A Comparison Between People With and Without Subacromial Impingement Syndrome and a New Method for Measuring Thoracolumbar Fascia Flexibility

Kubra Sarioglu, PT, MSc, [a] and Nihan Ozunlu Pekyavas, PT, PhD [b]

Abstract

Objective: The purpose of this study was to compare the flexibility of the thoracolumbar fascia (TLF) in individuals with and without subacromial impingement syndrome (SAIS). A secondary purpose was to demonstrate a new method for measuring TLF flexibility.

Methods: A total of 60 participants—30 diagnosed with SAIS and 30 asymptomatic—were included. In both groups, trunk flexibility was assessed by the modified Schober test, TLF flexibility by rotational measurement on a goniometric platform, and shoulder posterior capsule tightness by tape measurement. The data obtained were compared using *t* tests for independent variables.

Results: No statistically significant difference was observed for any parameter between participants with SAIS and healthy controls ($P > .05$).

Conclusion: For the participants we studied, the flexibility of the TLF was not associated with SAIS. The goniometric evaluation method used in this study was affordable and feasible. The validity and reliability of this measurement method should be assessed further in future studies. (J Chiropr Med 2021;20;9-15)

Key Indexing Terms: *Pliability; Fascia; Shoulder; Lumbosacral Region*

Introduction

Subacromial impingement syndrome (SAIS) is a common disorder of the shoulder, resulting in functional loss and disability in patients.[1] This musculoskeletal disorder affects structures of the subacromial space, which are the tendons of the rotator cuff and the subacromial bursa. It is caused by various factors. Evidence exists to support the presence of anatomic factors of inflammation of the tendons and bursa, degeneration of the tendons, weak or dysfunctional rotator cuff musculature, weak or dysfunctional scapular musculature, posterior glenohumeral capsule tightness, postural dysfunctions of the spinal column and scapula, and bony or soft tissue abnormalities of the borders of the subacromial outlet. These may cause dysfunctional glenohumeral and scapulothoracic movement patterns. These various mechanisms, alone or in combination, may cause SAIS.[1-3] The factors that determine SAIS include weakness in the rotator cuff muscles, shortness of the posterior capsule, weak scapulohumeral rhythm, and muscle imbalance between the muscle forces that lead to the upward rotation of the scapula. Athletes and overhead workers have a different pattern of scapular kinematics compared with the general population; the scapular plane is most likely to demonstrate altered kinematics.[4]

The fascia is a system of connective tissue fibers as part of the skin. It spreads all over the body and is an ongoing 3-dimensional network for stability and mobility of body structures.[5,6] The insertion of collagen fibers of the interspinous ligaments on the thoracolumbar fascia (TLF) firmly anchors the ligament to the spinal column while transmitting the tension of the TLF to the interspinous ligament. For example, when a weight is being lifted, the contraction of the abdominal muscles stretches the TLF and consequently the interspinous ligament. The stabilization of the spinal column by the erector spinae muscles is synchronized in this manner.[7] The posterior part of the interspinous ligament, which inserts into soft tissue such as the supraspinous ligament, participates in movement coordination. It perceives tension either produced by the paravertebral muscles or transmitted to the supraspinous ligament from the TLF. In effect, in this region, fibers with origins from

[a] Upright Pilates Studio, Ankara, Turkey.
[b] Baskent University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Ankara, Turkey.
Corresponding author: Nihan Ozunlu Pekyavas, Başkent Üniversitesi, Sağlık Bilimleri Fakültesi, Fizyoterapi ve Rehabilitasyon Bölümü, Bağlıca Kampüsü Eskişehir Yolu 18.km 06790 Etimesgut, Ankara, Turkey.
(e-mail: *nihan_2002@hotmail.com*).
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various structures—the supraspinous and interspinous ligaments, TLF, and paravertebral muscles—cross each other.[6]

The TLF provides load transfer between the arm motions and is crucial. Posterior movement of the arm on the sagittal plane is effected by monoarticular (teres major or the part of the deltoid attached to the scapular spine) and biarticular fibers (latissimus dorsi and the long head of the triceps). The center of coordination of these forces is over the muscle belly of the teres major, behind the posterior axillary wall. Internal rotation of the shoulder is effectuated by monoarticular (subscapularis) and biarticular fibers (pectoralis major and latissimus dorsi). The center of coordination of these forces is beneath the pectoralis major tendon over the coracoclavicular fascia, which is continuous with the subscapularis muscle.[6] The TLF is a crucial aponeurotic fascia that provides load transfer between the trunk and limbs and helps maintain lumbosacral region stabilization.[5,6] It is considered crucial for the strength of the latissimus dorsi and gluteus maximus muscles. It also constitutes a major area where apical (paraspinal muscles) and hypaxial (anterior trunk muscles) muscles are joined together.[5] The posterior layer of the TLF can be considered a large retinaculum. This structure allows proper balance and power distribution. It has been reported that the contralateral upper and lower limbs provide power transfer, particularly during walking and running, by pendulum-like movements.[5]

On the basis of this information, we wanted to investigate and evaluate the flexibility of the TLF in people with SAIS. Therefore, the purpose of this study was to evaluate the flexibility of the TLF in individuals with and without SAIS. We hypothesized that there would be differences between the groups.

Methods

Participants

The study included 30 asymptomatic participants and 30 participants aged 20 to 40 years who were diagnosed with SAIS by a medical physician and referred to Baskent University Hospital's Physical Medicine and Rehabilitation Department. The participants with SAIS had symptom duration of 62.0 ± 8.0 days. The exclusion criteria were problems in the shoulder soft tissue or bone tissue (rotator cuff tear, glenohumeral joint problem, etc) other than SAIS; failure to perform 90° shoulder flexion because of joint limitation of motion or pain above 8 according to a visual analog scale; body mass index > 25); lumbar surgery; lumbar pain problems in the past 6 months; scoliosis; radiological diagnosis of kyphosis; herniation of thoracic or lumbar regions diagnosed by magnetic resonance imaging; sacroiliac joint problems; limited pelvic joint range of motion (anterior-posterior pelvic tilt); and scapular dyskinesia. Of the 65 people recruited, 2 were not included because they had experienced back pain within the last 6 months, 2 were diagnosed with lumbar hernia, and 1 was excluded because body mass index was more than 25. An experienced physiotherapist performed all measurements. The flowchart of the study is shown in Figure 1.

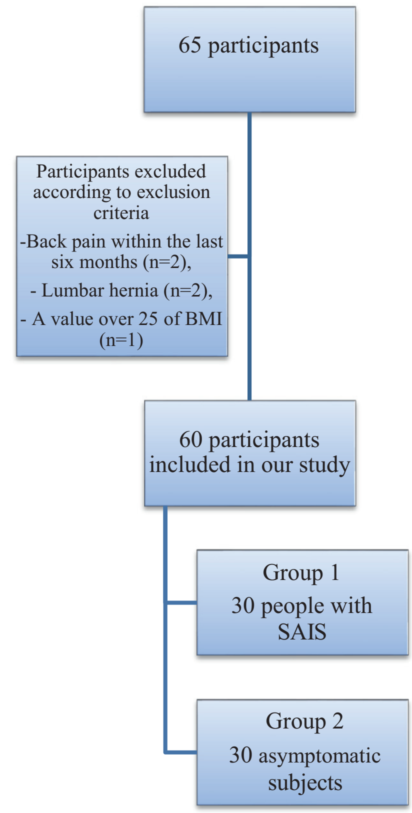

Fig 1. *Flowchart of the study.*

Measures

Trunk Flexibility. Trunk flexibility was assessed using the modified Schober test. The physiotherapist stood behind the individual, marking the midpoint of the line connecting posterior superior iliac spines. An area 10 cm above this point and 5 cm below was determined by tape measurement. The distance between these 2 points was measured while the person was asked to perform a maximum lumbar flexion. If the distance between the 2 measurements was shorter than 5 cm, this suggested that lumbar movement was not flexible.[8-10] The test has been found moderately valid ($r = 0.67$) and excellently reliable (intraclass correlation coefficient > 0.91).[8]

TLF Flexibility. During TLF flexibility test, the TLF or latissimus dorsi was considered to be less flexible if the individual rotated less compared with the other side.[8-10] In addition to this evaluation, a more objective evaluation platform was established in this study. A large goniometric evaluation platform made of plastic was placed on the table

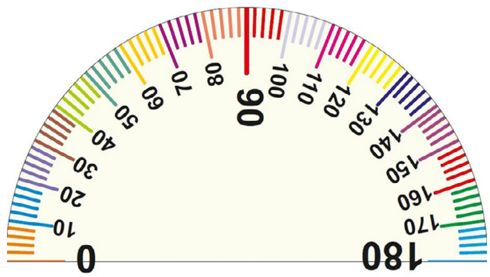

Fig 2. *Goniometric platform.*

in front of the participant (Fig 2).[8-10] The posterior superior iliac spines of the participant were fixed by the physiotherapist (Fig 3A, 3B). It was requested that the arms follow the trunk rotation, with verbal warnings. The extent of trunk rotation was marked on the goniometric platform (with a 90° shoulder flexion, and a marker pen clamped between the hands in front of the body). Rotational angle (in degrees) was recorded 3 times in the same direction, and the mean of the 3 measurements calculated.

We also analyzed the reliability of this new measurement. The reliability of our measurement was determined by the Cronbach's α coefficient, which is the intraclass correlation coefficient. The α values for right and left rotation were 0.80 and 0.96, respectively. The results were found statistically significant; α values greater than 0.07 showed us that the test can be used reliably.

Shoulder Posterior Capsule Tightness. Shoulder posterior capsule tightness was measured with a tape measure. The participant was positioned in the side-lying position on the bed, with the hip and knee flexed. The scapula of the side to be measured by the physiotherapist was fixed, and the arm placed in horizontal abduction. The distance between the olecranon and the bed was measured and recorded in centimeters (Fig 4).[8] The test has been found reproducible, with an intraclass correlation coefficient of 0.80.[11]

Ethics

The study protocol was approved by Baskent University Ethics Committee, and written consent was obtained from all participants. The clinical trial number is NCT03415438. According to the sample-size analysis, 30 participants per group were required to provide 80% power. The primary output was determined as TLF flexibility. All participants were assessed once for the study measurements by an experienced physiotherapist, and all provided consent to participate.

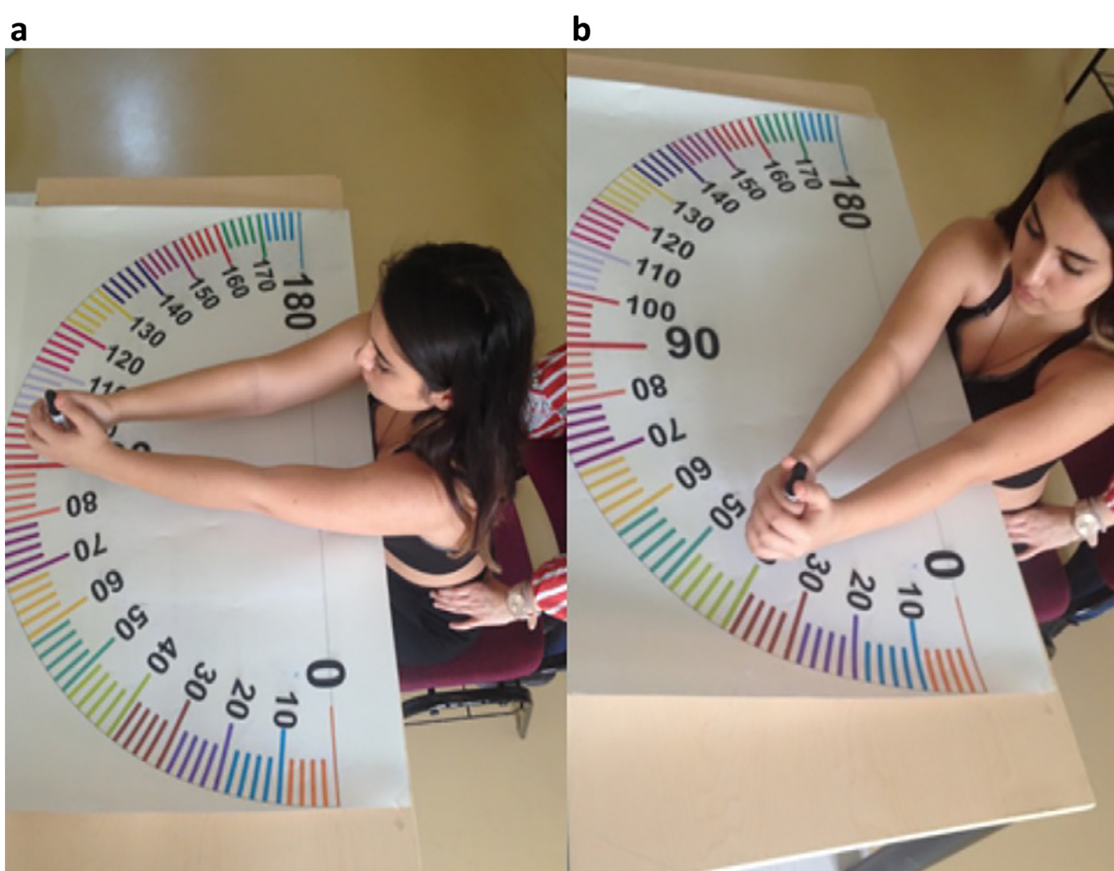

Fig 3. *Measurement of the flexibility of the thoracolumbar fascia with the goniometric platform: beginning (A) and end position (B).*

Fig 4. *Shoulder posterior capsule tightness assessment.*

Statistical Analysis

The mean (±SD) and percentage were calculated for numerical data, with confidence intervals of 95% ($P < .05$). The data were analyzed using statistical software (SPSS version 18, SPSS Inc, Chicago, Illinois). The normality of the groups in terms of descriptive statistics was analyzed using the Levene test. The data obtained were compared using *t* tests for independent variables.[12]

Results

Descriptive statistics of the participants are shown in Table 1. No statistically significant difference was found between the groups regarding lumbar flexibility or shoulder posterior capsule tightness ($P > .05$). Similarly for the primary outcome of this study, no statistically significant difference between the groups was found in TLF flexibility for either side (right, $P = .789$; left, $P = .971$; Table 2).

Discussion

We aimed to investigate the effects of SAIS on TLF flexibility. We found in this group of participants that the TLF was not associated with shoulder pathologies such as SAIS. We also describe a new evaluation method for TLF flexibility.

Table 2. *Comparison of the 2 Groups in Terms of Assessment Parameters*

Parameter	Group 1 (SAIS; n = 30)	Group 2 (Control; n = 30)	*P*
TLF flexibility, °			
Right	73.97 ± 10.31	73.20 ± 12.04	0.789
Left	74.00 ± 9.32	73.91 ± 9.45	0.971
Trunk flexibility, cm	10.83 ± 4.54	10.16 ± 3.64	0.123
Shoulder posterior capsule tightness, cm	11.80 ± 3.29	10.60 ± 2.29	0.107

Values are expressed as mean ± SD, and *t* tests were used for comparison of indepenent variables.
SAIS, subacromial impingement syndrome; *TLF*, thoracolumbar fascia.
t test.

Collagen fibrils are held together by glycosaminoglycans (group of mucopolysaccharides). This structure is thought to be like mucosa or gelatin.[13] Collagen fibrils are solid, sticky, liquid, and oily. Mucosa opens and closes to absorb water, and can even bind a small amount of water to itself. Depending on the chemical structure, the strata tie together and allow sliding on each other. The fibrils have a sliding background on the sticky glycosaminoglycans.[14,15] This elongates the muscle or shifts the "stretch" fibrils. The less the water content, the weaker this viscoelastic (quality of plasticity) property. Although fascial elasticity is not clearly defined in the literature, several researchers emphasize fascial plasticity.[14,15] We found that the TLF was not associated with shoulder pathologies such as SAIS. In addition, the inclusion of younger participants (<40 years) in this study may have affected the loss of fluid in the fascia, with less effect on fascial flexibility. Differences in fascial aging may affect its motion pattern and may have a direct effect on its flexibility over the years.[5]

According to another study, nature's continuous evolution toward greater velocity has resulted in the migration of the limbs under and parallel to the trunk.[16] To elevate the

Table 1. *Descriptive Statistics of the Participants*

Statistic	Group 1 (SAIS; n = 30)	Group 2 (Control; n = 30)	Total (n = 60)	*P*
Age, y	24.83 ± 7.1	21.57 ± 4.53	23.20 ± 5.9	0.001[a]
Height, cm	165.33 ± 15.70	165.27 ± 10.11	165.3 ± 12.90	0.350
Weight, kg	61.53 ± 9.97	59.27 ± 11.79	60.4 ± 10.88	0.661
BMI, kg/m^2	22.91 ± 5.14	21.49 ± 1.96	22.20 ± 3.92	0.164

Values are expressed as mean ± SD.
BMI, body mass index; *SAIS*, subacromial impingement syndrome.
[a] $P < .05$.

trunk from the ground level, various modifications in the previous anatomic relationships became necessary.[6]

Plasticity occurs when tissue adapts or remodels because of imposed loads to support the load and prevent injury. Ultimately, when the applied force ceases, there should be a return to the original nondeformed state (viscoelasticity). The restoration of shape occurs by elastic recoil through hysteresis, a process known for energy utilization and loss, when tissues are loaded and subsequently unloaded. The time taken for tissue to return to normal via elastic recoil depends on the uptake of water by the tissue and whether the elastic potential has been exceeded. When loaded for any length of time, tissues lengthen and distort until a point of balance is reached. If such pressure, force, or loading is sustained, permanent deformation or fascial plasticity will result over time. The fascia organizes itself along the line of tension imposed on it, adding support to misalignment and contracting to protect the individual from any further trauma (real or imaginary). This has the potential to considerably alter organ and tissue physiology.[17] Plasticity can initially offer a supportive mechanism and structural benefits. However, once it begins to hinder movement and function, it becomes problematic and has a negative influence on the body.[18,19]

For the relationship between the TLF and shoulder movements, we wanted to evaluate the flexibility of the TLF and shoulder in terms of SAIS and non-SAIS groups. In the clinical TLF flexibility test, the person sits in a chair with the knee and hip at 90° flexion and the lumbar vertebrae in a neutral position. The person lifts the shoulders to 90° flexion, clamps the hands in front of the trunk, and rotates in 1 direction.

The TLF is deemed not flexible if the rotation to 1 side is less during a second assessment.[8-10] We wanted to provide an objective assessment method to evaluate TLF flexibility. Therefore, a goniometric platform was placed on the table in front of the participant, who was asked to move the upper extremities following trunk rotation (along with the trunk), the same as the TLF flexibility test. During the evaluation, the physiotherapist fixed the participant's posterior superior iliac spines (Fig 3A, 3B) and requested that the participant's arms follow the trunk rotation, with verbal warnings. The degree of trunk rotation was marked on the goniometric platform (with 90° shoulder flexion, and a marker pen clamped between the hands in front of the body). Rotational angle (in degrees) was recorded 3 times in the same direction, and the mean of the 3 measurements calculated.

The angle of maximum rotation was marked with a board marker placed in the participant's hands. The measurements were repeated 3 times for both sides. Our measurement method is a cheap and easy clinical test for measuring TLF flexibility. A previous study has shown "intra- and inter-rater reliability of a goniometric lower trunk rotation measurement," so we aimed to evaluate a different method, the goniometric platform.[20]

The other measurement methods are elastography and ultrasound. Imaging methods such as these are promising tools for explicitly quantifying the mechanical properties of fascial tissues under in vivo conditions.[21] Producing a distortion of the measured tissue (eg, through compression or shear waves), elastography provides ultrasound images reflecting the relative hardness of the targeted area. Recently, the technique has been increasingly applied in musculoskeletal research. However, the existence of several different methods, lack of standardization, and frequent appearance of artifact during measurements threaten the validity of the results obtained.[22] Without the use of elastography, conventional ultrasound can be reliably used to display and measure the morphology of fascial tissues, such as myofascial tissues, ligaments, and tendons.[23] Some initial studies, moreover, have attempted to quantify relative movement (eg, sliding of fascial layers and shear strain) using cross-correlation calculations.[24]

Fascia has the potential for elastic recoil and energy storage. It is dominantly shaped by tensional strain against compression, and intricately connected to the muscle. It can absorb force along its entire network and use it to great potential along with muscular coordination. The fascia of young people is oriented in a more linear manner, whereas that of older people depends on dehydration, postural adaptations, and deformation of the soft tissues in later years.[25,26] With regard to fascial elasticity and flexibility, the amount of fluid in the connective tissue fibers is crucial. We believe that the inclusion of participants with higher average age might affect the results, because the amount of fluid possessed by connective tissue fibers and their tolerance to flexion will change. In addition, although the pelvis was stabilized by the therapist and through verbal stimuli, we believe that more rigid fixation might lead to more accurate results.[26]

All layers of the TLF at the lumbar spine fuse together into a thick composite that attaches firmly to the posterior superior iliac spine and the sacrotuberous ligament. This thoracolumbar composite is in a position to assist in maintaining the integrity of the lower lumbar spine and the sacroiliac joint. The 3-dimensional structure of the TLF and its caudally positioned composite have been analyzed in light of recent studies concerning the cellular organization of the fascia and its innervation.[27] The concept of a thoracolumbar composite has been used to reassess biomechanical models of lumbopelvic stability, static posture, and movement.[28] In addition, another study describes anatomic structures as the interaction of hip, pelvic, and leg muscles with the arm and spinal muscles through the TLF. These structures allow effective load transfer between the spine, pelvis, legs, and arms—an integrated system. Specific electromyographic studies should reveal whether the gluteus maximus muscle and contralateral latissimus dorsi muscle are functionally coupled, particularly during trunk rotation. In that case, the combined action of these muscles assists in rotating the trunk while simultaneously stabilizing the lower lumbar spine and sacroiliac joints.[29]

The latissimus dorsi is the large, flat, dorsolateral muscle on the trunk, posterior to the arm and partly covered by the trapezius on its median dorsal region. The latissimus dorsi originates from the spinous processes of the T7 to T12 vertebrae, TLF, iliac crest and inferior 3 or 4 ribs, inferior angle of the scapula, and insertion on the floor of the intertubercular groove of the humerus. Authors have studied 50 cadavers at different medical colleges and found that in 2%, anterior and posterior slip of the muscle fibers involved extension up to the pectoralis major and teres major, respectively.[28] Typically, the latissimus dorsi is involved in extension, abduction, transverse extension (also known as horizontal abduction), flexion from an extended position, and internal rotation of the shoulder joint. In addition, it has a synergistic role in extension and lateral flexion of the lumbar spine. The latissimus dorsi may be used for tendon graft surgeries. A tight latissimus dorsi has been shown to be a cause of chronic shoulder and back pain. Since the latissimus dorsi connects the spine to the humerus, tightness in this muscle can manifest as either suboptimal glenohumeral joint function (which leads to chronic shoulder pain) or tendinitis in the tendinous fascia connecting the latissimus dorsi to the thoracic and lumbar spine. The latissimus dorsi is used for pedicle transplant, rotator cuff repair, and reconstruction of breast, face, scalp, and cranium defects. [30] Our study reveals the connection between the latissimus dorsi and shoulder motion and shoulder pain. It should be emphasized that in the process of rehabilitation from injuries, the fascia should also be assessed, and a holistic approach pursued. Therefore, evaluating the fascia and adding it to the treatment protocol should aim for a different point of view. Exercise programs and treatment approaches should be developed to improve fascial mobility and other parameters. Methods such as magnetic resonance imaging and ultrasonography can also be used to evaluate the fascia.[29]

Limitations

The amount of fluid in connective tissue fibers is important for fascial elasticity and hence flexibility. Since the amount of fluid that connective tissue fibers hold will change with age, we think that the inclusion of individuals with higher average age will affect the results. While the difference between the 2 groups in terms of lateral flexion in trunk range of motion is thought to be related to TLF flexibility and the contribution of the latissimus dorsi muscle to lateral flexion, it may also be associated with shortness or strength in any of the trunk muscles. Although the pelvis was stabilized by the therapist and the participant was given verbal warnings to keep the pelvis stable, it could be further fixed with the help of a belt. Participants were diagnosed with SAIS after clinical examination. The fact that it was not diagnosed with more objective methods and was not classified according to stages may have affected the study results.

Conclusion

This study showed that in our participants, the flexibility of the TLF was not associated with SAIS. The goniometric platform we used in this study offered a different perspective, and can be considered an open evaluation method. The validity and reliability of the tests used in this study need to be assessed further in future studies.

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No funding sources or conflicts of interest were reported for this study.

Contributorship Information

Concept development (provided idea for the research): K.S., N.O.P.
Design (planned the methods to generate the results): K.S., N.O.P.
Supervision (provided oversight, responsible for organization and implementation, writing of the manuscript): N.O.P.
Data collection/processing (responsible for experiments, patient management, organization, or reporting data): K.S.
Analysis/interpretation (responsible for statistical analysis, evaluation, and presentation of the results): K.S., N.O.P.
Literature search (performed the literature search): K.S., N.O.P.
Writing (responsible for writing a substantive part of the manuscript): K.S., N.O.P.
Critical review (revised manuscript for intellectual content, this does not relate to spelling and grammar checking): K.S., N.O.P.

Practical Applications

- Biomechanical changes in people with subacromial impingement syndrome were not associated with the flexibility of the thoracolumbar fascia.
- Our measurement method may be a cheap, easy clinical test of the flexibility of the thoracolumbar fascia.
- Further research should be carried out on this method.

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