Establishing the Content Validity of Palpatory Examination for the Assessment of the Lumbar Spine Using Ultrasonography: A Pilot Study

K. Aaron Shaw, OMS IV; John J. Dougherty, DO; Kevin D. Treffer, DO; and Alan G. Glaros, PhD

Context: Practitioners of manipulative medicine have long sought to prove the intra- and interexaminer reliability of palpatory examinations in assessing somatic dysfunction. However, decades of research have yet to achieve the level of reproducibility needed to satisfy evidence-based criteria.

Objectives: To examine the content validity of segmental motion evaluations using ultrasonographic measurements and to investigate the implication of these results for understanding the effects of an osteopathic manipulative treatment technique—high-velocity, low-amplitude (HVLA)—applied to somatic dysfunction in the lumbar spine.

Methods: A repeated-measures design was used, with the ultrasonographer blinded to the findings for each participant. The study was divided into 2 phases: (1) palpatory and ultrasonographic examination with no treatment and (2) palpatory and ultrasonographic examination with HVLA treatment. During phase 1, measurements were taken of tissue depth corresponding to bony landmarks of the dysfunctional vertebrae. Dysfunction was identified by means of palpatory examination and captured in sequential (ie, test-retest) ultrasonographic images. Content validity of somatic dysfunction was addressed by comparing palpatory examination with ultrasonographic data. During phase 2, the same protocol for tissue depth measurements was applied to the pre- and posttreatment images for comparison.

Results: Twelve young, healthy, asymptomatic students with no contraindications to HVLA treatment were recruited at Kansas City University of Medicine and Biosciences. The test-retest reliability, as determined by a Pearson correlation coefficient, was 0.997. For all participants, objectively identified side of dysfunction correlated with palpatory evaluation of segmental motion. A within-subjects analysis of variance was performed on the raw data, corrected for lumbar lordosis, showing statistical significance for main effect for side of measurement ($P < .001$) and interaction of side and time ($P < .001$), and showed no statistically significant effect for time ($P = .259$).

Conclusion: Ultrasonography is a reliable instrument for the assessment of somatic dysfunction of the lumbar spine. The data also establish the content validity of palpatory examinations. In addition, this study provides the first objective evidence, to our knowledge, of the effect of a thrusting manipulative treatment on dysfunctional lumbar vertebrae.

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The concept of somatic dysfunction, or an alteration to the optimal mechanical state of the body with resultant effects to its functional capacity and surrounding structures, is vitally important to practitioners of manipulative medicine. Somatic dysfunction is important because of its local effect on the body and its multifaceted effect on a patient’s overall health. The manipulative medicine research community has diligently sought an objective means to identify somatic dysfunction, focusing its effort on a standardized approach with independent verification. Without a consistent and reproducible diagnostic method, however, it is difficult to establish an evidence-based use of manipulative techniques to correct dysfunction.

Somatic dysfunctions are commonly identified by palpatory examinations. Criteria used for palpatory evaluation...
of somatic dysfunction include assessing for changes in the texture of adjacent tissues, asymmetry in bony position, restricted range of motion, and tenderness to palpation.1,3 Throughout the early history of the osteopathic medical profession, somatic dysfunction was identified by components specific to each physician’s respective understanding, creating a wholly unreliable basis for osteopathic research.2 Johnston et al4 pioneered the use of standardized protocols to detect somatic dysfunction—consisting of “deep tapping” (a percussion style of palpation), tape markers, and a light cloth that mapped the location of somatic lesions—which provided one set of approaches to which investigations could be calibrated. However, despite this enhancement in reliability provided by standardization and later consensus training,9 a majority of the published protocols have failed to report a level of reproducibility (ie, results that are statistically similar among investigators and across populations) that supports the use of palpatory examination in evidence-based clinical practice.5

Protocols were developed to remove aspects of variability from previous research through the use of instruments such as electromyography,6,7 kinematic analyses,8 myoelectric data,9 and thermography.10 Researchers sought to evaluate somatic dysfunction by using a more quantifiable method that incorporated these instruments as reference standards (also known as “gold standards”) to measure the same phenomena investigated by means of palpatory examination. These studies6–10 attempted to assess the validity—defined by Najm et al11 as the accuracy of a measurement of the true state of a phenomenon—of aspects of manipulative medicine, placing a special emphasis on content validity.

Content validity is the extent to which a measure adequately and comprehensively measures what it claims to be measuring,11 assessed by the incorporation of a reference standard, which is a measure accepted as the best available for the assessment of particular phenomena. Because previous studies of manipulative medicine lacked acceptable reference standards,11 however, the full potential of this avenue of research has remained elusive. Fortunately, continuous advances in medical technology have provided new modalities to address and surmount this issue.

Ultrasonography represents one such advance in medical technology. Ultrasonography stands apart from invasive procedures (eg, surgery, histopathology, angiography)11 or radiography; it allows for the direct visualization of underlying anatomy through a noninvasive technology that is free of radiation exposure. A study by Fryer et al12—which was, to our knowledge, the first to use ultrasonography for assessing palpatory examinations—compared readings of muscle thickness from paraspinal tissues that exhibited tenderness to palpation with nontender tissues. Palpation remains a cornerstone of manipulative medical education curricula and a common technique used in clinical practice. The standard palpatory examination assesses for the asymmetrical change in position of the vertebra followed by motion testing for restriction of motion in 1 or more planes of motion.1 Additional research is needed to confirm the reliability of palpatory examinations in identifying positional asymmetry. Such studies will begin to satisfy the requirements of evidence-based medicine and support the continued use of palpation examination in osteopathic medical education by demonstrating a reliable and reproducible way to assess motion restriction. Previous research5,11,13 however, has failed to demonstrate reliable evaluation of motion restriction. In the present study, we sought to examine the content validity of segmental motion evaluations by using ultrasonographic images and to investigate the implication of these results for understanding the effects of high-velocity, low-amplitude (HVLA) treatment applied to somatic dysfunction in the lumbar spine.

Methods
Participants were recruited from the freshman and sophomore classes of the student population at Kansas City University of Medicine and Biosciences’ College of Osteopathic Medicine by announcement after daily lectures. We obtained approval from the university’s Institutional Review Board. Exclusion criteria for the study included diagnosis of chronic back pain, spondylolisthesis, spondylosis, herniated nucleus pulposus, osteopenia, osteoporosis, osteoarthritic changes in the lumbar spine, and prior back surgery. For those who met the inclusion criteria, informed consent was obtained and demographic information was gathered from participants, including age, height, and weight.

All images in the present study depicted specific vertebral levels, as assessed by an ultrasonographer certified in cardiovascular and echo technology. The ultrasonographer ensured that soft tissue landmarks were uniform between subsequent images captured over time and, when scoring, the ultrasonographer measured the spinous process depth first, followed by the right and then left transverse process depths. The ultrasonographer relied on visual information, unaided by software, to correlate anatomic landmarks between images.

Phase 1: Pretreatment Examination and Imaging
For phase 1 of the current study, participants underwent palpatory examination by means of the lumbar rotoscoliosis test,15,16 which assesses the rotational motion of a vertebral segment. This test consists of the application of an anterior force applied alternately on the most lateral aspect of both transverse processes of each vertebral segment, while restriction and freedom of motion in the prone position were noted (Figure 1). (A video of the pretreatment palpa-
A physician (K.D.T.) who was board certified in neuromusculoskeletal and osteopathic manipulative medicine performed the assessment. When a somatic dysfunction was identified, the physician marked the dysfunctional vertebra bilaterally (Figure 2) at its transverse processes for identification by the ultrasonographer, who was blinded to the specific diagnosis. Imaging was then performed at the particular level of dysfunction with the participant in the prone position by using the LOGIQ E9 Imaging System (GE Healthcare; Waukesha, Wisconsin), set to factory-established musculoskeletal imaging settings (Figure 3). The participant’s body was maintained in a constant position for ultrasonographic examination and subsequent imaging.

After the initial imaging, participants were assisted from the examination table to a standing position. The participants immediately returned to the prone position on the examination table for a second (ie, retest) image capture at the marked level of dysfunction.

After both (ie, test and retest) images were captured, the ultrasonographer measured tissue depths as seen on the ultrasonographic images (Figure 4). Software included with the ultrasonographic imaging device was used to calculate the depth, in centimeters, from the superficial-most layer of skin to the most posterior aspect of the transverse processes of the dysfunctional lumbar vertebrae, bilaterally. The side demonstrating the shortest tissue depth was coded as the posterior transverse process, in accordance with the osteopathic postulates forming the foundation of palpatory examinations. This same method was used to calculate the depth of the spinous process.

Statistical analyses were performed using IBM SPSS software (version 19; IBM Corporation, Armonk, New York). We computed test-retest reliability of ultrasonographic depth measurements by using Pearson product moment correlation. To assess content validity, the side of dysfunction identified at palpatory examination was compared with the most posterior side indicated by the ultrasonographic examination using the lumbar rotoscoliosis test. (Figure 1) A physician (K.D.T.) who was board certified in neuromusculoskeletal and osteopathic manipulative medicine performed the assessment. When a somatic dysfunction was identified, the physician marked the dysfunctional vertebra bilaterally (Figure 2) at its transverse processes for identification by the ultrasonographer, who was blinded to the specific diagnosis. Imaging was then performed at the particular level of dysfunction with the participant in the prone position by using the LOGIQ E9 Imaging System (GE Healthcare; Waukesha, Wisconsin), set to factory-established musculoskeletal imaging settings (Figure 3). The participant’s body was maintained in a constant position for ultrasonographic examination and subsequent imaging.

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sonographic imaging. Means of the findings were calculated from test-retest findings.

**Phase 2: Treatment and Posttreatment Imaging**

In phase 2, the identified somatic dysfunction was treated using an HVLA technique. This technique begins with the participant in the lateral recumbent position, with the side of the named dysfunction (ie, identified at the most posterior aspect of the transverse process) facing upward (Figure 5). The physician flexed the participant’s knees and hips until motion was localized at the level of dysfunction (Figure 6). Next, the physician used the participant’s arm in contact with the table as a lever to induce trunk rotation; motion was localized at the level of the dysfunctional vertebra (Figure 7). Once positioned, the participant crossed his or her arms and straightened the leg in contact with the table, while keeping the opposite thigh and leg flexed (Figure 8). Next, the physician placed his forearm closest to the participant’s head between the participant’s crossed arms and axilla, initiating contact with the participant’s midaxillary region. With the patient properly positioned, the physician placed his forearm closest to the participant’s feet on the posterior aspect of the innominate. The physician asked the participant to inhale and exhale. During exhalation, the physician used his arms to rotate the participant’s pelvis and lumbar spine toward the physician while rotating the participant’s cephalic torso away from the physician. At the end of exhalation, the physician applied an HVLA thrust with his forearm closest to the participant’s feet (Figure 8), following the same rotation seen in Figure 7. At the conclusion of the intervention, the participant was returned to the prone position and the physician re-
examined the participant’s lumbar spine by using the palpation technique previously described. (A video of this procedure is available at http://www.jaoa.org/content/112/12/775/suppl/DC1.)

After HVLA treatment, ultrasonography was again performed (subsequently referred to as posttreatment imaging). The ultrasonographer adjusted the transducer until the anatomic landmarks in the posttreatment image converged with the landmarks in the pretreatment image. By using the same amount of force with the transducer, the ultrasonographer was able to use pre- and posttreatment images to calibrate transducer head placement. Ultrasonographic images were used to calculate the bilateral depths in centimeters from the superficial layer of skin to the most posterior aspect of the transverse processes and spinous process of the dysfunctional lumbar vertebrae before and after treatment (Figure 9). Once all measurements were obtained, the raw transverse process data were corrected for spinous process depth by subtracting the spinous process depth of the pre- and posttreatment images from their respective transverse process measurements to account for variation in the lordotic curvature of the lumbar spine.

**Results**

A convenience sample of 12 participants (5 men, 7 women) ranging in age from 22 to 30 years participated from January 2011 through February 2011. Posttreatment data were inadvertently deleted for 1 participant.

**Phase 1**

Test-retest measurements from the most superficial layer of skin to the transverse process, collected by means of ultrasonography before HVLA treatment, are provided in Table 1. The Pearson correlation between the calculated measurements from the 2 measurement sessions of the transverse process depths from the sequential ultrasonographic images was 0.997 ($P < .001$). Additionally, the findings of the segmental motion palpatory examination, compared with the objectively determined side of rotation measurements as previously described, revealed a concordance of 1.0 for the identification of side of rotation.

**Phase 2**

Raw data for transverse process depths, both before and after treatment, are summarized in Table 2. For the spinous process data (Table 3), no statistically significant differences were noted within individual participants as a function of time ($P = .47$). Between study participants, however, the posttreatment spinous process depth was noted to fluctuate inconsistently from the pretreatment depth measurements. To account for this degree of variability in
our transverse process data, the transverse process measurements were corrected for the lordotic curvature as previously described. A within-subjects analysis of variance compared the obtained measurements from the pre- and posttreatment images and left and right sides using data corrected for lordosis (Table 2). The analysis showed a statistically significant main effect for side ($F_{1,10} = 23.23, P < .001$, partial $\eta^2 = 0.699$), a statistically significant interaction of side and time ($F_{1,10} = 29.74, P < .001$, partial $\eta^2 = 0.748$), and no statistically significant effect for time. The interaction is illustrated in Figure 10.

### Table 1.

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$^a$ All participants were rotated to the left side, as identified by means of palpatory examination. The first (ie, test) ultrasonographic image was captured when the participant was in prone position on the examination table, and the second (ie, retest) image was captured after participant stood up and then was re-placed in a prone position.

$^b$ Represents tissue depth to tip of spinous process (SP).

Abbreviation: BMI, body mass index.

**Comment**

The results indicate that ultrasonography can be a reliable method for the assessment and quantification of somatic dysfunction in the lumbar spine. Pearson correlation tests have a maximum value of 1.00, and our correlation of 0.997 indicates a very high degree of reliability for assessing tissue depth. Additionally, the correlation between palpatory examination of dysfunction and tissue depth measurements to identify the side of dysfunction revealed full concordance between the measures, providing support for the content validity of palpatory examination of segmental motion of the lumbar spine.

Phase 2 results indicated statistically significant side and side-by-time effects from data corrected for lordosis. The statistically significant results of the present study suggest that HVLA treatment improves segmental somatic dysfunctions as indicated by the return of restricted vertebra to a more symmetrical position as expressed by tissue depth measurements (Figure 10). Our data support the use of the lumbar rotoscoliosis test$^{15,16}$ in palpatory examination; a central tenet of the test is that dysfunctional vertebrae are held in an asymmetrical position of rotation. However, we also note that the measurement of tissue depth, when corrected for lordosis, showed a uniform presence of left-sided somatic dysfunctions. These findings may reflect either an unknown bias in measurement or a common biomechanical response such as the “common compensatory pattern” described by Zink and Lawson.$^{18}$

Because the current study is, to our knowledge, the first attempt to use ultrasonography to assess the bony landmarks in palpatory examination, the possibility of a measurement bias cannot be excluded, particularly considering the magnitude of the depth being assessed. This potential for bias is compounded by the use of a single ultrasonographer
for the collection and analysis of the ultrasonographic images. In an attempt to minimize the risk of bias, the ultrasonographer approached the imaging and image scoring in a reproducible, stepwise manner. Future studies could allay this bias by using multiple examiners to assess interexaminer reliability for image measurements and by incorporating more advanced ultrasonographic imaging software to limit measurement variability.

One limitation of the current study was the inability to validate tissue location for imaging. We were unable to use volume navigation technology, which enables the ultrasonographer to use global positioning system markers to more precisely mark and calibrate tissue locations. Future studies could use this technology to more accurately duplicate measurements, thus removing some of the traditional obstacles to observing the relationship between vertebral positional changes and HVLA.

**Conclusion**

Through the implementation of ultrasonography, this study demonstrates a method for objectively identifying somatic dysfunction by reliably and quantitatively demonstrating the positional characteristics of rotation in the lumbar spine, and by establishing the content validity of palpatory examination for the identification of somatic dysfunction.
dysfunction in the lumbar spine. This modality provides the manipulative medicine research community with a new means for palpatory examinations to meet evidence-based criteria.

The data from phase 2 of the present study suggest that a thrusting manipulative treatment technique can reduce segmental rotational dysfunction in the lumbar spine. This finding supports long-held postulates regarding the mechanism of this form of manipulative treatment. Additional research is needed to confirm these findings for the lumbar spine. Long-term sequential imaging could be conducted to assess the longitudinal effects of HVLATreatment on dysfunctional vertebra of the lumbar spine. The use of volume-navigational ultrasonographic technology in future research would further enhance the validity of diagnostic imaging.

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References

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