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Intra-observer reliability study of lumbar segmental measurements utilizing ultrasonography

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Background: *Spinal Manipulative Therapy (SMT) benefits LBP patients, but its mechanism is not well documented. One hypothesis indicates that SMT restores interspinal movements. Ultrasound measurement (UM) of spinous process separation (SPS) assesses the intersegmental movements.*

Methods: *We used the test-retest reliability of UM between the L3, L4, L5, and S1 spinous processes on fifteen asymptomatic volunteers while lying prone on a chiropractic table. The participants then walked around for over 5 minutes, and ultrasound images were re-performed prone. UM identified the tips of the spinous processes and distances between L3-L4, L4-L5, and L5-S1. Reliability was assessed using intra-class correlation coefficient (ICC).*

Étude de la fiabilité intra-observateur des mesures segmentaires lombaires par échographie

Contexte: *La thérapie par manipulation vertébrale (TMV) est bénéfique pour les patients souffrant de lombalgie, mais son mécanisme n'est pas bien établi. L'une des hypothèses est que la TMV rétablit les mouvements intervertébraux. La mesure par échographie (UM) de la séparation de l'apophyse épineuse évalue les mouvements intersegmentaires.*

Méthodologie: *Nous avons utilisé la fiabilité de test-retest de l'UM entre les apophyses épineuses L3, L4, L5 et S1 sur quinze bénévoles asymptomatiques en position couchée sur une table de chiropratique. Les participants ont ensuite marché pendant plus de 5 minutes et les images échographiques ont été refaites en position couchée. L'UM a permis de repérer les extrémités des apophyses épineuses et de déterminer les distances entre L3-L4, L4-L5 et L5-S1. La fiabilité a été évaluée à l'aide du coefficient de corrélation intraclasse (CCI).*

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Results: *ICC values of SPS measurements were 0.982 for L3-L4, 0.992 for L4-L5, and 0.997 for L5-S1. Root-mean square difference between the two measures were 0.35mm for L5-S1, 0.36mm for L4-L5, and 0.57mm for L3-L4.*

Conclusions: *This study found UM to be reliable in measuring interspinous distance.*

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KEY WORDS: diagnostic ultrasound, intersegmental motion, low back pain, reliability, spinal manipulation, chiropractic

Résultats: *Les valeurs CCI des mesures de la séparation de l'apophyse épineuse étaient de 0,982 pour L3-L4, 0,992 pour L4-L5 et 0,997 pour L5-S1. La différence quadratique moyenne entre les deux mesures était de 0,35 mm pour L5-S1, 0,36 mm pour L4-L5 et 0,57 mm pour L3-L4.*

Conclusions: *Cette étude a montré que l'UM était fiable pour mesurer la distance interépineuse.*

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MOTS CLÉS : échographie, mouvement intersegmentaire, lombalgie, fiabilité, manipulation vertébrale, chiropratique

Introduction

Lower back pain is a common cause of pain and disability affecting many people. Chiropractic has been documented to decrease pain and disability in this population but the physiological mechanisms behind these clinical findings are not well-documented.[1-4] Clinical studies which include quantification of separation of lumbar spinous processes under various loads would be useful in determining the biomechanical effects of certain manual therapeutic procedures.[5] Assessing the reliability of ultrasound to measure the distance between bony landmarks is an essential initial step.

Measuring the forces delivered with Spinal Manipulative Therapies (SMT) and correlating them with clinical outcomes could potentially improve spine care. This new field of chiropractic force delivery lacks the proper measurements that will allow the understanding of the biomechanical mechanisms underlying the improvement of pain and disability. This knowledge may guide chiropractic force delivery in low and high velocity SMT. The objective of this study is to determine the reliability of spinous process separation using diagnostic ultrasound imaging with the participant in a prone position.

Methods

This study was approved by the Keiser University Institutional Review Board (IRB000JU21GM99). For this reliability study we recruited 15 volunteers, considered generally healthy, without low back pain. Recruitment was done by announcements in the classroom and posting notices on the university campus. All volunteers received a detailed explanation of the study and their involvement. Volunteers willing to participate signed the written informed consent. Participants were screened for any health issues that would not permit them to lie prone for at least five minutes. Pregnant women were excluded.

Volunteers were asked to lie prone on a chiropractic flexion distraction table with their anterior superior iliac spine placed two inches above the bottom of the thoracic piece. The ankle mortise rested over the foot support, and the table tension was adjusted for the patients' specific height and weight. A single ultrasound imaging sonographer using diagnostic ultrasound (*GE Model LOGIQ P9, General Electric, Chicago, IL, USA*) performed scanning using a curvilinear 2-5 MHz transducer. The sonographer has been registered with the American Registry for Diagnostic Medical Ultrasound since 1997 and has 13 years of experience as a college sonography instructor. Imaging was performed to visualize the spinous processes from L3-S1 on participants positioned as they would be for a flexion distraction treatment without any load.

After ultrasound images were taken, volunteers were asked to get off the table, walk around, and come back after five minutes. Volunteers were asked again to lie down, positioned as before, and ultrasound images of the spinous processes from L3-S1 were taken. A typical ultrasound image collected is shown in Figure 1. Measurements were made by the sonographer using the features of the software supplied by the ultrasound manufacturer and recorded by identifying the tips of the spinous pro-

Figure 1.
A photograph of volunteer in prone position, experienced sonographer performing an ultrasound scan of the lumbar spine.

cesses and distances between L3-L4, L4-L5, and L5-S1 (Figure 2). The most dorsal aspect of the spinous processes was identified and utilized as the tips for measurement purposes. Intraclass correlation coefficients (ICC) were computed using the SPSS statistical software (v28, IBM Corporation, Chicago, IL).

Results

Fifteen volunteers participated in this reliability study and were positioned on the chiropractic table per flexion distraction treatment protocols to assess pre-treatment reliability. The descriptive statistics of the participants demographics were, mean age: 31.9 years old, mean weight: 69.1kg, mean height: 170.2cm, male n= 9; female n = 6. ICC values found were 0.982 for L3-L4, 0.992 for L4-L5, and 0.997 for L5-S1. Root-mean square differences between the two measures were 0.35mm for L5-S1, 0.36mm for L4-L5, and 0.57mm for L3-L4. Table 1 demonstrates the mean distances between spinous processes.

Table 1.
Descriptive statistics on spinal process distance (mm)

Test Number	L3 – L4 Mean (SD)	L4 – L5 Mean (SD)	L5 – S1 Mean (SD)
1	26.9 (2.1)	24.7 (3.7)	15.8 (3.2)
2	27.1 (2.1)	24.8 (3.8)	15.9 (3.1)

Discussion

Participants in this study were positioned, per treatment

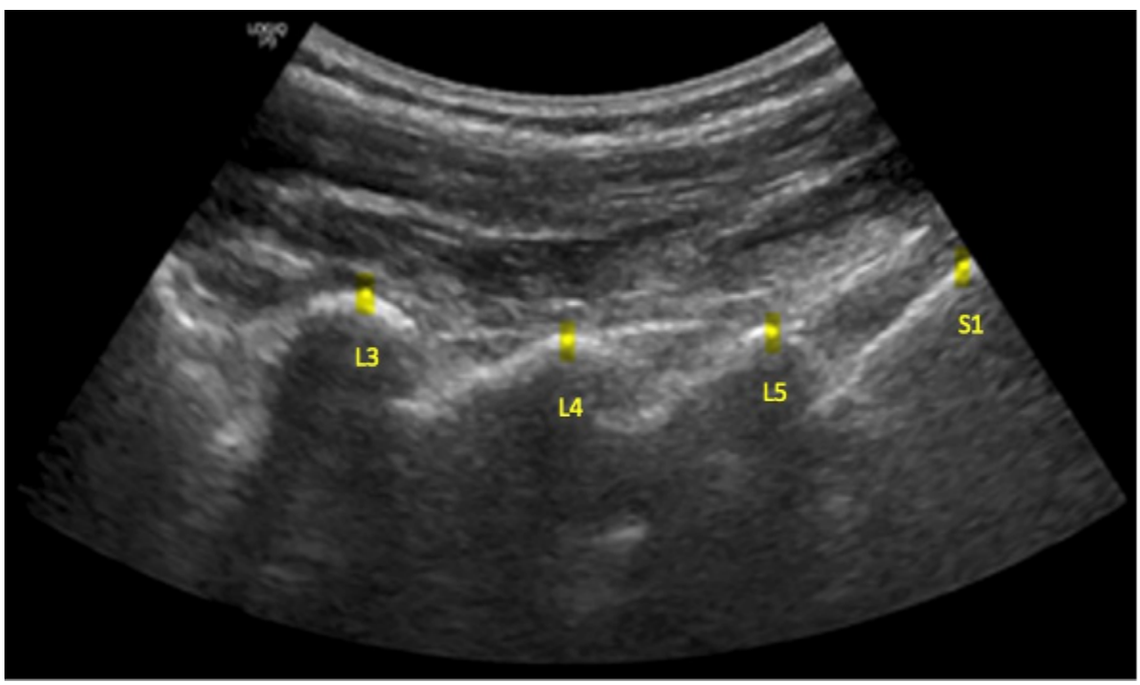

Figure 2.
Spinous process landmarks for measuring distance between vertebrae

protocols, on the flexion distraction chiropractic table before and after ambulation, to assess pre-treatment reliability. The reliability of the spinous process distance between L2 and L3 on 10 men with mean age of 21 years old has been reported and showed intra and inter examiner reliability using five different examiners. This work assessed the reliability in prone position, prone with elbow support, and kneeling with lumbar spine fully flexed and it found excellent reliability.[6] The same team repeated the reliability experiments at the levels of L1-L2, L2-L3, L3-L4, and L4-L5 in prone position, puppy posture, and kneel sitting and found excellent intra and inter-examiner reliability (ICC values greater than 0.985).[7]

A study on 20 volunteers focused on the transverse process distance to assess asymmetry found intra-examiner reliability of 0.984 and inter-examiner reliability of 0.988.8 Ishida *et al*.[9] measured the PA spinous process distance from the top of the skin contact to the top of the spinous process in eight healthy volunteers and found intra-rater reliability using ultrasound.

According to Nambi *et al*.[10] current clinical treatments, clinical perspective and directions of future therapies justify the need to model painful disc degeneration as a therapeutic platform and identify pathways as therapeutic targets for the future treatments of discogenic pain. The effectiveness of spinal traction is questioned, and ultrasound measures of force changes may answer these questions.[11]

Tozowa *et al*.[12] reported on the reliability of ultrasound to measure the distance between interspinous processes of the lumbar spine at the L1-L2, L2-L3, L3-L4, and L4-L5 levels on 10 asymptomatic men, and they concluded that using ultrasound to measure the distance between lumbar segmental interspinous processes could be applied in clinical settings to evaluate lumbar segmental mobility.

Ultrasound imaging provides excellent reliability to measure interspinous process distance compared to MRI and may offer an alternative to other imaging techniques to monitor clinical outcomes considering it is easy to use and generates consistent measurements.[13] Ultrasonographic measurements of the length of the ligamentum flavum (LF), the LF-skin distance and the interspinous distance are critical for the application of neuraxial anesthesia.[14] Manual induced sacral motion to identify the L5 and then the L4 spinous process was 78% accurate compared to 36% accurate for the inter-crestal line locating the L4 level.[15] Ultrasound is readily available, involves no radiation, and it has lower cost than MRI, CT, and other more invasive diagnostic procedures. It has limitations at this time for chiropractic use because facet joint visualization is less than desirable, however, spinous processes and interspinous spaces are well visualized as shown in this paper. The full extent of this measurement is not known but it will be studied in more detail. Further studies aim to yield new beneficial results to aid in chiropractic clinical care and outcomes for the biomechanics of spinal manipulation and mobilization.

Patients with low back pain (LBP) who respond to spinal manipulative therapy (SMT) differ biomechanically from non-responders, with responders displaying decreases in spinal stiffness and increases in multifidus thickness ratio.[16] Ultrasonography is a reliable tool for the assessment of somatic dysfunction of the lumbar spine.[17] Ultrasound can potentially be an imaging tool to the understanding of biomechanical changes seen in the lumbar spine.[6,7,12] This current study agrees with those findings.

Future studies could evaluate changes in interspinous space under various forces of SMT as a mechanistic outcome variable in clinical treatment. The level of force delivered with SMT may determine the clinical outcome.

Limitations

Limitations of this study include the small number of participants and the lack of an absolute and standardized method of determining the tip of the spinous process. Any variability in participant position on the table during the two measurements, as well as alterations that may occur from walking in between the two measurements could affect results. Limitations also include using a single sonographer. A larger scale replication of this study utilizing multiple sonographers would provide further solidifying evidence regarding the reliability of utilizing ultrasound to evaluate segmental mobility in future studies.

Conclusion

The results of this study showed excellent reliability between two interspinous process measurements at the L3-L4, L4-L5, and L5-S1 levels, taken before and after five minutes of ambulation. Comparison studies of diagnostic ultrasound with other standard imaging procedures would be beneficial to evaluate the accuracy of measuring ver-

tebral segmental motion. The authors conclude that diagnostic ultrasound may be a valuable and reliable tool to measure interspinous changes with chiropractic procedures involving delivery of various forces in future studies.

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