive list of diagnostic tests for shoulder assessment, there are fewer that are accepted as useful for subacromial impingement syndrome. The tests that are most often utilized in an evaluation and reviewed in the literature include Neer's,<sup>1,2,27,63,64</sup> Hawkins-Kennedy,<sup>1,2,27,63,64</sup> Painful Arc,<sup>1,27,63,64</sup> Drop Arm,<sup>1,2,27</sup> External Rotation Resistance,<sup>27,63,64</sup> and Empty Can.<sup>2,63,64</sup> Difficulty in assessing the accuracy of some of these tests presents in the form of the technique used, as some tests are less defined and may be interpreted differently by clinicians. These tests should all be performed with the patient standing to increase reliability unless otherwise noted. Neer's test is performed by the clinician stabilizing the scapula of the seated patient with one hand and passively flexing the humerus until pain is produced or full flexion is achieved.<sup>66</sup> A positive Neer's test is any production of pain. The Hawkins-Kennedy test involves the clinician placing the patient in 90° of shoulder flexion and elbow flexion.<sup>67</sup> The examiner then passively internally rotates the arm and notes any pain, which indicates a positive result. For the Painful Arc test, the patient actively abducts the arm through the full ROM and then lowers the

arm back to the side.<sup>1,27,63,64</sup> A positive result is considered if there is pain produced between 60° and 120°. In the Drop Arm test, the patient is passively placed in to 90° of shoulder abduction and instructed to lower arm back to neutral.<sup>65</sup> A positive test is observed with the inability of the patient to lower the shoulders in a controlled manner due to pain. To perform the External Rotation Resistance test, also considered the Infraspinatus Manual Muscle test (MMT), the clinician resists external rotation with the shoulder fully adducted and the elbow in 90° of flexion.<sup>65</sup> A positive result is considered if weakness is noted by the clinician as compared bilaterally or if pain is reproduced. For the Empty Can test, also considered the Supraspinatus MMT, the patient is asked to flex their shoulders to 90° in the scapular plane with full elbow extension and internal rotation.<sup>2,63,68</sup> The examiner then applies downward pressure on the upper surface of the arm. The test is considered positive if the clinician notices weakness compared bilaterally. While these tests are commonly performed in similar ways, some slight variations are noted between studies that could impact accuracy of the test and the diagnostic values found in studies.<sup>65</sup>

There have been multiple studies which have examined the diagnostic value of typical diagnostic tests used for subacromial impingement syndrome as well as related tests.<sup>1,2,27,63,64</sup> One such study conducted by Çalis et al<sup>1</sup> investigated the sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of seven tests: Neer's, Hawkins-Kennedy, Horizontal Adduction, Painful Arc, Drop Arm, Yergason's, and Speed's. There were 120 patients recruited for this study; five patients had bilateral shoulder pain for a total of 125 pathological shoulders. The subjects were separated into two groups after undergoing the subacromial injection test (SIT), wherein an injection of 10 cc of 1% lidocaine was placed in the subacromial space. Marked reduction in pain or ROM after 30 minutes was considered a positive test and subjects with a positive SIT were diagnosed with subacromial impingement syndrome and placed in the experimental group. The patients also underwent an MRI to further examine the structures involved and classify the type of impingement. After the MRI, each subject underwent each of the listed tests performed by two physicians. Results of the study are listed in Table 1. The Hawkins-Kennedy test recorded the highest sensitivity at 92.1%, but also recorded the lowest specificity (25.0%). In contrast, the Drop Arm test was found to have the highest specificity (97.2%), but also the lowest

sensitivity (7.8%). The sensitivity of a test indicates its ability to result with a true positive and the specificity of a test represents its ability to detect true negatives. Furthermore, a high sensitivity indicates that the test is useful in identifying subjects without the condition, while a high specificity is useful in identifying patients with the condition. Therefore, if a test with high sensitivity returns a negative result, the clinician can be confident in ruling out the pathology. On the other hand, if a test with high specificity returns with a positive result, the condition is likely present. The results of this study indicate that there is no single test with high sensitivity and specificity and a combination of tests and thorough evaluation must be implemented by the clinician in order to diagnose subacromial impingement syndrome.

**Table 1:** Sensitivity, Specificity and Predictive Values in Clinical Diagnostic Tests

Test	Sensitivity (%)	Specificity (%)	Accuracy (%)	PPV(%)	NPV(%)
<b>Hawkins-Kennedy</b>	92.1	25.0	72.8	75.2	56.2
<b>Neer</b>	88.7	30.5	72.0	75.9	52.3
<b>Horizontal Adduction</b>	82.0	27.7	66.4	73.7	38.4
<b>Speed</b>	68.5	55.5	64.8	79.2	41.6
<b>Yergason</b>	37.0	86.1	51.2	86.8	35.6
<b>Painful Arc</b>	32.5	80.5	46.4	80.5	32.5
<b>Drop Arm</b>	7.8	97.2	33.6	87.5	29.9

A similar study investigated the diagnostic value of seven tests for subacromial impingement syndrome: Neer’s, Hawkins-Kennedy, Painful Arc, Empty Can, Full Can, Resisted External Rotation, and Resisted Abduction.<sup>63</sup> This study recruited 34 patients that were diagnosed with subacromial impingement syndrome. Diagnosis was made using ultrasonography and patients were classified into one of three groups after imaging: full-thickness rotator cuff tear, partial-thickness rotator cuff tear, or subacromial/subdeltoid bursitis. The tests were performed immediately after ultrasound imaging by a physiotherapist who was blinded to the results. Similar to the previous study, the Hawkins-Kennedy test was found to have the highest sensitivity (74.1%), but had a lower specificity (50.0%). In addition, the external rotation resistance test was found to have a specificity of 100%, although the sensitivity of the test was low (34.5%). This pattern was consistent with the majority of the tests in that a test with higher sensitivity often had lower specificity and vice-versa. Full results from this study are presented in Table 2. This study concluded that these diagnostic tests for subacromial impingement syndrome may not be as

accurate as desired by a clinician. In addition, a combination of tests as well as a strong understanding of subacromial impingement syndrome are necessary for an accurate diagnosis.

**Table 2:** Sensitivity, Specificity and Likelihood Ratios in Clinical Diagnostic Tests

<b>Test</b>	<b>Sensitivity (%)</b>	<b>Specificity (%)</b>	<b>Accuracy (%)</b>	<b>Likelihood ratio</b>
<b>Neer</b>	62.1	0.0	54.5	0.62
<b>Hawkins-Kennedy</b>	74.1	50.0	71.0	1.48
<b>Painful arc</b>	29.6	50.0	31.0	0.59
<b>Abduction weakness</b>	37.9	50.0	39.4	0.76
<b>Abduction pain</b>	55.2	75.0	57.6	2.21
<b>External rotation weakness</b>	55.2	25.0	51.5	0.74
<b>External rotation pain</b>	34.5	100.0	42.4	∞
<b>Empty can weakness</b>	51.9	66.7	53.3	1.56
<b>Empty can pain</b>	51.9	33.3	50.0	0.78
<b>Full can weakness</b>	44.8	75.0	48.5	1.79
<b>Full can pain</b>	34.5	25.0	33.3	0.46

While the previous study investigated the diagnostic value of common tests, Michener et al<sup>64</sup> investigated the reliability and accuracy of five diagnostic tests and, in addition, examined the values of combined results of these tests. This prospective blinded cohort study included 55 subjects and utilized arthroscopic surgery as the reference standard. The five tests that were studied were Hawkins-Kennedy, Neer's, Painful Arc, Empty Can, and External Rotation Resistance. After examination, 16 of the 55 subjects were diagnosed with subacromial impingement syndrome through arthroscopic findings. Notably, the sample size in this study is small and results may not be indicative of the population. However, preliminary findings exhibited the highest sensitivity in Neer's test (81%) and the highest specificity in the Empty Can and External Rotation Resistance tests (87%). After computing individual statistics for each test, researchers performed a binary logistic regression analysis to find the best combination of tests to rule in subacromial impingement syndrome. They also performed a binary logistic regression analysis to identify the strongest combination to rule out the pathology. However, both analyses yielded no optimal test combination for either ruling in or out the pathology. While no optimal combination was found, the results of the study did indicate that the threshold of positive tests to discriminate between patients with and without subacromial impingement syndrome was significant at three ( $P = .001$ ). This indicates that if three or more of the five tests are positive, the clinician can confidently conclude that the patient has subacromial impingement syndrome and if less than three of

the tests are positive, the likelihood of the presence of the pathology is unlikely. This concept of three tests holding significance in differentiating patients with and without subacromial impingement syndrome has been reinforced by other research and may aid clinicians in diagnosis.<sup>27</sup>

Systematic reviews and meta analyses on the diagnostic value of subacromial impingement tests have also been performed.<sup>2,65</sup> One such study conducted by Alquanaee et al<sup>2</sup> included 16 studies in their review primarily focusing on five diagnostic tests: Neer's, Hawkins-Kennedy, Empty Can, Drop Arm, and Lift-Off. While few studies have examined the Lift-Off test for subacromial impingement syndrome, this systematic review found that this test had the highest diagnostic accuracy with a positive likelihood ratio of 16.47 and a specificity and sensitivity of 97% and 42%, respectively. Additionally, Neer's test was found to have the highest pooled sensitivity at 78%, although, similar to most individual studies, the specificity of Neer's test was lower (58%). The Hawkins-Kennedy test followed this same pattern as well (sensitivity: 74%, specificity: 54%). These results indicate that two diagnostic tests may be useful in ruling out subacromial impingement syndrome in the case of a negative result, but a positive result does not definitively indicate the pathology is present. One conclusion from this study was the diagnostic value of the lift-off test being much higher than any other test examined. Also, as in previous studies, most tests sacrifice sensitivity for specificity or specificity for sensitivity and there are no cases where both are high.

In one of the most extensive systematic reviews on special tests for subacromial impingement syndrome, Hanchard et al<sup>65</sup> examined studies of diagnostic accuracy of tests for shoulder impingement and pathologies related to shoulder impingement. The authors concluded that evidence upon which to base selection of special tests for subacromial impingement syndrome is insufficient due, in large part, to the diversity of performance of these tests.<sup>65</sup> Nevertheless, the research indicates some trends in the diagnostic tests including the abilities of certain tests to be highly sensitive (Neer's, Hawkins-Kennedy) and others to be highly specific (Drop Arm, Lift-Off, Painful Arc, External Rotation Resistance). The accepted clinical prediction rule is given by Park et al<sup>27</sup> and states that if the Hawkins-Kennedy, painful arc, and external rotation resistance test are positive, there is a 95% accuracy in diagnosing subacromial

impingement syndrome (+LR: 10.6). While there is no consensus, it is important for clinicians to understand where the literature is valuable and where there are shortcomings.

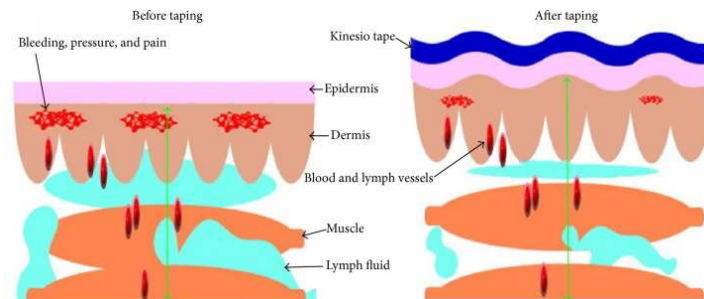
Once the diagnosis of subacromial impingement is made, treatments for the condition must be considered. One common treatment approach is to manage the acromiohumeral distance (AHD). This measurement has been theorized to be diminished in patients with subacromial impingement syndrome.<sup>20-24,69</sup> A study performed by Mackenzie et al<sup>28</sup> was designed to discover if AHD was a cause or effect of subacromial impingement. This descriptive review examined the literature available on subacromial impingement as well as internal impingement to better understand the etiology behind these two conditions. The researchers concluded that the hypothesis of AHD being a cause for subacromial impingement syndrome has not been definitively established and no conclusion can be made on this subject. Likely, as many authors have suggested, the cause of subacromial impingement syndrome is multifactorial. However, maintenance of the subacromial space may be important for managing symptoms of subacromial impingement syndrome regardless of whether the relationship is a cause or effect. In addition, there are many treatment options available including therapeutic exercise, manual therapy, laser therapy, modalities, and taping. One form of taping that has been suggested to improve symptoms related to subacromial impingement syndrome by increasing the AHD is Kinesio® Tape.

### ***2.3. Kinesio® Tape***

Kinesio® Tape originated in the 1970s by way of a Japanese Chiropractor, Dr. Kenzo Kase, and use has subsequently increased steadily, particularly in the last decade.<sup>12</sup> One of the biggest contributors to the growing popularity of Kinesio® Tape was the Olympic Games as athletes from around the world were televised with brightly colored tape used to treat various musculoskeletal conditions.<sup>12</sup> Kinesio®

Tape is an elastic therapeutic tape that can stretch up to 60% of its resting length in order to treat various musculoskeletal and neuromuscular maladies including pain, proprioceptive deficits, swelling, under/overactive muscles, and postural alignment.<sup>12,13,70-72</sup> The theory behind Kinesio® Tape differs depending on the intended result. For example, Kinesio® Tape is claimed to aid with swelling by lifting the epidermis from the underlying layers of skin, thus opening the subcutaneous interstitial area and the body's natural lymphatic system and allowing fluid to flow out of the area (Figure 2).<sup>6,13,73</sup>

Additionally, Kinesio® Tape may be used to facilitate or inhibit musculature by stimulating mechanoreceptors in the tissue which may increase or decrease muscle activity based on the direction of tape application.<sup>13</sup> The need for evidence-based treatment options has led to an increase of Kinesio® Tape research in recent years as researchers try to support or refute the claims made by the inventor.



**Figure 2.** Kinesio® Tape Lifting Mechanism<sup>73</sup>

### ***2.3.1. Pain Regulation***

Treatment of pain is an important part of Kinesio® Tape and has been researched extensively, albeit with varying results. Parreira et al<sup>74</sup> conducted a systematic review to determine the clinical efficacy of Kinesio® Tape. Included in this systematic review were randomized controlled trials that had been published in peer-reviewed journals. Additional inclusion criteria included participants with musculoskeletal conditions, application following the Kinesio Taping Method®, and outcome measures of pain intensity, disability, quality of life, return to work, and global impression of recovery. A total of 12 studies were reviewed and the authors found no significance or minimal significance with many different applications and goals. Many of the articles indicated that while a slight decrease in pain is noted in the short-term, this reduction may be too small to be clinically significant. An earlier systematic review similarly found inadequate evidence to support the use of Kinesio® Tape following musculoskeletal injury.<sup>75</sup> Six articles were included in this review, with two indicating there was no benefit in Kinesio® Tape, one reporting no difference between Kinesio® Tape and other treatments, and three suggesting short-term benefits. While the authors concluded there is insufficient evidence for the efficacy of Kinesio® Tape, they also mentioned that a possible benefit could not be disregarded.

In contrast, a study examining the pain control aspect of Kinesio® Tape in patients with acute whiplash indicated diminished pain in the treatment compared to a sham group.<sup>76</sup> This study employed a cervical extensor inhibition technique as well as a space correction technique over the midcervical region in the experimental group, while a control group received Kinesio® Tape in the same pattern with no tension applied to the tape. Pain levels were taken immediately after Kinesio® Tape application as well as 24 hours post application. Reported pain levels were reduced both immediately and 24 hours after Kinesio® Tape application in the experimental group compared to the control group. Additionally, a review of the research into Kinesio® Tape for myofascial pain conducted by Wu et al<sup>73</sup> reported significant benefits found in multiple studies due to the lifting of the subcutaneous layer surrounding a myofascial trigger point, allowing for increased blood flow, increased lymphatic drainage, and muscle relaxation. Overall, the literature on the effectiveness of Kinesio® Tape to treat pain varies substantially, with some articles reporting no benefits and others indicating short-term pain relief.

### ***2.3.2. Muscle Activity Regulation***

Muscle activity regulation through facilitating or inhibiting musculature is one of the most common research questions used when applying Kinesio® Tape.<sup>14-17,77-80</sup> Specifically, in one study, the effects of Kinesio® Tape on muscle facilitation of the biceps brachii were examined using a handheld dynamometer<sup>77</sup>. Sixteen participants completed the double-blind, repeated measures study in which four different Kinesio® Tape application techniques were utilized: proximal-to-distal, distal-to-proximal, horizontal, and no tape. The proximal-to-distal technique, theorized by Kase to facilitate a muscle,<sup>13</sup> was applied in a “Y” strip with anchors on the anterior shoulder. A 30% tension was applied throughout the length of the tape until it terminated with an anchor above the radial tuberosity. The distal-to-proximal technique, intended to inhibit a muscle, was applied as a “Y” strip; however, the first anchor was placed above the radial tuberosity. A 30% tension was then placed throughout the tape until it terminated in two anchors on the anterior shoulder. The Kinesio® Tape tails were placed around the muscle belly in both of these techniques. The horizontal Kinesio® Tape application was applied with two “I” strips horizontal to the biceps area. It should be noted that this is not a technique approved by the Kinesio Taping Association International® (KTAI). The final group tested had no tape applied and served as the control.



Each subject completed a maximal isometric contraction four times, once with each Kinesio® Tape application. Evaluation of peak force was performed using a hand-held dynamometer as the subject sat on a stool with his/her back and arm against a wall at the elbow flexed at 90°. There was no statistical difference ( $P > .05$ ) in force when comparing the proximal-to-distal, distal-to-proximal, and no tape. However, the two horizontal "I" strips produced statically significant higher muscle peak forces than no tape ( $P = .003$ ), proximal-to-distal group ( $P = .001$ ), and distal-to-proximal group ( $P = .001$ ). This study concluded that traditional methods of Kinesio® Taping to facilitate or inhibit musculature are unsupported; however, Kinesio® Tape application in different manners does seem to have different effects on muscle strength. Therefore, there may be some efficacy behind the use of Kinesio® Tape for this effect, but more research must be conducted to establish a consistent method.

Other authors have agreed that Kinesio® Tape does not alter the isokinetic or isometric muscle strength through inhibitory or facilitatory pathways.<sup>14-17</sup> In one such study, a total of 112 pathological knees that were diagnosed with patellofemoral pain syndrome underwent treatment with Kinesio® Tape to observe its effects on joint position, sense, isokinetic strength, pain, and functional limitation.<sup>17</sup> Subjects were split into two groups: Kinesio® Tape and sham tape. The Kinesio® Tape group received facilitatory tape to the vastus medialis oblique (VMO) as well as mechanical correction of the patella. The former taping technique involved 30% tension from origin to insertion of the VMO while the latter was applied with medium tension across the patella. The sham group received two pieces of tape, one seven cm above the superior patellar pole and the other seven cm below the inferior patellar pole. Outcome measures of pain, isokinetic strength, and proprioception were among those recorded. The Visual Analog Scale (VAS) was used for pain and an isokinetic dynamometer was used for isokinetic strength and proprioception. Patients were tested both before and after the Kinesio® Tape application. Isokinetic strength was not significantly improved in the Kinesio® Tape group when compared to the sham group ( $P > .05$ ). However, other outcome measures including pain ( $P < .001$ ) and joint position sense ( $P < .001$ ) yielded positive results in favor of the Kinesio® Tape. The authors of this study concluded that while an increase in strength of the quadriceps is not supported, Kinesio® Tape may be able to show benefits in the realm of joint position sense and pain.

In contrast, other authors have reached the alternative conclusion that Kinesio® Tape can immediately increase muscle strength.<sup>78-81</sup> In a 2016 study conducted by Kim et al<sup>78</sup>, 20 healthy subjects were divided into two groups: Kinesio® Tape and non-elastic tape. Baseline isometric grip strength was recorded using a handheld dynamometer. The first group received Kinesio® Tape for facilitation of the wrist extensors with 50% tension from origin to insertion. The second group received a non-elastic tape with the same pattern: origin to insertion of the wrist extensors, but with no tension. Immediately after the taping, participants completed a second grip strength trial using the same procedure as the baseline testing. The Kinesio® Tape group showed a significant increase in maximal isometric grip strength immediately after tape application ( $P < .05$ ). This measurement increased from  $31.6 \pm 7.1$  kg prior to tape application to  $33.1 \pm 8.4$  kg post application. Meanwhile, the non-elastic group showed no significant change from pretest to posttest ( $P > .05$ ). The authors concluded that Kinesio® Tape can immediately increase the isometric grip strength when applied to facilitate the wrist extensor musculature. A separate study examined how facilitating the flexor digitorum superficialis instead of the wrist extensors with Kinesio® tape would affect grip strength as measured with a handheld dynamometer.<sup>79</sup> The authors of this study incorporated three groups: experimental, sham, and control. The experimental group received Kinesio® Tape with 25-35% tension from the muscle origin to insertion, the sham group received Kinesio® Tape with no tension, and the control group had no tape applied. Following Kinesio® Tape application, the experimental group was found to have an average increase in right hand grip strength of 1.9kg/F after 30 minutes, 2.5kg/F after 24 hours, and 2.3kg/F after 48 hours ( $P < .05$ ) compared to baseline measurements. This trend was similarly seen in the left hand, but there was no statistically significant difference between any measurements in the sham or the control group. This study may indicate more clinically significant results than prior research designs as the grip strength continued to be heightened in the control group 48 hours after initial Kinesio® Tape application.

There have been minimal research projects that have examined the effect that Kinesio® Tape has on muscular strength in unhealthy individuals. One of these studies specifically examined the isokinetic knee flexion and extension strength in football players with a knee injury.<sup>81</sup> Ten subjects were recruited at a physical therapy clinic to undergo this study which used an isokinetic dynamometer to

measure outcomes including peak torque, total work, and average power. Subjects completed standardized baseline testing with the isokinetic dynamometer after familiarizing themselves with the protocol. Participants were instructed to push as hard as possible against the resistance arm at three velocities: 60°/s, 120°/s, and 180°/s for both flexion and extension. After baseline testing, Kinesio® Tape was applied to the subjects. A facilitation application technique of both the quadriceps and hamstring muscle groups was employed with a tape-off tension from origin to insertion. Participants then completed a second battery of isokinetic knee flexion and extension measurements with the isokinetic dynamometer at the same velocities as the baseline. A significant increase from baseline was measured in peak torque and total work at 120°/s and 180°/s of knee flexion ( $P < .05$ ). In addition, a significant increase in average power of extension at 180°/s was indicated in the results ( $P < .05$ ). The authors concluded that while Kinesio® Tape is not the main therapy for increasing knee muscle function in injured athletes, it may be an effective adjunct therapy.

Studies on this topic often examine the quadriceps or forearm muscle groups, and the generalizability to other muscle groups may not be adequate. In addition, many available studies do not examine an unhealthy population, and results may not be the same when working with this group. The research that is available is conflicting in the efficacy of Kinesio® Tape for altering muscular function. The variation in application methods as well as data collection methods or demographic differences are likely at fault for the varying results found in the literature. Overall, while no definitive consensus statement may be made on the use of Kinesio® Tape to facilitate or inhibit a muscle's function, numerous authors have concluded that this treatment can provide a positive treatment outcome.

### ***2.3.3. Kinesio® Tape for Subacromial Impingement Syndrome***

As stated previously, treatments for subacromial impingement syndrome are thoroughly analyzed in the literature. One of the newer treatments gaining popularity is Kinesio® Tape, although many clinicians may be hesitant to employ this modality for a multitude of reasons including lack of knowledge of the application technique or of the literature. Multiple studies have been conducted which compare Kinesio® Tape to other common treatments for subacromial impingement syndrome in patients with the condition.<sup>6,10,11,82</sup>

Pekyavas et al<sup>10</sup> compared the short-term effects of high-level laser, manual therapy, and Kinesio® Tape in patients with subacromial impingement syndrome. The researchers utilized the Kinesio Tape Method® application of inhibiting the deltoid and the supraspinatus and measured pain as well as shoulder range of motion. Participants were split into four groups. The first group received exercise as treatment (EX); the second group received exercise and Kinesio® Tape (EX+KT); the third group received exercise, Kinesio® Tape, and manual therapy (EX+KT+MT); and the final group received exercise, Kinesio® Tape, manual therapy, and high-intensity laser therapy (EX+KT+MT+HILT). Researchers report that all three treatments were more effective in treating pain, as measured by the Shoulder Pain and Disability Index (SPADI), related to subacromial impingement syndrome when compared to the EX group ( $P < .05$ ); however, the EX+KT+MT and EX+KT+MT+HILT groups were found to have a statistically significant decrease in pain compared to the EX+KT group as well. Also, the EX+KT group, unlike manual therapy and high-level laser, was not shown to provide a significant change in range of motion ( $P > .05$ ), but did indicate reduced pain as recorded by the SPADI ( $P = .02$ ). This study concluded that exercise in conjunction with manual therapy and Kinesio® Tape or a combination of Kinesio® Tape, manual therapy, and high-intensity laser therapy was most effective in minimizing pain as well as disability and increasing ROM in patients with subacromial impingement syndrome.

Similar to Pekyavas et al, Kaya et al<sup>8</sup> compared Kinesio® Tape with exercise to manual therapy with exercise for individuals suffering from subacromial impingement syndrome over the course of six weeks. In this research, the Kinesio® Tape application followed the general guidelines for rotator cuff impingement/tendonitis given by Kase et al<sup>13</sup> and added tape as deemed necessary by a special assessment. The general application included three strips: supraspinatus inhibition, deltoid inhibition, and glenohumeral mechanical correction. Additional inhibition, facilitation, or mechanical correction strips were included upon evaluation of musculature and posture. Research measures included pain measured by the Visual Analog Scale (VAS), disability determined with the Disability of Arm Shoulder and Hand Questionnaire (DASH) and supraspinatus thickness assessed with diagnostic US. Kinesio® Tape and exercise was found to be equally as beneficial as manual therapy with exercise, and also surpassed the latter in reducing night pain (Table 3). Kaya et al concluded that exercise in conjunction with either

manual therapy or Kinesio® Tape have similar outcomes on reducing pain and disability in patients with subacromial impingement syndrome, with Kinesio® Tape additionally offering decreased pain at night.

**Table 3:** Functional Assessment Results of Manual Therapy and Kinesio® Taping Groups

Outcome Measure	Group 1 (exercise + MT)			Group 2 (exercise + KT)			Between Groups ( <i>P</i> )	
	Pre, Mean	Post, Mean	Within groups ( <i>P</i> )	Pre, Mean	Post, Mean	Within groups, <i>P</i>	Pre	Post
<b>Pain (VAS)</b>								
Pain at rest (cm)	3.11	1.50	< .001*	2.89	1.82	.04*	.79	.58
Pain during activity (cm)	7.84	5.11	< .001*	7.21	3.92	< .001*	.19	.57
Pain at night (cm)	5.15	3.19	< .001*	4.92	1.28	< .001*	.80	.01*
<b>Function</b>								
DASH score	64.97	35.61	< .001*	65.01	38.71	< .001*	.99	.46
<b>Tendon thickness</b>								
Affected side (cm)	5.97	5.74	.08	6.19	6.17	.84	.43	.17
Nonaffected side (cm)	5.44	5.48	.46	5.91	6.00	.35	.08	.08

\**P* < .05

A similar study investigated the role of Kinesio® Tape and a home exercise program versus physical therapy modalities including ultrasound, transcutaneous electrical nerve stimulation, exercise, and hot pack.<sup>82</sup> The Kinesio® Tape application in this study was a space and lymphatic correction technique using three strips focusing on the supraspinatus, deltoid, and teres minor, respectively. The base of the first strip began just below the greater tuberosity of the humerus. The patient was then asked to adduct the shoulder and laterally flex the neck to the opposite side. The rest of the I strip was then placed along the spine of the scapula with 15-25% tension. The second strip was a Y strip that began three cm below the deltoid tuberosity. The anterior and posterior tails were placed on the anterior and posterior aspect of the deltoid with 15-25% tension. The final strip was initiated on the lower facet of the greater tuberosity. The patient was then instructed to abduct and internally rotate the humerus and the rest of the I strip was placed on the axillary border of the scapula with 15-25% tension. After two weeks, participants in both groups had significant improvements in the Disability of Arm, Shoulder, and Hand (DASH) scale. In the modalities group, the DASH interquartile range was measured at 39.5-73.5 before treatment and decreased to 23-48 post treatment (*P* < .001). Similarly, the interquartile range of DASH scores in the Kinesio® Tape group decreased from 50.3-70.3 prior to the intervention to 17.8-32 at the conclusion of the study (*P* < .001). The two groups were not statistically different after these two weeks (*P* > .05); however, outcome measures recorded after one week indicated an increased benefit in the Kinesio® Tape group compared to the modalities group (*P* < .01). The researchers concluded that

Kinesio® Tape and physical therapy modalities have similar long-term outcomes in patients with subacromial impingement syndrome, but Kinesio® Tape may be more effective for short-term relief, which may facilitate patient compliance with prescribed exercises.

Kinesio® Tape was compared to another common treatment, injection therapy, for patients with subacromial impingement syndrome.<sup>11</sup> Participants were divided into two groups, one of which received Kinesio® Tape while the other received Betamethasone plus Prilocaine. Both groups also completed a three-month physical therapy program consisting of exercises and stretching. As found in the other studies examined, there was a significant difference in both groups when compared to baseline ( $P < .05$ ), but the groups themselves did not statistically differ ( $P > .05$ ) apart from active shoulder flexion ROM in favor of the injection group ( $P = .04$ ). This study concluded that Kinesio® Tape is a comparable treatment to injection therapy and may be beneficial when non-invasive techniques are preferred.

While many studies have indicated a noticeable benefit with Kinesio® Tape for subacromial impingement syndrome, this finding is not always consistent.<sup>83</sup> In a randomized, double-blind, clinical trial that compared Kinesio® Tape to a sham, improvements in the treatment group were only significant in immediate active shoulder abduction ( $P = .005$ ). The authors of this study recruited 42 subjects that had been referred to a physical therapy clinic due to shoulder pain. Kinesio® Tape was applied for rotator cuff tear/impingement as recommended by Kase<sup>13</sup> in one group and applied as a non-therapeutic sham in the other group. The treatment group received three strips: one to inhibit the supraspinatus, one to inhibit the deltoid, and one mechanical correction strip on the GH joint. Outcomes of disability, general shoulder ROM, and pain were measured by the SPADI, a standard goniometer, and the VAS, respectively, after one and six days. The only result of statistical significance on day one was that of active abduction, which increased by a mean of  $19.1^\circ$  compared to baseline ( $P = .005$ ). Results from day six indicated that both groups had improved over baseline, but were not statistically different ( $P > .05$ ). The conclusions reached by the authors was that Kinesio® Tape may immediately increase pain-free shoulder abduction in symptomatic patients, but the efficacy for use as pain or disability control is unfounded.

Kinesio® Tape has been shown to have positive outcomes when used as treatment for subacromial impingement syndrome, but the literature varies in some aspects. The majority of these

studies support the use of Kinesio® Tape as treatment for subacromial impingement syndrome and show that it is equally as, and in some cases, more beneficial than more traditional options including exercise, manual therapy, high-intensity laser therapy, and physical therapy modalities. More research is necessary in order to understand the mechanism by which these benefits occur.

#### ***2.3.4. Effects on the Subacromial Space***

The effects of Kinesio® Tape on the subacromial space was the subject of one study conducted by Luque-Suarez et al.<sup>84</sup> This study used diagnostic US to measure the distance between the humerus and the acromion at different shoulder joint angles before and after application of Kinesio® Tape. Forty-nine healthy participants were randomized into three different groups based on Kinesio® Tape application: anterior-to-posterior, posterior-to-anterior, and sham. Upon arrival, participants' AHD was measured with diagnostic US at 0° and 60° of active shoulder elevation in the scapular plane. Two measurements were taken at each angle, one from the most anterior part of the acromial arch to the superior humeral head and the second one-centimeter posterior to this position. The mean of these two measurements was recorded. The participants in the first group were placed in humeral adduction and full external rotation and had Kinesio® Tape applied with an anchor on the coracoid process and 100% tension applied throughout the tape until the terminal anchor was placed on the superior angle of the scapula. The second group received the same technique, except the Kinesio® Tape was initiated on the superior scapular angle and terminated on the coracoid process. The final group received a sham taping that appeared visually identical to groups one and two, but with no tension. All three groups immediately underwent the same diagnostic US procedure. The results of this study found a statistically significant average increase in AHD for both groups one (1.158 mm,  $P < .001$ ) and two (0.856mm,  $P = .006$ ) when compared to the sham group (0.128mm). The difference in increase between groups one and two was not statistically significant ( $P > .05$ ). There was also no statistical difference between joint angles of 0° and 60° of shoulder elevation ( $P > .05$ ). Authors of this study concluded that Kinesio® Tape immediately increases the AHD in healthy tissue at both 0° and 60° of shoulder elevation, but the direction of pull of the Kinesio® Tape does not make a difference.

Notably, this study incorporated a Kinesio® Tape application method that is not the advised method to treat subacromial impingement syndrome. Kase et al<sup>13</sup> recommends Kinesio® Tape for deltoid and supraspinatus inhibition to treat this pathology and neither an anterior-posterior nor posterior-anterior technique satisfies this recommendation. Another concern with the application of the Kinesio® Tape in this study is the amount of tension the researchers applied to the tape. Both techniques incorporated a 100% tension with the tape; however, a stretch of over 35% is not indicated when applying the tape to affect the pathological muscles associated with subacromial impingement syndrome. A third limitation to this study was the timing between Kinesio® Tape application and AHD measurement. The study stated that measurement was taken “immediately” after application; however, this is a subjective statement and it is recommended that approximately 30 minutes should pass for physiological effects due to tape application<sup>46</sup>. While this study is one of the only designs to specifically assess the effects of Kinesio® Tape on AHD, the validity and reliability must be considered and altered in future research.

A separate study on the effects of Kinesio® Tape on the subacromial space was conducted by Lyman et al<sup>85</sup> to address some of the limitations of the previous study. These authors compared the effects of various components the Kinesio Taping® Method recommended by Kase et al:<sup>13</sup> deltoid inhibition, supraspinatus inhibition, and a combination of both deltoid and supraspinatus inhibition. Forty-eight healthy participants were recruited for this study. The AHD of all participants was measured with diagnostic ultrasound prior to and five minutes after Kinesio® Tape application. The baseline and post-taping values were compared and the authors concluded that inhibition of the deltoid significantly increased the subacromial space ( $P < .05$ ) and inhibition of the supraspinatus increased the subacromial space, but not at a significant level ( $.05 < P < .10$ ). Combined inhibition technique of the deltoid and supraspinatus did not yield an increase in AHD. The results of this study agree with those of Luque-Suarez et al<sup>84</sup> in that Kinesio® Tape does impact the AHD in healthy individuals.

While there is some available research regarding Kinesio® Tape, the lack of consistency in application method provides a barrier for quality and comparable studies. Even with this barrier, many studies have returned results for the efficacy of Kinesio® Tape; however, more research must be



conducted with consistent guidelines to build on these claims. After an exhaustive review of the literature, there were no studies found that investigated the effects of Kinesio® Tape applied according to published guidelines on the AHD in subjects with diagnosed subacromial impingement syndrome.

#### **2.4. Diagnostic Ultrasound**

Diagnostic ultrasound (US) is an imaging technique that is well-known for its use in imaging fetal development, but has recently grown in practice for musculoskeletal conditions.<sup>22,23,25,37</sup> Diagnostic US uses a coupling medium (often gel) to transmit sound waves into the tissue, which then creates a sonogram from which the clinician can evaluate defects in soft tissue.<sup>29</sup> Compared to other imaging techniques, diagnostic US is quick, inexpensive, and noninvasive.<sup>22,25</sup> Additionally, the results are available immediately and no radiation is required as in radiographs. While there are limitations to ultrasonography, certain situations such as examining superficial muscles and tendons may call for diagnostic US as the imaging technique of choice.<sup>22,25,29</sup> This portion of the literature review will focus on diagnostic US as is related specifically to the shoulder complex.

The aforementioned benefits of diagnostic US allow for easy diagnosis of superficial conditions, and the reliability and validity of the imaging tool specific to the shoulder has been reported extensively.<sup>20-24,86,87</sup> A systematic review conducted by McCreesh et al<sup>22</sup> focused on studies describing the reliability of various radiological methods (MRI, CT, diagnostic US, or radiographs) for measuring AHD. The authors included 18 articles for their review that met the inclusion criteria. Of these 18 articles, 10 employed diagnostic US as their radiological method for measuring AHD, four used radiographs, two used MRI, and two employed a combined method of MRI and CT. Most of these studies reported reliability as an intraclass correlation coefficient (ICC). An ICC is a correlation between two variables and ranges from 0.00 to 1.00. An ICC under 0.50 is considered to indicate poor reliability, while values between 0.51 and 0.75 indicate moderate reliability, values between 0.76 and 0.90 indicate good reliability, and values above 0.90 indicate excellent reliability. All 10 studies examining reliability with diagnostic US reported high intrarater reliability (ICC > 0.75), but lower interrater reliability (ICC < 0.70). Similarly, MRI and CT measures had high reliability for measuring the AHD (ICC > .75), but there were a lower number of quality studies available for these imaging techniques. In contrast, radiographic methods had

inconsistent results in reliability with various methodologies and no specific comparison was possible. Overall, the authors concluded that diagnostic US and MRI/CT are reliable methods with which to measure AHD.

A separate study specifically examined both the interrater and intrarater reliability associated with diagnostic US when used for measuring AHD and supraspinatus tendon thickness.<sup>23</sup> The participants in this study were broken down into two groups, healthy subjects and patients with rotator cuff tendinopathy. Subjects in the symptomatic group were included if diagnosis of rotator cuff tendinopathy could be made through diagnostic US. Two examiners with experience in diagnostic US calculated both interrater and intrarater reliability. Sonographic measurements of the AHD and the supraspinatus thickness were recorded. AHD was measured with the subject seated with their elbow bent to 90° and their hand resting on their lap. The transducer was then placed longitudinally along the center of the acromion and was moved forward until the most anterior part of the acromion was in view along with the humeral head. The AHD was recorded as the shortest distance between the inferolateral acromion and the humeral head. For the supraspinatus thickness, the subject was seated with their palm on their iliac crest and the elbow directed posteriorly. The US transducer was placed on the acromion and moved laterally until the supraspinatus tendon was visible. The transducer was then moved anteriorly into the intraarticular portion of the glenohumeral joint where two measurements were taken at separate points. The average of these two measurements were recorded as the supraspinatus thickness. Interrater and intrarater reliability expressed as ICCs were calculated for each group, as well as for both AHD measurement and supraspinatus tendon thickness. The interrater ICC for the AHD was reported at 0.95 with a 95% confidence interval (CI) of 0.88-0.98, while ICC for supraspinatus tendon thickness was reported at 0.94 with a 95% CI of 0.80-0.98. Intrarater reliability was found to be similar, with ICCs ranging from 0.92-0.98 and narrow 95% CIs. With these high ICC values reported, the researchers concluded diagnostic US is a highly reliable method for measuring AHD and supraspinatus tendon thickness.

Another study examining the interrater reliability of diagnostic US was conducted in real time.<sup>87</sup> This study recruited 10 patients for a total of 20 shoulders. Two examiners with two years of experience

with diagnostic US recorded AHD measurements in each shoulder. Three measurements were taken on each shoulder: one with the shoulder in a neutral position, one in 60° of passive shoulder abduction, and the last in 60° of active shoulder abduction. ICC values were calculated for each of the positions. The ICC values were reported as 0.88 for neutral, 0.65 for passive abduction, and 0.68 for active abduction. While these values are lower than the previous study,<sup>23</sup> the authors were still able to conclude that diagnostic US has fair-to-good interrater reliability, with the highest reliability noted in a neutral position. The reliability of diagnostic US has been studied extensively, with positive results indicating use of the imaging modality for AHD and supraspinatus evaluation is justified.

The validity of diagnostic US in relation to AHD was investigated to compare the AHD of 200 individuals in the coronal axis associated to this measurement in radiographs.<sup>24</sup> In addition to comparing the measurements of the two imaging techniques, participants were also divided into separate groups depending on the degree of rotator cuff injury. There was a significant correlation in AHD measurements in every group between the sonographic and radiographic images, with no group reporting a correlation coefficient ( $r$ ) less than 0.77 ( $P > .8$ ). A correlation coefficient ( $r$ ) is a number between -1 and +1 that illustrates the amount of relationship between two variables, with -1 being a direct inverse relationship and +1 being a direct correlation. The authors concluded that diagnostic ultrasound is a valid technique compared to radiographs when measuring AHD.

With the reliability and validity of diagnostic US concluded to be strong, an association between AHD and subacromial impingement syndrome can be examined with this technique. To evaluate this association, a systematic review examining five articles on this topic was conducted.<sup>25</sup> Exclusion criteria for this systematic review included studies completed on asymptomatic individuals only and patients with conditions other than rotator cuff disease. In addition, studies had to describe the details of diagnostic US to quantify AHD to be included. While there was no common US unit used in the studies, the frequencies ranged from 5-12.5 MHz, which are generally accepted values for superficial structures<sup>20-25,31,69</sup>. The authors concluded that patients with rotator cuff disease demonstrated decreased AHD compared to asymptomatic patients. With a significant difference observed with this measurement, AHD is an important component when examining subacromial impingement syndrome. Furthermore, the ability to

increase the AHD may help alleviate symptoms related to this pathology. This systematic review also noted the method of measuring the AHD varied in the five studies with respect to anatomical landmarks. Three of the studies measured the AHD using the acromion and humeral head as landmarks.<sup>20,24,26</sup> Another study used the acromion and greater tuberosity as measurement landmarks,<sup>86</sup> significantly increasing the reported AHD as the greater tuberosity is both inferior and lateral to the humeral head. The third variation of measurement utilized the superior aspect of the supraspinatus tendon as the superior landmark.<sup>69</sup> This method does not account for any space superior to the tendon and inferior to the acromion and is not truly representative of the subacromial space. The distance between the inferior aspect of the acromion and the superior aspect of the humeral head is the most often used and most representative measurement of the subacromial space.<sup>20,24,26</sup>

With regards to the AHD, diagnostic US has been shown to be a reliable and valid imaging technique when used properly by trained professionals.<sup>20-24,86,87</sup> The AHD is an important concept when discussing subacromial impingement syndrome. While a direct cause and effect relationship is not supported in the literature, there is a relationship between the two as this measurement has been found to be smaller in patients with the pathology when compared to control groups.<sup>22,24,25</sup> The AHD should be measured using an US device at a frequency between 5 and 12.5 MHz and should utilize the inferior aspect of the acromion and the superior aspect of the humeral head as bony landmarks.<sup>25</sup> Increasing the AHD can help relieve the signs and symptoms associated with subacromial impingement syndrome and methods that may aid in this aspect of rehabilitation should be evaluated using ultrasonography.<sup>3,5,20,84</sup>

## ***2.5. Conclusion***

In summary, future research is warranted to determine the effect Kinesio® Tape has on the AHD in patients with subacromial impingement syndrome. Since AHD has been shown to be decreased in patients with subacromial impingement syndrome, the ability to increase the space may lessen the symptoms reported in the short-term. Furthermore, symptom reduction would allow for greater patient compliance in a rehabilitation program designed to target the true etiology behind the condition. One method that has been theorized to increase this measurement is Kinesio® Tape, specifically through inhibition of the deltoid and supraspinatus. With regards to measuring AHD, diagnostic US is supported in

the literature to be a valid and reliable imaging method. Therefore, diagnostic US may be used to measure the AHD in symptomatic patients when treated with Kinesio® Tape in order to objectively examine any effect the treatment has on subacromial impingement syndrome.

## CHAPTER 3. METHODOLOGY

The purpose of this study was to determine if application of Kinesio® Tape has an effect on acromiohumeral distance (AHD) for patients suffering from subacromial impingement. This study used diagnostic ultrasound to compare the effects of Kinesio Taping Methods® to a sham taping technique. This chapter describes the population of the study, setting of the study, data collection instrumentation, procedures, and the data analysis. The research was guided by the following research questions:

- 1) What are the differences in AHD when Kinesio® Tape is applied on individuals who are diagnosed with subacromial impingement?
- 2) What are the differences on participants' perceived shoulder disability and pain levels with and without Kinesio® Tape applications?

### ***3.1. Participants***

A convenience sample of 20 participants between the ages of 18 and 55 were recruited through email listserv, word-of-mouth, physical therapist referral, and doctor referral in the Fargo-Moorhead area. The maximum age of 55 was set due to a study by Sher et al<sup>56</sup> that found that 54% of asymptomatic participants aged 60 or over had some level of rotator cuff degeneration. Participants had to have been diagnosed with subacromial impingement syndrome and have been experiencing symptoms for at least one month. Exclusion criteria for the study included history of shoulder surgery in the past year, acute injury, or neck or elbow pain. Additionally, any contradictions for Kinesio® Tape, including allergy to adhesive, malignancy sites, cellulitis, skin infection, open wounds, diabetes, or fragile skin,<sup>13</sup> were cause for exclusion. Subjects were compensated for their participation with twenty dollars following completion of the study. Informed written and verbal consent was obtained from each participant before enrollment and baseline demographic and clinical data were collected by the Health History Questionnaire (HHQ).

### ***3.2. Setting***

This study was conducted in the Athletic Training Laboratory in the Bentson Bunker Fieldhouse on the campus of North Dakota State University, Room 14, 1301 Centennial Blvd. Fargo, ND 58102 in the spring and fall of 2017. This laboratory was used because the equipment (Kinesio® Tape, Terason

t3200™ Diagnostic Ultrasound) for this study is located at this site. In addition, participants had easy access to this room as they were recruited from the surrounding area.

### **3.3. Equipment and Instruments**

In order to visualize and measure the subacromial space, the Terason t3200™ Diagnostic Ultrasound (MedCorp, LLC., Tampa, FL) and the 15L4 Linear transducer (4.0-15.0 MHz) (MedCorp, LLC., Tampa, FL) were used with Aquasonic® 100 ultrasound gel (Parker Laboratories, INC., Fairfield, NJ) as the coupling medium. The AHD was measured from the lateral aspect of the cortical layer of the acromion to the superior aspect of the cortical layer of the humeral head for each participant.<sup>67,69,81</sup>

Kinesio® Tex Tape was used as the elastic tape that has been theorized to alleviate symptoms of subacromial impingement syndrome.<sup>6,11,13,82,84</sup> Kinesio® Tape can help increase or decrease muscular activity by providing sensory information from the skin and muscle to the brain which can alter the neural signals that stimulate a given muscle. The recommendation given by Kase et al<sup>13</sup> involves using the Kinesio® Tex Tape to inhibit the supraspinatus and the deltoid, as overactivity of these muscles can decrease the AHD.<sup>5,7,18,19</sup>

The Shoulder Pain and Disability Index (SPADI) was used as a patient-reported outcomes measure to subjectively quantify each participant's pain and disability throughout the study. The SPADI consists of thirteen questions and two subcategories: pain (five questions) and disability (eight questions). Each question is ranked as a score from zero to ten, with zero indicating no pain or disability and ten indicating extreme pain or disability. The SPADI has been shown to be a reliable and valid self-assessment of any shoulder pathology, and compares favorably with other shoulder-specific questionnaires<sup>88,89</sup>. Additionally, using the SPADI to measure patient-reported outcomes in patients with subacromial impingement syndrome has been validated.<sup>90</sup>

### **3.4. Procedures**

Participants for this research project were recruited through North Dakota State University email listserv, word-of-mouth, physical therapist referral, and doctor referral in the surrounding area. The first 20 people that met the inclusion criteria were included in this study. Prior to data collection, this research project was approved by the North Dakota State University Institutional Review Board. Research was

conducted in the spring and fall of 2017 in Room 14 of the Bentson Bunker Fieldhouse on the NDSU campus. Upon arrival of the participants to the lab, each participant completed necessary paperwork including the HHQ and Informed Consent. Participants were excluded from the study if they indicated any of the following on the HHQ: neurological impairment (i.e., Parkinson's disease; nerve entrapment; multiple sclerosis; ALS; paresthesia); prior history of general medical conditions involving joints, muscles, bones, or connective tissue of the upper extremity (i.e., osteoarthritis; fibromyalgia; Lyme disease); or reported allergy to adhesive or Kinesio® Tex Tape.

Subjects were asked to report to the research laboratory twice throughout the duration of the study. Following completion of necessary forms on the initial appointment, participants underwent a variety of special tests in order to confirm the diagnosis of subacromial impingement syndrome. The three tests that were performed were the Painful Arc test, Hawkins-Kennedy impingement test, and External Rotation Muscle test as the combination of these tests gives the highest likelihood of diagnosing subacromial impingement syndrome.<sup>6</sup> For continuance in the study, the subjects were required to have positive test results for at least two of these three diagnostic tests as performed by a trained clinician. The Painful Arc test was performed first. For this test, the subject was standing upright and asked to abduct his/her arms as high as possible before returning them back to neutral. For consistency, each subject performed this test in anatomical position, which was cued by instructing the subject to keep his/her thumbs up throughout the movement. A positive result was indicated if pain was present between 60 and 120° of shoulder abduction. The Hawkins-Kennedy impingement test was also conducted with the subject standing. The clinician passively flexed the participant's shoulder and elbow to 90°. Once in this position, the clinician supported the subjects arm at the elbow and applied an internal rotation force to the forearm. A positive result was indicated if pain was produced upon passive internal rotation. The final test, the External Rotation Muscle test, was also performed with the patient standing. The participant was instructed to place his/her shoulder in adduction at his/her side and flex his/her elbow to 90° with his/her palm facing in. The clinician then placed one hand on the scapula for support and applied a medially directed force to the distal forearm with the other hand while the participant resisted this movement. This test was performed on both shoulders to determine any weakness. A positive result for the External



Rotation Muscle test was indicated if the test resulted in pain or weakness was noted as compared bilaterally. If positive results were indicated for at least two of the three tests, the subject qualified for the study. If a negative result was found with more than one of the three tests, the participant did not qualify and was dismissed from the study without compensation.

Subjects that qualified for the study then completed the Shoulder Pain and Disability Index (SPADI) as a baseline measurement. Next, subjects were randomly assigned into two groups: the experimental group and the control group. This randomization was determined prior to arrival of any participant. A random number generator picked numbers between one and twenty. The first ten numbers selected by the random number generator were placed in the experimental group and the control group consisted of the remaining ten participants. The experimental group received Kinesio® Tape with tension, while the control group received the same Kinesio® Tape pattern but without tension, resulting in a sham application.

Following randomization, a clinician trained in diagnostic ultrasound and blinded to the randomization measured each participant's AHD. The subject was instructed to be seated in an upright posture with his/her arm relaxed at his/her side in neutral position and the elbow extended.<sup>29</sup> The anterior aspect of the acromion process was palpated. The Terason t3200™ diagnostic ultrasound unit was set to either medium or high frequency depending on the participants' body type with a depth of four cm. The transducer that was used was a 15L4 linear transducer with frequencies between 4.0 and 15.0 MHz (The medium to high frequency used was between 8.0 and 15.0MHz). The clinician then applied ultrasound gel to the transducer and placed the transducer in the coronal-oblique plane over the acromion process. The transducer was then moved inferiorly until the superior aspect of the humeral head was visible. The transducer was then toggled as necessary to refine the image and obtain a hyperechoic acromion and humeral head. At this point, the screen was frozen and a perpendicular line was drawn from the cortical layer of the lateral acromion to cortical layer of the superior humeral head. This line was measured and recorded as the AHD. Additionally, marks were made on the patient at the proximal and distal ends of the transducer for repeatable measures. The screen was then unfrozen and the transducer was removed from the participant's skin. Next, a second measurement of the AHD was

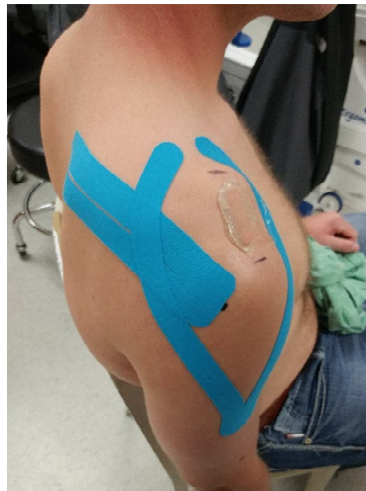
obtained by the same clinician with the same procedure. These two measurements were averaged for the initial AHD measurement. A clinician then placed an inclinometer on the midshaft of the humerus in order to measure the angle of the glenohumeral joint as it was placed in 60, 90, and 120 degrees of abduction. At each angle of abduction, the subject was instructed to and hold the position while the clinician measured the AHD with the procedure previously outlined. The clinician then wiped the participant's skin dry and exited the lab to ensure blinding of the clinician to the Kinesio® Tape application.

A second clinician who is a Certified Kinesio Tape® Practitioner (CKTP) then applied the Kinesio® Tape. The subject's skin was cleaned with an isopropyl alcohol preparation pad and excess hair was trimmed. While the skin dried further, the clinician cut a strip of Kinesio® Tape to match the distance between the greater tuberosity and the most medial point of the scapular spine with the tissue on stretch. A second strip was cut to match the distance from the deltoid tuberosity to the middle of the clavicle with the tissue on stretch. Both strips were then cut in half length-wise until one-half block remained intact on one side of the tape, forming two Y strips. All edges were then rounded to enhance tape adherence. A tension measurement table (Table 4) was followed in order to ensure consistency in treatments: a distance that matches a 15% tension of the given size was measured, and marks were placed at the start and ends of the tape measure. The first Y strip was placed to inhibit activity of the supraspinatus. The base was applied with no tension to the greater tuberosity of the humerus. The muscle was then placed in a stretched position by instructing the subject to fully horizontally adduct his/her shoulder and pronate his/her hand. The superior tail was applied directly superior to the scapular spine with 15% tension and the inferior tail was applied with the same tension directly inferior to the scapular spine. The final half block of each tail was applied with no tension. Next, the second strip was applied to inhibit the anterior and posterior deltoid. The base was applied at the deltoid tuberosity with no tension. The shoulder was then placed in extension to stretch the anterior deltoid and the tape was applied following the muscle belly of the anterior deltoid with 15% tension. Next, the shoulder was placed in flexion to stretch the posterior deltoid, and the tape was applied along the muscle belly of the posterior deltoid with 15% tension. Both tails terminated with no tension over the final half block. The two strips of tape were then rubbed with the paper backing to activate the adhesive. The control group

received the same application technique, but the tape was applied with 0% tension throughout, also following Table 4. The completed Kinesio® Taping application is shown in Figure 3.

**Table 4:** Length of Kinesio® Tape at Various Tensions

Squares on Paper	On Paper	Tension Applied			
		0%	100%	15%	25%
<b>Three</b>	15 cm	14.1 cm	23 cm	15.4 cm	16.3 cm
<b>Four</b>	20 cm	19 cm	31 cm	20.8 cm	22 cm
<b>Five</b>	25 cm	24 cm	39 cm	26.25 cm	27.75 cm
<b>Six</b>	30 cm	28 cm	47 cm	30.85 cm	32.75 cm



**Figure 3:** Completed Kinesio® Tape application

Following tape application, the participant was asked to sit in a self-determined position with his/her arm at his/her side for 15 minutes. The clinician that performed the initial AHD measurement with diagnostic ultrasound then returned to the room. The transducer was placed between the proximal and distal marks as determined prior. The clinician confirmed that the acromion and humeral head were visible and repositioned the transducer if not. Once visible, the screen was frozen and the distance between the lateral cortical layer of the acromion and the superior aspect of the humeral head was measured. The investigator then obtained a second measurement using the same procedure. The average of these two numbers were recorded as the Post-Intervention Value 1 (PIV1). This measurement was taken at 60°, 90°, and 120° with the same procedures as the initial measurements. The participant was then instructed to complete normal activities of daily life with the tape in place and to return to the research lab 48 hours later for follow-up measurements. Upon dismissal on the first day, each participant

was given a SPADI form to complete 24 hours after the initial measurement which they were instructed to return to the researcher upon follow-up.

Upon arrival for the follow-up appointment, the clinician confirmed that the Kinesio® Tape remained in place on the subject since initial application. All participants returned with the tape in place and completed a third SPADI while the clinician prepared the diagnostic ultrasound. The clinician then measured the AHD in the subjects using the procedure outlined prior. Two measurements were taken at each angle and averaged for the Post-Intervention Value 2 (PIV2). Next, the Kinesio® Tape was removed and the skin was cleansed with an alcohol preparation pad. Following tape removal, the participant was asked to sit in a self-determined position with his/her arm at his/her side for 15 minutes. After 15 minutes, an AHD measurement was taken twice using the procedure outlined prior at each angle of abduction. These measurements were then averaged and recorded as the Post-Tape Removal Value (PTRV). Upon completion, the participant received twenty dollars for his/her time and cooperation and was dismissed.

### ***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. Post hoc statistical significance was determined by Tukey's honestly significant difference test.

### ***3.6. Conclusion***

The purpose of this study was to determine if application of Kinesio® Tape has an effect on AHD for patients suffering from subacromial impingement. The accepted clinical prediction rule for diagnosing subacromial impingement syndrome given by Park et al<sup>27</sup> was used as inclusion criteria for the participants. Diagnostic ultrasound was used to quantify the AHD throughout the course of the study. Kinesio® Tape was applied to the participants with either a Kinesio Taping Methods® technique or a sham technique to compare outcomes. In addition to the objective diagnostic ultrasound measurements, the participants completed the SPADI three times throughout the course of the study. This prospective

research will be used to determine the effect Kinesio® Tape has on subacromial impingement syndrome in order to expand treatment options and increase patient outcomes.

## CHAPTER 4. MANUSCRIPT

### **4.1. Abstract**

[Study Design] Randomized Controlled Trial

[Background] Subacromial impingement syndrome is the most commonly diagnosed shoulder pathology but is complex and poorly understood.<sup>1-6</sup> Kinesio® Tape has the potential to optimize the treatment of subacromial impingement syndrome.<sup>6,10,11,82</sup> There is a need for objective measurements of the subacromial space in response to Kinesio® Tape to understand the mechanism by which this modality may alleviate symptoms.

[Objectives] To determine the effect Kinesio® Tape has on patient-reported outcome measures and acromiohumeral distance (AHD) in patients with subacromial impingement syndrome.

[Methods] This study consisted of twenty volunteers exhibiting subacromial impingement syndrome symptoms as determined by the combination of three orthopedic Special Tests. Participants were divided into two groups, one receiving Kinesio® Tape inhibition technique (15% tension from insertion to origin) of the supraspinatus and deltoid muscles and the other receiving a sham Kinesio® Tape technique (0% tension from insertion to origin) of the same muscles. Patient-reported SPADI scores and AHD measured by diagnostic ultrasound at various angles of shoulder abduction were recorded at 24- and 48-hour intervals.

[Results] SPADI scores of both the experimental and sham groups were statistically significant when compared between baseline and 24 hours, baseline and 48 hours, and the 24- and 48-hour intervals. The participants showed no statistically significant change in AHD at any interval in the study.

[Conclusions] Inhibition technique of Kinesio® Tape on the supraspinatus and deltoid muscles alleviated pain and disability symptoms related to subacromial impingement syndrome as reported by a patient outcome survey, but did not alter the subacromial space according to diagnostic ultrasound scanning.

[Level of Evidence] Therapy, level 2b

[Key Words] Diagnostic ultrasound, subacromial space, SPADI

#### **4.2. Introduction**

Subacromial impingement syndrome is the most commonly diagnosed shoulder condition in the general population, accounting for 44-65% of all shoulder complaints.<sup>1-6</sup> Subacromial impingement syndrome is often used as a catch-all term for more specific pathologies occurring in the subacromial space including supraspinatus tendinopathy, subacromial bursitis, and long head of the biceps tendinopathy.<sup>1,3-5,7</sup> As a whole, patients diagnosed with subacromial impingement syndrome demonstrate mild to severe pain, particularly with overhead motions. Even with the high prevalence of diagnosis, the proper course of treatment is highly individualized and often unclear to clinicians. One theorized cause of subacromial impingement is overactivity of the supraspinatus and the deltoid.<sup>5,7,18,19</sup> Due to the attachments of the supraspinatus and deltoid, overactivity in these muscles leads to a decrease in the subacromial space as the humeral head is pulled superiorly. One proposed modality to aid in recovery from subacromial impingement syndrome is Kinesio® Tape to decrease the activity of the supraspinatus and deltoid.<sup>13</sup>

Kinesio® Tape is an elastic therapeutic tape that can stretch up to 60% of its resting length in order to treat various musculoskeletal and neuromuscular maladies including pain, proprioceptive deficits, swelling, under/overactive muscles, and postural alignment.<sup>12,13,70-72</sup> Kinesio® Tape is theorized to aid

these conditions through various pathways, including altering muscle activation by stimulating mechanoreceptors in muscles, lifting the epidermis to open the interstitial subcutaneous area, and increasing kinesthetic awareness by stimulating proprioceptors.<sup>6,13,73</sup> Research on Kinesio® Tape is fickle due to inconsistencies in taping methods and types of tape applied. The creator of Kinesio® Tape has published recommendations both on proper taping techniques and techniques for specific pathologies,<sup>13</sup> but these are seldom followed in the literature.

Diagnostic Ultrasound (US) is an imaging technique that clinicians have recently used in practice for visualizing musculoskeletal structures and conditions.<sup>22,23,25,37</sup> Diagnostic US is beneficial over other imaging techniques because it is inexpensive and noninvasive. Additionally, the images are available in real time; therefore, movements throughout a range of motion can be visualized as opposed to still pictures. Diagnostic US has been shown to be valid and reliable for measuring the subacromial space, which can be quantified in terms of the AHD.<sup>20-24,86,87</sup> While a cause and effect relationship cannot be determined, subjects with subacromial impingement syndrome often have a smaller AHD than asymptomatic individuals.<sup>22,24,25</sup>

Currently, there is one study that examined the effects of Kinesio® Tape applied as recommended for subacromial impingement syndrome on AHD; however, it should be noted the research was conducted on participants with no known history of subacromial impingement.<sup>85</sup> Authors of this study found that inhibition of the deltoid increased the AHD ( $P < .05$ ). In contrast, inhibition of only the supraspinatus did not increase the AHD ( $P > .05$ ). Interestingly, a combination of applying both techniques, as recommended by Kase et al,<sup>13</sup> did not yield an increase in AHD ( $P > .05$ ). The current study aimed to challenge these results reported by Lyman et al<sup>85</sup> and to examine the effects Kinesio®



Tape has on the AHD in symptomatic individuals, as well as obtain subjective patient outcome measures of pain and disability.

The ability to justify certain treatment options with evidence-based recommendations is imperative to clinicians. The literature is lacking on studies objectively evaluating the effects of Kinesio® Tape on the subacromial space in patients with subacromial impingement syndrome. We hypothesized that, when applying Kinesio® Tape with the Kinesio Taping® Method to inhibit the supraspinatus and deltoid, symptoms of pain and disability related to subacromial impingement syndrome would decrease and there would be a corresponding increase in AHD.

### **4.3. Methods**

#### **4.3.1 Subjects**

Twenty adults (f=10, m=10) ranging in age from 18 to 51 (M=24.55, SD=8.876) volunteered for this study through word-of-mouth and email recruitment. Inclusion criteria for this study were previous diagnosis of shoulder impingement from a healthcare provider and pain in the affected shoulder for at least one month. Factors excluding participants were shoulder surgery in the past year, acute injury, neck or elbow pain, history of general medical conditions to joints, muscles, bones, or connective tissue, or any contradictions for Kinesio® Tape, including allergy to adhesive, malignancy sites, cellulitis, skin infection, open wounds, diabetes, or fragile skin.<sup>13</sup> To screen for the inclusion and exclusion criteria, participants completed a health history questionnaire. Additionally, an athletic trainer performed three orthopedic special tests to confirm the presence of subacromial impingement syndrome: the Painful Arc Test, Hawkins-Kennedy Impingement Test, and the External Rotation Muscle Test. These three tests were chosen as they have the highest post-test probability of any combined tests, with 90% probability of subacromial impingement syndrome if two positive results are found and 95% if all three tests are

positive.<sup>27</sup> Results for each participants' Special Tests are reported in Table 5. If positive results were indicated in two or three of these tests, the participant qualified for the study.

**Table 5.** Special Testing Results of Participants

	Painful Arc Test	Hawkins-Kennedy Impingement Test	External Rotation Muscle Test
Participant 1	+	+	-
Participant 2	+	+	-
Participant 3	+	+	+
Participant 4	+	+	-
Participant 5	+	+	-
Participant 6	+	+	+
Participant 7	+	+	-
Participant 8	+	+	+
Participant 9	+	+	+
Participant 10	+	+	-
Participant 11	+	+	-
Participant 12	-	+	+
Participant 13	+	+	-
Participant 14	+	+	+
Participant 15	+	+	+
Participant 16	+	+	-
Participant 17	+	+	+
Participant 18	+	+	-
Participant 19	+	+	-
Participant 20	+	+	+
Total	19/20	20/20	9/20

This study was approved by the University's Institutional Review Board. Prior to initiation of the study, all participants read and signed a written informed consent outlining the procedures and risks involved.

#### ***4.3.2. Study Design and Protocol***

This within-subject research study utilized a pretest/posttest design with subjects randomly divided into two groups: experimental and control. All participants completed the Shoulder Pain and Disability Index (SPADI) as a baseline measurement. Next, a clinician trained in diagnostic ultrasound with four years of experience and blinded to the randomization measured each participant's baseline AHD. All diagnostic imaging was completed using the preset shoulder parameters on a Terason t3200™ diagnostic ultrasound machine (United Medical Instruments Inc, San Jose, California) with a 15L4 linear transducer (4 MHz to 15 MHz) (Teratech Corporation, Burlington, Massachusetts) and Aquasonic® 100 ultrasound gel (Parker Laboratories, INC., Fairfield, NJ) as the coupling medium. The subject was instructed to be seated in an upright posture with his/her arm relaxed at his/her side in neutral position and the elbow extended.<sup>29</sup> The anterior aspect of the acromion process was palpated. The transducer was placed in the coronal-oblique plane over the acromion process and was then moved inferiorly until the superior aspect of the humeral head was visible. The transducer was then toggled as necessary to refine the image and obtain a hyperechoic acromion and humeral head. At this point, the screen was frozen and a perpendicular line was drawn from the cortical layer of the lateral acromion to cortical layer of the superior humeral head. This line was measured and recorded as the baseline AHD value (BLV). Two measurements were obtained and averaged in order to ensure intratester reliability. The participant then had an inclinometer placed on the midshaft of the humerus by a second clinician. The participant was asked to abduct his/her humerus to 60° and hold this position while the ultrasound clinician measured the AHD with the procedure previously outlined. Additionally, the participant was asked to abduct his/her arm to 90° and 120°, with the ultrasound clinician measuring AHD at each position.

### **4.3.3. Intervention**

The second clinician, a Certified Kinesio Tape® Practitioner (CKTP), then applied the Kinesio® Tape. The experimental group received Kinesio® Tape with 15% tension from insertion to origin applied to inhibit the supraspinatus and the deltoid while the control group received identical tape with 0% tension in a sham technique. Two Y-strips of Kinesio® Tape were cut to match the length of the participant's supraspinatus and deltoid. In order to address the methodological issues of tension, the researchers measured varying tensions with corresponding measurements. Marks of appropriate measurement were applied to a participant's skin in order to ensure proper tension was applied to the Kinesio® Tape. These values are reported as a tension measurement table in Table 4.

Tape application for the supraspinatus was conducted by placing a mark on the participant's greater tuberosity and, using the tension measurement table, a distance was measured with the humerus fully pronated and horizontally abducted to stretch the muscle; a mark was placed where the tape was to terminate on the scapular spine. The base of the tape was applied with 0% tension posterior to the participant's greater tuberosity with the arm at rest. The humerus was then again placed in the pronated and horizontally abducted position to stretch the supraspinatus and the two tails of the tape were placed to encompass the breadth of the supraspinatus. The second strip was applied from insertion to origin of the deltoid in a manner suggested by the creator of the tape to inhibit an overactive muscle. For this application, a mark was placed on the participant's deltoid tuberosity and a distance was measured to ensure proper tension. A mark was placed where this strip was to terminate, approximately mid-clavicle. The base was then applied with 0% tension on the deltoid tuberosity. For the anterior tail, the participant was placed in slight humeral extension and for the posterior tail, the participant was placed in slight humeral flexion in order to stretch the specific portion of the deltoid targeted.

**Table 4:** Length of Kinesio® Tape at Various Tensions

Squares on Paper	Tension Applied				
	On Paper	0%	100%	15%	25%
<b>Three</b>	15 cm	14.1 cm	23 cm	15.4 cm	16.3 cm
<b>Four</b>	20 cm	19 cm	31 cm	20.8 cm	22 cm
<b>Five</b>	25 cm	24 cm	39 cm	26.25 cm	27.75 cm
<b>Six</b>	30 cm	28 cm	47 cm	30.85 cm	32.75 cm

Following tape application, the participant was asked to sit in a self-determined position with his/her arm at his/her side for 15 minutes. The clinician who performed the initial AHD measurement with diagnostic ultrasound then returned to the room. This clinician then measured the AHD at 0°, 60°, 90°, and 120° using the same methods as previously described to obtain the Post-Intervention Value 1 (PIV1). The participant was then instructed to complete normal activities of daily living with the tape still intact and to return to the research lab 48 hours later for follow-up measurements. Following all AHD measurements, each participant was given a SPADI form to complete 24 hours after the initial measurement which they were instructed to return to the researchers upon follow-up.

Upon arrival for the follow-up appointment, the clinician confirmed that the Kinesio® Tape remained in place on the subject. All participants returned with the tape in place and completed a third SPADI, which enabled researchers to evaluate patient outcomes at three separate time intervals. The ultrasound clinician then measured the AHD in the subjects using the procedure outlined prior. Two measurements were taken at each angle and averaged for the Post-Intervention Value 2 (PIV2). Next, the Kinesio® Tape was removed and the skin was cleansed with an alcohol preparation pad. Following tape removal, the participant was asked to sit in a self-determined position with his/her arm at his/her side for 15 minutes. After 15 minutes, an AHD measurement was taken twice using the procedure

outlined prior at each angle of abduction. These measurements were then averaged and recorded as the Post-Tape Removal Value (PTRV).

#### **4.3.4. Statistical Analysis**

Statistical analysis for the approved research was computed using SPSS software (Version 23.0). Patient outcome data (SPADI) were analyzed with a repeated measures analysis of variance (ANOVA) model. In order to analyze differences in AHD, additional ANOVAs were employed to examine the within-subject and between-group models at the four separate intervals. All tests used a significance level of 5%. No data transformations were necessary.

#### **4.4. Results**

The repeated measures ANOVA model for the SPADI measurements was statistically significant in terms of both time ( $F[1.56, 23.44] = 37.06, P < .001$ ) and the interaction of group and time ( $F[1.56, 23.44] = 7.01, P = .007$ ). The between-subjects effect due to taping technique was significant only at the 10% level ( $F[1, 15] = 3.11, P = .098$ ). Therefore, pain reduction was significant over time, but the difference between the two groups was not significant at the 5% level. In the pain subset of the SPADI, scores were significantly lower in both groups over time ( $F[1.823, 27.35] = 31.00, P < .001$ ), but were only significant at the 10% level in the interaction of group and time ( $F[1.823, 27.35] = 2.96, P = .073$ ) and the between-subjects effect ( $F[1, 15] = 3.91, P = .067$ ). Additionally, the disability subset yielded significant results in terms of time ( $F[1.52, 22.80] = 25.88, P < .001$ ) and the interaction of group and time ( $F[1.52, 22.80] = 9.81, P = .002$ ). However, in this subset, the between-subjects effect due to technique was not significant ( $F[1, 15] = 2.28, P = .152$ ). All participants, regardless of taping technique, reported lower SPADI scores at the conclusion of the experiment (Table 5).

No statistically significant difference was found in AHD at any of the four angles or any of the diagnostic ultrasound scans (Tables 6-9). Overall, US measurements of participants' AHD in either group did not differ from their baseline measurements immediately after taping, after 48 hours, or after tape removal.

**Table 6:** Effect of Kinesio® Tape on Mean Self-Reported SPADI Scores Over Time

<b>Time</b>	<b>SPADI Pain Subset Score</b>			<b>SPADI Disability Subset Score</b>			<b>SPADI Total Score</b>		
	Base	24H	48H	Base	24H	48H	Base	24H	48H
<b>Experimental</b>	25.2±7.2	16.8±6.2	11.7±6.0	23.6±9.52	12.2±6.29	12.0±8.79	48.8±15.9	29.0±10.45	22.3±14.48
<b>Control</b>	17.7±3.37	13.1±7.34	10.4±6.70	12.1±6.23	10.8±7.29	9.2±6.99	29.8±8.43	23.9±13.89	21.3±12.89



**Table 7:** Effect of Kinesio® Tape on AHD at 0° Over Time

	<b>Acromiohumeral Distance (mm)</b>			
	<b>BLV</b>	<b>PIV1</b>	<b>PIV2</b>	<b>PTRV</b>
<b>Experimental</b>	12.1±1.97	12.5±1.73	12.3±1.63	12.2±2.31
<b>Control</b>	13.1±1.59	12.7±1.26	12.7±0.98	12.4±0.85

**Table 8:** Effect of Kinesio® Tape on AHD at 60° Over Time

	<b>Acromiohumeral Distance (mm)</b>			
	<b>BLV</b>	<b>PIV1</b>	<b>PIV2</b>	<b>PTRV</b>
<b>Experimental</b>	10.6±1.72	9.58±1.80	9.53±2.08	9.78±1.73
<b>Control</b>	10.5±1.90	10.2±2.09	10.3±2.06	9.84±2.43

**Table 9:** Effect of Kinesio® Tape on AHD at 90° Over Time

	<b>Acromiohumeral Distance (mm)</b>			
	<b>BLV</b>	<b>PIV1</b>	<b>PIV2</b>	<b>PTRV</b>
<b>Experimental</b>	10.2±1.37	9.73±1.53	9.08±1.55	9.41±1.26
<b>Control</b>	10.3±2.53	10.3±2.63	9.97±2.92	9.32±1.59

**Table 10:** Effect of Kinesio® Tape on AHD at 120° Over Time

	<b>Acromiohumeral Distance (mm)</b>			
	<b>BLV</b>	<b>PIV1</b>	<b>PIV2</b>	<b>PTRV</b>
<b>Experimental</b>	9.23±2.75	8.65±2.63	8.31±2.13	9.31±3.04
<b>Control</b>	8.94±2.33	8.12±2.19	7.83±1.60	8.68±2.27

#### **4.5. Discussion**

The prevalence of subacromial impingement syndrome beckons new treatments, one of which is using Kinesio® Tape in conjunction with other typical therapies. This is the first study to quantify the

effect Kinesio® Tape has on the AHD in people with subacromial impingement syndrome. The results of this research will give practitioners a better understanding of how this modality may aid patients with subacromial impingement syndrome.

To qualify for the study, participants had to demonstrate the presence of pathology, indicated by three orthopedic special tests: Painful Arc, Hawkins-Kennedy, and External Rotation Muscle tests.

Interestingly, all participants except one demonstrated a positive Painful Arc, and all participants were found to have positive Hawkins-Kennedy test results. The External Rotation Muscle test varied the most, as nine participants were found to have weakness or pain on the affected side, but eleven did not function any differently during this test as compared bilaterally. Park et al<sup>27</sup> established the clinical prediction rule of using these three tests by comparing eight tests used individually and in combination. The combination of the Painful Arc, Hawkins-Kennedy, and External Rotation Muscle tests indicated the highest post-test probability. However, when examining the results closer, the overall accuracy of the Painful Arc (76.1%) and Hawkins-Kennedy (69.7%) tests outperformed that of the External Rotation Muscle test (58.7%), which may explain the differences observed in the current study.

Participants in both groups reported decreased pain and disability outcomes; however, the SPADI results of the experimental group improved significantly more than the control group. The experimental groups' total SPADI scores decreased 26.5 points, but the control groups' SPADI score only decreased by 8.5 points. The creators of the SPADI determined the minimal detectable change with a 90% confidence interval to be 13 points; therefore, the experimental group satisfies this finding, but the control groups' decrease may have been due to chance. The AHD did not change significantly when compared across groups. These results suggest that while Kinesio® Tape did not alter the space available for the subacromial structures, it apparently decreased pain through a separate pathway and this decrease was

more substantial in the group with tension placed through the Kinesio® Tape. The results of this experiment only allow for speculation on what this pathway may be, but other authors have suggested pain modulation due to the gate control theory or due to increased afferent feedback as opposed to simply increasing the AHD.<sup>91</sup>

The findings of the research compliment previous findings that Kinesio® Tape may reduce pain associated with subacromial impingement syndrome. A previous study by Kaya et al<sup>8</sup> who compared relief of subacromial impingement through Kinesio® Tape and exercise to manual therapy and exercise found equal benefits in each treatment. A similar study compared patient-reported outcomes between a group receiving Kinesio® Tape and a group receiving physical therapy modalities.<sup>82</sup> The Kinesio® Tape group reported better outcomes than the physical therapy modalities group after the first week and showed similar results after two weeks. Previous literature as well as the results of the current study make a case that Kinesio® Tape can be applied to aid in the reduction of pain associated with the symptoms of subacromial impingement syndrome, thereby aiding in patient compliance with exercises to correct pathomechanics associated with the condition.

While Kinesio® Tape is often found to be a valid treatment in subacromial impingement syndrome cases, this finding is not always consistent. Thelen et al<sup>83</sup> conducted a study to examine the efficacy of Kinesio® Tape for shoulder pain related to rotator cuff tendonitis or impingement. Using similar taping techniques as the current study, the authors did not find any statistically significant decrease in pain immediately after, 3 days after, or 6 days after application, but did find significant increase in immediate shoulder abduction ( $P = .005$ ). Interestingly, both the experimental and the sham group reported better outcomes at the end of the study; however, it was not significant ( $P > .05$ ).

Results reported by Thelen et al align with the current study, where both the experimental group and the control group experienced a decrease in pain and disability.

Research examining the effect of Kinesio® Tape on the AHD is minimal, although it was the subject of one study conducted by Luque-Suarez et al.<sup>84</sup> In this study, healthy participants were divided into three groups, with different taping techniques in each. The authors found an increase in AHD in the two experimental groups as compared to the control group and concluded that Kinesio® Tape can immediately increase the AHD in healthy tissue. Notably, neither of the two experimental groups utilized the taping techniques recommended by Kase et al<sup>13</sup> which were applied to the participants in the current research project. The results of the current study contrast the results reported by Luque-Suarez et al, as no change in AHD was significant at any time period or angle of abduction.

Similarly, a recently published manuscript examined how different Kinesio® Tape applications affect the subacromial space as measured by diagnostic US. Lyman et al<sup>85</sup> conducted a study investigating three different applications: inhibition of the deltoid, inhibition of the supraspinatus, and inhibition of both deltoid and supraspinatus. AHD was then measured with diagnostic US after a five minute period of time. Results of this study indicated an initial increase in AHD with deltoid inhibition and supraspinatus inhibition, but not when used in combination. The current research study aimed to address some limitations of this study including recruiting symptomatic individuals, measuring AHD at different angles of humeral abduction, and obtaining subjective SPADI measurements in addition to the US values. Additionally, the current research project utilized a combined taping method of deltoid and supraspinatus inhibition, for which Lyman et al also found no statistically significant increase in AHD.

This research study is not without limitations due to the numerous variables present. First, this study was limited to participants between the ages of 18 and 55; therefore, the results will not be

generalizable to populations outside of this age range including pediatric and geriatric patients.

Additionally, participants clearly presented with varying severity of subacromial impingement as noted by their baseline SPADI scores. Parameters for differentiating severities of this condition have not been clearly outlined in previous literature, but Kinesio® Tape may impact them differently. Finally, the AHD measurement at 120° of glenohumeral abduction was difficult to obtain and ultimately unreliable in this study. Researchers of the current study recommend using alternate methods to measure AHD at this angle of abduction if this is a desired measurement.

Future research on this topic should aim to investigate the reason why SPADI scores were decreased in all participants regardless of taping tension. Studying muscle activation in participants with subacromial impingement syndrome with regards to Kinesio® Tape may give insight into the mechanism of pain reduction. Additionally, since the AHD did not statistically significantly increase with the Kinesio® Tape application, future research should consider various Kinesio® Taping techniques to explore if any technique may increase the AHD in symptomatic individuals.

#### ***4.6. Conclusions***

The results support the use of Kinesio® Tape to decrease pain and disability in patients with subacromial impingement syndrome. SPADI scores were lower in the group who received the inhibition technique of the supraspinatus and deltoid compared to the control group with no tension applied, but both groups significantly improved from their baseline. The AHD was not statistically affected with either group or at any of the four angles measured. The pathway by which Kinesio® Tape decreases pain remains a question; however, Kinesio® Tape may confidently be used to aid patients with pain and disability in the treatment of subacromial impingement syndrome.

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## **APPENDIX A. INFORMED CONSENT**

### **NDSU North Dakota State University**

Health, Nutrition and Exercises Science  
Department #2620, PO Box 6050  
Fargo, ND 58108-6050  
701-231-5590

**Title of Research Study:** The Effects of Kinesio® Tape on Acromiohumeral Distance in Patients with Subacromial Impingement Syndrome

#### **This study is being conducted by:**

Dr. Katie Lyman, HNES Assistant Professor, [Katie.Lyman@ndsu.edu](mailto:Katie.Lyman@ndsu.edu), office number: (701)231-8208

Nicholas Sample, HNES Advanced Athletic Training Masters Student, [nicholas.sample@ndsu.edu](mailto:nicholas.sample@ndsu.edu), cell number: (314) 971-5548

#### **Why am I being asked to take part in this research study?**

We are looking for 20 participants between the ages of 18 and 55 in the Fargo-Moorhead region. You will not be allowed to participate if you have had: 1) shoulder surgery in the past year; 2) symptoms related to impingement occurring for less than one month; 3) have a neurological impairment (Parkinson's, nerve entrapment, multiple sclerosis, ALS, etc.); 4) prior history of general medical conditions involving joints, muscles, bones or connective tissue such as fibromyalgia, osteoporosis, etc., 5) reported allergies to Kinesio Tex Tape® or any other adhesive material, or 6) any contraindications for the usage of Kinesio® Tape.

#### **What is the reason for doing the study?**

Kinesio® Tape is a modality used by many members of the medical community including athletic trainers and physical therapists. However, use of Kinesio® Tape continues to be a controversial treatment option due to lack of consistent evidence. While the effects of Kinesio® Tape on shoulders is a popular topic, no previous research design has investigated the effect that the recommended application has on the objective measure of acromiohumeral distance in individuals with symptomatic impingement. Overall, this study will aid clinicians in determining if Kinesio® Tape is a viable treatment option in patients with subacromial impingement syndrome.

### **What will I be asked to do? What information will be collected about me?**

You will come to the Bentson Bunker Fieldhouse, room 14 wearing a shirt that can be removed or has easy access to the shoulder. You will be asked to read the consent form, ask any questions you may have, sign the consent form, and complete the Health History Questionnaire. Next, a certified athletic trainer will test your shoulder by attempting to reproduce your pain. If the athletic trainer confirms the diagnosis of subacromial impingement, you will be asked to complete the SPADI and your shoulder will be cleaned and excess body hair will be trimmed with scissors. Then, an ultrasound probe with ultrasound gel will be placed on your lateral shoulder. You will be asked to hold your shoulder in 4 different positions, as tolerated, for the measurements. After your shoulder has been measured, it will be cleansed again if necessary and then taped with Kinesio® Tape. A second series of ultrasound measurements will then be taken. If possible, we would like you to wear the tape for 48 hours while you complete your normal daily activities including working out, showering, etc. You will be given a second SPADI form to fill out at the 24 hour mark. If at any time you feel discomfort, you should remove the tape and contact Katie Lyman. If you are able to wear the tape for the entire 48-hour period, we want you to return to the lab to undergo follow up ultrasound measurements and to remove the Kinesio® Tape. The researchers have been trained and are qualified to perform all of the techniques (diagnostic ultrasound use and Kinesio Taping® Methods).

### **Where is the study going to take place, and how long will it take?**

The study will be completed on the North Dakota State University campus in the Bentson Bunker Fieldhouse Research Laboratory in room 14. Filling out all of the paperwork (consent form, HHQ) and all of testing will be completed in two visits spaced 48 hours apart. Each session will take no more than 45 minutes each.

### **What are the risks and discomforts?**

You may feel slight physical discomfort after the Kinesio Tape has been applied. The session will be stopped at any time and tape removed upon request. Most people do not have any adverse reaction to the Kinesio® Tape and do not notice it as they are completing activities of daily life. During the ultrasound measurement, you may be asked to hold your shoulder in an uncomfortable position. If pain with this position is significant, this measurement will not be taken. It is not possible to identify all potential risks in research procedures, but the researchers have taken reasonable safeguards to minimize any known risks to the participant.

### **What are the benefits to me?**

This study could yield useful information, including a treatment technique that may alleviate your symptoms related to subacromial impingement syndrome. However, you may not get any benefit from being in this research study.

**What are the benefits to other people?**

This study could discover useful information for athletic trainers, physical therapists, and any other health care professionals who use the Kinesio Taping® Methods for subacromial impingement syndrome.

**Do I have to take part in the study?**

Your participation in this research is your choice. If you decide to participate in the study, you may change your mind and stop participating at any time without penalty or loss of benefits to which you are already entitled.

**What will it cost me to participate?**

If serious injury or distress occurs during or as a result of this research, you may be taken to local care facilities where your own personal insurance will be needed to cover medical costs. We deem the risk of this to be low based on the precautions taken and the populations being studied.

**What are the alternatives to being in this research study?**

Instead of being in this research study, you can choose not to participate.

**Who will see the information that I give?**

We will keep private all research records that identify you. Your information will be combined with information from other people taking part in the study. When we write about the study, we will write about the combined information that we have gathered. We may publish the results of the study; however, we will keep your name and other identifying information private.

We will make every effort to prevent anyone who is not on the research team from knowing that you gave us information, or what that information is. For example, your name will be kept separate from your research records. Your name and research records will be stored in different places under lock and key. If you withdraw before the research is over, your information will be removed at your request, and we will not collect additional information about you.

If you withdraw before the research is over, your information will be (retained in the research record) OR (removed at your request), and we will not collect additional information about you.

### **Can my taking part in the study end early?**

If you fail to show up to all sessions, you may be removed from the study. You may elect to end your participation in the study at any time.

### **Will I receive any compensation for taking part in this study?**

You will be compensated \$20 for the successful completion of the two sessions.

### **What happens if I am injured because of this research?**

If you receive an injury in the course of taking part in the research, you should contact Dr. Katie Lyman at the following phone number (218) 443-6446, or Nicholas Sample (314) 971-5548. If needed, he/she may refer you to local care facilities. Payment for this treatment must be provided by you and your third party payer (such as health insurance or Medicare). This does not mean that you are releasing or waiving any legal right you might have against the researcher or NDSU as a result of your participation in this research.

### **What if I have questions?**

Before you decide whether to accept this invitation to take part in the research study, please ask any questions that might come to mind now. Later, if you have any questions about the study, you can contact either researcher: Dr. Katie Lyman at (218) 443-6446 or [katie.lyman@ndsu.edu](mailto:katie.lyman@ndsu.edu) and/or Nicholas Sample at (314) 971-5548 or [nicholas.sample@ndsu.edu](mailto:nicholas.sample@ndsu.edu)

### **What are my rights as a research participant?**

You have rights as a participant in research. If you have questions about your rights, or complaints about this research, you may talk to the researcher or contact the NDSU Human Research Protection Program by:

- Telephone: 701.231.8995 or toll-free 1-855-800-6717
- Email: [ndsu.irb@ndsu.edu](mailto:ndsu.irb@ndsu.edu)
- Mail: NDSU HRPP Office, NDSU Dept. 4000, PO Box 6050, Fargo, ND 58108-6050.

The role of the Human Research Protection Program is to see that your rights are protected in this research; more information about your rights can be found at: [www.ndsu.edu/irb](http://www.ndsu.edu/irb) .

**Documentation of Informed Consent:**

You are freely making a decision whether to be in this research study. Signing this form means that

1. you have read and understood this consent form
2. you have had your questions answered, and
3. you have decided to be in the study.

You will be given a copy of this consent form to keep.

---

Your signature

---

Date

---

Your printed name

---

Signature of researcher explaining study

---

Date

---

Printed name of researcher explaining study

## 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 baby 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?

If you have any problems or any questions, please email or call Nick Sample at [nicholas.sample@ndsu.edu](mailto:nicholas.sample@ndsu.edu) or (314) 971-5548.

## APPENDIX C. HEALTH HISTORY QUESTIONNAIRE (HHQ)

# Health History Questionnaire

Please answer the following questions to the best of your ability. For the following questions, unless otherwise indicated, circle the single best choice for each question. As is customary, all of your responses are completely confidential and may only be used in group summaries and/or reports. All information collected is subject to the Privacy Act of 1974. If you have any physical handicaps or limitations that would require special assistance with this questionnaire, please let your trainer know. This form is in accordance with the American College of Sports Medicine guidelines for risk stratification when followed correctly by your trainer. Your trainer should be certified with a national organization in order to use these forms correctly.

Name: \_\_\_\_\_ Ht.: \_\_\_\_\_ Wt.: \_\_\_\_\_

Gender: \_\_\_\_\_ Age: \_\_\_\_\_ Birthdate: \_\_\_\_\_

Address: \_\_\_\_\_

City: \_\_\_\_\_ State: \_\_\_\_\_ ZIP: \_\_\_\_\_ Phone: \_\_\_\_\_

Emergency Contact: \_\_\_\_\_ Phone: \_\_\_\_\_

Personal Physician: \_\_\_\_\_ Phone: \_\_\_\_\_

E-mail: \_\_\_\_\_

1. Have you ever had a definite or suspected heart attack or stroke? ..... Yes No

2. Have you ever had coronary bypass surgery or any other type of heart surgery? ..... Yes No

3. Do you have any other cardiovascular or pulmonary (lung) disease  
(*other than* asthma, allergies, or mitral valve prolapse)? ..... Yes No

4. Do you have a history of: diabetes, thyroid, kidney, liver disease. .... Yes No  
(**circle all that apply**)

5. Have you ever been told by a health professional that you have had  
an abnormal resting or exercise (treadmill) electrocardiogram (EKG)? ..... Yes No

6. If you answered YES to any of Questions 1 through 5, please describe:

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

7. Do you currently have any of the following:
- a. pain or discomfort in the chest or surrounding areas that occurs when you engage in physical activity? .....Yes No
  - b. shortness of breath .....Yes No
  - c. unexplained dizziness or fainting .....Yes No
  - d. difficulty breathing at night except in upright position .....Yes No
  - e. swelling of the ankles (recurrent and unrelated to injury) .....Yes No
  - f. heart palpitations (irregularity or racing of the heart on more than one occasion) .....Yes No
  - g. pain in the legs that causes you to stop walking (claudication) .....Yes No
  - h. known heart murmur .....Yes No
- Have you discussed any of the above with your personal physician? .....Yes No
8. Are you pregnant or is it likely that you could be pregnant at this time? .....Yes No  
If yes, what is your expected due date? \_\_\_\_\_
9. Have you had surgery or been diagnosed with any disease in the past 3 months? .....Yes No  
If yes, please list date \_\_\_\_\_ and surgery/disease \_\_\_\_\_
10. Have you had high blood cholesterol or abnormal lipids within the past 12 months or are you taking medication to control your lipids? .....Yes No
11. Do you currently smoke cigarettes or have quit within the past 6 months? .....Yes No
12. Have your father or brother(s) had heart disease prior to age 55 OR mother or sister(s) had heart disease prior to age 65? .....Yes No
13. Within the past 12 months, has a health professional told you that you have high blood pressure (systolic  $\geq$  140 OR diastolic  $\geq$  90)? .....Yes No
14. Currently, do you have high blood pressure or within the past 12 months, have you taken any medicines to control your blood pressure? .....Yes No
15. Have you ever been told by a health professional that you have a fasting blood glucose greater than or equal to 110 mg/dl? .....Yes No
16. Describe your regular physical activity or exercise program:  
 type: \_\_\_\_\_  
 frequency: \_\_\_\_\_ days per week  
 duration: \_\_\_\_\_ minutes  
 intensity: *low*      *moderate*      *high*      (circle one)  
 BMI: \_\_\_\_\_
17. If you have answered YES to any of questions 7-16, please describe:

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

18. Are you currently under any treatment for any blood clots? .....Yes No
19. Do you have problems with bones, joints, or muscles that may be aggravated with exercise? .....Yes No
20. Do you have any back/neck problems? .....Yes No
21. Have you been told by a health professional that you should not exercise? .....Yes No
22. Are you currently being treated for any other medical condition by a physician? .....Yes No
23. Are there any other conditions (mitral valve prolapse, epilepsy, history of rheumatic fever, asthma, cancer, anemia, hepatitis, etc.) that may **hinder** your ability to exercise? .....Yes No
24. During the past six months, have you experienced any **unexplained** weight loss or gain (greater than ten pounds for no known reason)? .....Yes No

25. If you have answered YES to any of questions 18-24, please describe:

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

26. Please list below all prescription and over-the-counter medications you are currently taking:

Medicine:	Reason for taking:	Dosage:	Amount/Frequency:
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

27. Are there any medicines that your physician has prescribed to you in the past 12 months which you are currently not taking? .....Yes No

If so, please list:

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

I have answered the Health History Questionnaire questions accurately and completely. I understand that my medical history is a very important factor in the development of my fitness/wellness program. I understand that certain medical or physical conditions which are known to me, but that I do not disclose to my trainer, may result in serious injury to me. If any of the above conditions change, I will immediately inform my trainer of those changes. I, knowingly and willingly, assume all risks of injury resulting from my failure to disclose accurate, complete, and updated information in accordance with the attached questionnaire. I also understand that in order to properly risk stratify my Health History Questionnaire, my trainer should have a minimum of a national certification as a personal trainer. My trainer also verbally explained this statement to me to my understanding.

Client's Signature: \_\_\_\_\_ Date: \_\_\_\_\_

Trainer's Signature: \_\_\_\_\_ Date: \_\_\_\_\_

**For Use by the Personal Trainer ONLY**

Check the identified ACSM major coronary risk factors below:

- |  |  |
|--|--|
| <input type="checkbox"/> Lipids (TCH $\geq$ 200 OR HDL $<$ 35)       | <input type="checkbox"/> Cigarette Smoking (or quit within the past 6 months)        |
| <input type="checkbox"/> Family History                              | <input type="checkbox"/> High Blood Pressure/Blood Pressure Medications              |
| <input type="checkbox"/> Diabetes/glucose $\geq$ 110 mg/dl           | <input type="checkbox"/> Sedentary   |
| <input type="checkbox"/> BMI $\geq$ 30                               | <input type="checkbox"/> Pregnancy   |
| <input type="checkbox"/> Metabolic Disease                           | <input type="checkbox"/> Respiratory Disease (asthma, emphysema, chronic bronchitis) |
| <input type="checkbox"/> Signs or Symptoms of Cardiovascular Disease |  |
| <input type="checkbox"/> Cardiovascular Disease                      |  |

**Risk Stratification**

- Apparently Healthy
- Apparently Healthy Male  $\geq$  45; Female  $\geq$  55
- High Risk, No Signs or Symptoms
- High Risk, with Signs and Symptoms
- Known Disease
- Pregnancy

**Factors**

- One or No Risk Factors (No medical clearance required)
- One or No Risk Factors (Initial medical clearance required)
- Two or More Risk Factors (medical clearance required)
- One or More Signs/Symptoms With or Without Risks (medical clearance required)
- Diagnosed Cardiopulmonary/Metabolic Disease (annual medical clearance required)
- Medical Clearance Required

**All clients needing written medical clearance from their personal physician must give it to their trainer prior to beginning their exercise program.**

Additional Comments: \_\_\_\_\_

**Health History Questionnaire** follows the American College of Sports Medicine recommendations for risk stratification. This must be performed on all clients in order to determine the need for medical clearance and/or exercise modifications. Any trainer or those making exercise recommendations should be certified in the proper use of the risk stratification process through a national organization.

If a client has a YES response to anything on page 1, he/she has KNOWN DISEASE, and must have medical clearance prior to beginning exercise.

If he/she has a YES response to anything on #7 a-h on page 2, your client is HIGH RISK WITH SIGNS/SYMPTOMS and must have medical clearance prior to exercise. If your client has a YES response to questions # 8 or 9, he/she must have medical clearance.

YES responses to two or more on questions 10-16 on page 2, your client is HIGH RISK WITHOUT SIGNS OR SYMPTOMS and must have medical clearance (unless he/she also has a YES answer in question #7 making them still HIGH RISK WITH SIGNS/SYMPTOMS).

All other questions on page 3 are at your own discretion. Remember, **when in doubt, refer out.** Please also refer to the most recent edition of *ACSM's Guidelines for Exercise Testing and Prescription* (Williams & Wilkins) as well as the most recent edition of the *ACE Personal Trainer Manual* (American Council on Exercise) for more explanations on the risk stratification. It is your responsibility as a trainer to remain updated on all changes or modifications for risk stratification in determining the need for medical clearance and exercise modifications/recommendations.

Thank you for using Premier Performance, Inc. Fitness Forms. Due to copyrights, you are not allowed to modify these forms in any way without the expressed written permission of Premier Performance, Inc. You are also not allowed, by law, to sell these forms or modifications thereof.

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## APPENDIX D. SHOULDER PAIN AND DISABILITY INDEX (SPADI)

### Shoulder Pain and Disability Index

Please place a mark on the line that best represents your experience during the last week attributable to your shoulder problem.

#### Pain scale

##### How severe is your pain?

Circle the number that best describes your pain where: 0 = no pain and 10 = the worst pain imaginable.

At its worst?	0	1	2	3	4	5	6	7	8	9	10
When lying on the involved side?	0	1	2	3	4	5	6	7	8	9	10
Reaching for something on a high shelf?	0	1	2	3	4	5	6	7	8	9	10
Touching the back of your neck?	0	1	2	3	4	5	6	7	8	9	10
Pushing with the involved arm?	0	1	2	3	4	5	6	7	8	9	10

Total pain score \_\_\_\_\_/50 x 100 = \_\_\_\_\_%

(Note: If a person does not answer all questions divide by the total possible score, eg. if 1 question missed divide by 40)

#### Disability scale

##### How much difficulty do you have?

Circle the number that best describes your experience where: 0 = no pain and 10 = the worst pain imaginable.

Washing your hair?	0	1	2	3	4	5	6	7	8	9	10
Washing your back?	0	1	2	3	4	5	6	7	8	9	10
Putting on an undershirt or jumper?	0	1	2	3	4	5	6	7	8	9	10
Putting on a shirt that buttons down the front?	0	1	2	3	4	5	6	7	8	9	10
Putting on your pants?	0	1	2	3	4	5	6	7	8	9	10
Placing an object on a high shelf?	0	1	2	3	4	5	6	7	8	9	10
Carrying a heavy object of 10 pounds (4.5 kilograms)	0	1	2	3	4	5	6	7	8	9	10
Removing something from your back pocket?	0	1	2	3	4	5	6	7	8	9	10

Total disability score \_\_\_\_\_/80 x 100 = \_\_\_\_\_%

(Note: If a person does not answer all questions divide by the total possible score, eg. if 1 question missed divide by 70)

Total Spadi score \_\_\_\_\_/130 x 100 = \_\_\_\_\_%

(Note: If a person does not answer all questions divide by the total possible score, eg. if 1 question missed divide by 120)

Minimum Detectable Change (90% confidence) = 13 points  
(Change less than this may be attributable to measurement error)

Source: Roach et al. (1991). Development of a shoulder pain and disability index.

## APPENDIX E. INSTITUTIONAL REVIEW BOARD APPROVAL



March 6, 2017

Dr. Katie Lyman  
Health, Nutrition & Exercise Sciences

IRB Approval of Protocol #HE17152, "The Effects of Kinesio® Tape on Acromioclavicular Distance in Patients with Subacromial Impingement Syndrome"

Co-investigator(s) and research team: Nicholas Sample, Kassian Landin

Approval period: 3/6/2017 to 3/5/2018  
Continuing Review Report Due: 2/1/2018

Research site(s): NDSU Funding Agency: n/a  
Review Type: Expedited category # 4  
IRB approval is based on the revised protocol submission (received 2/17/2017).

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.

Other institutional approvals:

- Research projects may be subject to further review and approval/disapproval.

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,

Kristy Shirley, CIP, Research Compliance Administrator

For more information regarding IRB Office submissions and guidelines, please consult [www.ndsu.edu/irb](http://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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