

Assessing Palpation Thresholds of Osteopathic Medical Students Using Static Models of the Lumbar Spine

Eric J. Snider, DO; Kenneth Pamperin, MS; Jane C. Johnson, MA;
Natalie R. Shurtz, MHA; and Brian F. Degenhardt, DO

From the Department of Neurobehavioral Sciences at the A.T. Still University—Kirkville College of Osteopathic Medicine (Dr Snider); the A.T. Still Research Institute at A.T. Still University (Drs Snider and Degenhardt and Ms Johnson); and Research Support at A.T. Still University (Mr Pamperin, Ms Johnson, and Ms Shurtz), all in Kirkville, Missouri.

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Address correspondence to Eric J. Snider, DO, Department of Neurobehavioral Sciences, A.T. Still University—Kirkville College of Osteopathic Medicine, 800 W Jefferson St, Kirkville, MO 63501-1443.

E-mail: esnider@atsu.edu

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Context: Although spinal somatic dysfunction diagnosis is taught at all colleges of osteopathic medicine, few objective measures have been used to evaluate student accuracy.

Objective: To assess the palpatory skills of osteopathic medical students in evaluating positional asymmetry in the transverse plane using static block transverse process and lumbar spine models.

Methods: For this observational study, first-year osteopathic medical students completed 3 palpatory assessments using uncovered and covered block transverse process and lumbar spine models to simulate a range of positional asymmetries of the transverse processes. With use of logistic regression, 80%, 90%, and 95% thresholds were defined as the magnitude of asymmetry for which the predicted probability of students correctly determining the direction of asymmetry exceeded a specified amount (.80, .90, or .95).

Results: A total of 346 students completed the assessments. For the uncovered block transverse process model (assessment 1), students correctly identified the direction of asymmetry with .89 probability at 1 mm of asymmetry (80% threshold), .94 probability at 2 mm (90% threshold), and .95 probability at 3 mm (95% threshold). For the covered block transverse process model, students correctly identified the direction of asymmetry with .80 probability at 1 mm (80% threshold), .92 probability at 2 mm (90% threshold), and .98 probability at 3 mm (95% threshold) by the third assessment. For the uncovered lumbar spine model (assessment 2), students correctly identified the direction of asymmetry with .93 probability at 2 mm (80% and 90% thresholds) and .95 probability at 3 mm (95% threshold). For the covered lumbar spine model (assessments 2 and 3), students correctly identified the direction of asymmetry with .87 probability at 4 mm (80% threshold); 90% and 95% thresholds were not reached with the range of asymmetries tested.

Conclusion: Most first-year osteopathic medical students were able to discern the direction of positional asymmetry of transverse processes on static models. Depending on the model type, student performance improved (block transverse process models) or declined (lumbar spine models) over time. Future studies should evaluate whether accuracy of palpating lumbar spine models translates to accuracy of palpating human lumbar spines.

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The ability to determine asymmetry of bony landmarks in the musculoskeletal system is a necessary clinical skill for osteopathic physicians. To assess asymmetry in the lumbar spine, osteopathic physicians generally first identify anatomical structures, such as the spinous processes, transverse processes, and erector spinae muscles, with the patient in a seated, supine, or prone position. Once the transverse processes are accurately identified, physicians assess positional asymmetry and then apply posterior to anterior pressure to assess segmental rotational motion preference. An accurate diagnosis of positional asymmetry is often a prerequisite for an accurate diagnosis of motion restriction—which, for many physicians, often forms the basis for treatment.

Findings of several studies have suggested that osteopathic examiners can achieve an acceptable level of reliability in palpatory tests of the spine,^{1,2} that those skills can be retained over time,^{1,3,4} and that those tests can discriminate between those with low back pain and those without.⁵ However, such evidence has not been consistently demonstrated.⁶⁻¹⁷ These inconsistencies could be the result of differences in the investigators' reliance on the validity of conceptual paradigms used to predict spinal biomechanics, in the training of the examiners, or in the studies' methodologies.

To our knowledge, few studies have evaluated the use of training tools to assess palpatory skills.¹⁸⁻²¹ Currently, osteopathic medical students are taught palpatory skills in an educational environment that relies on the subjective feedback of their instructors. However, in current motor learning theory, fundamental forms of objective feedback, such as the knowledge of performance (whether a skill was performed correctly)^{22,23} and the knowledge of results (whether the results of the task were accurate),²⁴ are needed to facilitate the development of motor skills like palpation.²⁵ Such feedback is not a consistent component of the current osteopathic medical education environment.

For the present study, 2 calibrated models were designed to provide objective feedback about the ability of students to localize the transverse processes and

to determine the relative position of those landmarks within the horizontal plane. Using simulated block transverse process and anatomical lumbar spine models with set asymmetries, we evaluated the ability of first-year osteopathic medical students to correctly identify the direction of asymmetry between the right and the left transverse processes of the lumbar spine 3 times during their first academic year.

Methods

As part of the requirements for the osteopathic theory and methods course, first-year osteopathic medical students from the graduating classes of 2013 and 2014 at A.T. Still University–Kirksville College of Osteopathic Medicine (ATSU-KCOM) participated in the present observational study. The local institutional review board approved the study. In accordance with standard ATSU-KCOM procedures, students consented to have their deidentified performance data used for educational research at matriculation. Demographic data for all participants were collected at the first assessment.

Models

Block Transverse Process Models

Pairs of wooden blocks (10 mm × 15 mm surface area) were glued to a wooden base to simulate transverse processes of the lumbar spine (*Figure 1A*). Each block was a different height, with the height of the blocks from the wooden base ranging from 3 mm to 14 mm. The blocks were spaced 70 mm apart to represent the distance between the transverse processes and were separated by a midline ridge to simulate the lumbar spinous processes. The magnitude of the asymmetry, determined by the difference in the block heights between the right and left sides, ranged from 1 mm to 6 mm (within 0.5 mm). Calipers (General Tools Manufacturing Co.) were used to measure the exact height of the blocks from the surface of the wooden base. Block transverse process models comprised either 6 or 10 block pairs and were uncovered or covered depending on the assessment. For covered models, a

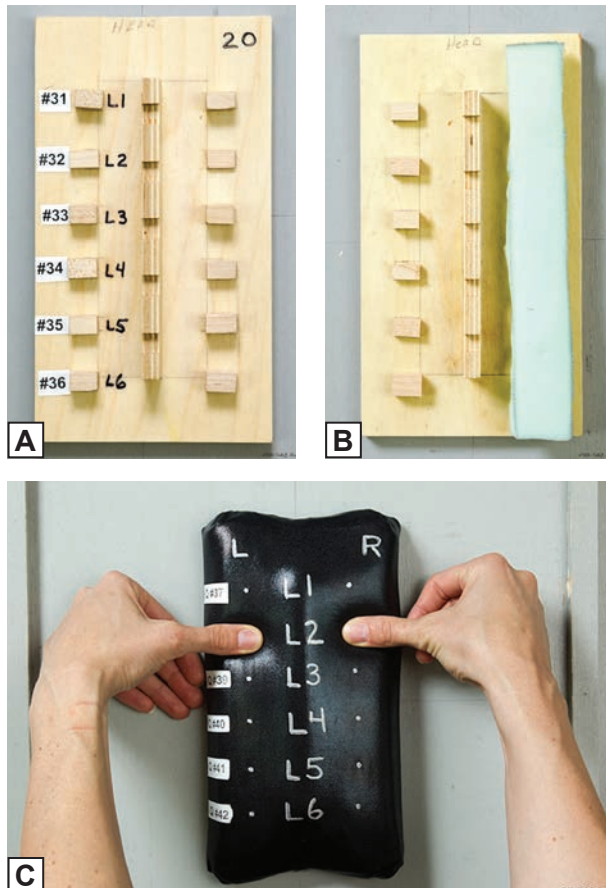


Figure 1.

Uncovered (A) and covered (B, C) block transverse process models used to assess the ability of first-year osteopathic medical students to correctly identify the direction of asymmetry between the right and left transverse processes.

were used to measure the exact height of the top of the transverse process from the surface of the wooden base. For covered models, a 25-mm layer of upholstery foam covered the transverse processes (*Figure 2B*) and an additional 12-mm layer of upholstery foam (37 mm total) and a 0.5-mm layer of fabric covered the entire model to mimic muscle and skin (*Figure 2C*). For the lumbar spine models, the upholstery layer was thicker than the block transverse process models to more closely simulate the salient aspects of palpating transverse processes on humans. Models were designed according to the authors' clinical experience.

Palpatory Skills Assessment

First-year osteopathic medical students completed 3 palpatory assessments using the lumbar models. For the 2 weeks before each assessment, students had access to the models during their osteopathic theory and methods course and at the university library, but actual preassessment use of the models was not documented.

For each assessment, the models were clamped to tables (height, 57-66 cm) to represent a patient in the prone position. Students were given a forced choice scenario for each transverse process pair: they were asked to decide whether the right transverse process was anterior or posterior relative to the left (ie, the direction of the asymmetry). This dichotomous design was chosen instead of a clinically realistic trichotomous design, in which the clinician decides if there is clinically significant asymmetry or not, and if so, which side the asymmetry is on.²¹ The dichotomous design enabled us to determine palpation thresholds without the complication of having to define "clinically significant" asymmetry.

Detailed instructions were provided for each model to guide students through the procedure for determining the direction of the asymmetry.

12-mm layer of upholstery foam covered the blocks (*Figure 1B*) and an additional 4-mm layer of upholstery foam (16 mm total) and a 0.5-mm layer of fabric covered the entire model to mimic muscle and skin (*Figure 1C*).

Lumbar Spine Models

For a more anatomically realistic model than the block transverse process model, 5 lumbar vertebrae were cast in bronze and secured to a wooden base with screws (*Figure 2A*). To achieve the desired asymmetry of the transverse processes, metal plates (shims) of 0.25-mm, 0.5-mm, or 1.0-mm thickness were placed under the right or left side of the vertebral bodies. The magnitude of the asymmetry, determined by the difference in the heights of the right and left transverse processes, ranged from 2 mm to 6 mm (within 0.5 mm). Calipers

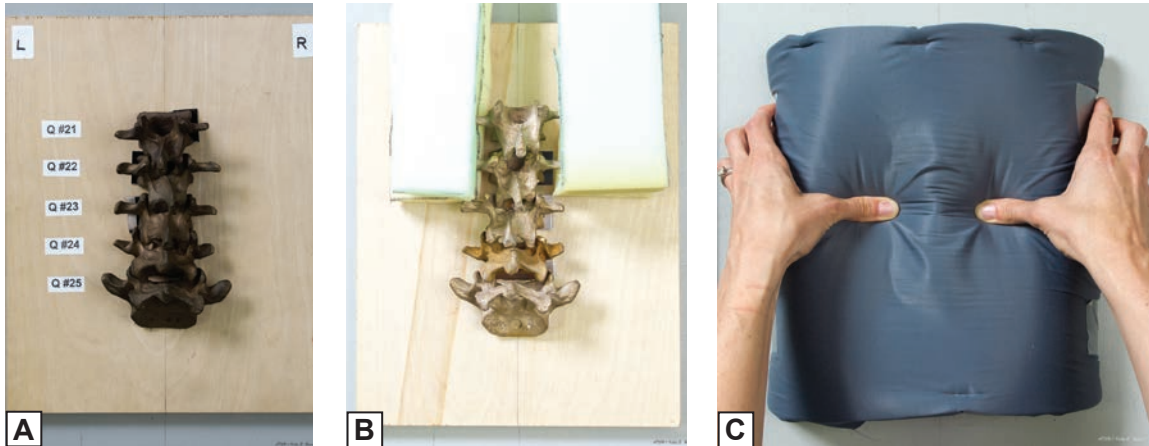


Figure 2.

Uncovered (A) and covered (B, C) lumbar spine models used to assess the ability of first-year osteopathic medical students to correctly identify the direction of asymmetry between the right and left transverse processes.

■ **Assessment 1** (beginning of first quarter): Two block transverse process models were used in assessment 1: an uncovered model and a covered model.

The uncovered model consisted of 6 block pairs: 1 pair each at 1 mm through 6 mm of asymmetry for the class of 2013 and 2 pairs each at 1 mm through 3 mm of asymmetry for the class of 2014.

The covered model also consisted of 6 block pairs: 1 pair each at 1 mm through 6 mm of asymmetry. For both models, the order of the block pairs was randomized with respect to magnitude and direction of the asymmetry using a random number generator.

■ **Assessment 2** (end of first quarter): Two block transverse process models and 2 lumbar spine models were used in assessment 2. The 2 covered block transverse process models each consisted of 10 block pairs. These 20 block pairs consisted of 5 pairs each at 1 mm through 4 mm of asymmetry. One of the lumbar spine models was uncovered, and 1 was covered. Each consisted of 5 lumbar vertebrae, 1 vertebra each at 2 mm through 6 mm of asymmetry of the transverse processes. For all models, the order of the asymmetries was randomized with respect to magnitude and direction of the asymmetry using a random number generator.

■ **Assessment 3** (end of first year): One block transverse process model and 1 lumbar spine model were included in assessment 3. The covered block transverse process model consisted of 6 block pairs: 2 pairs each at 1 mm through 3 mm of asymmetry. The covered lumbar spine model consisted of 5 lumbar vertebrae: 1 vertebra each at 2 mm through 6 mm of asymmetry of the transverse processes. For both models, the order of the asymmetries was randomized with respect to magnitude and direction of the asymmetry using a random number generator.

Statistical Analysis

A random-intercept logistic regression model was fit to the data using SAS statistical software (version 9.3; SAS Institute Inc). The outcome variable was whether the student correctly determined the direction of the asymmetry. The students were treated as random effects to allow for the correlation of performance within and between assessments for individual students. The predictor variables were the magnitude of the asymmetry, the type of lumbar model (block transverse process or lumbar spine; uncovered or covered), and the assessment (1, 2, or 3). $P < .05$ was considered statistically significant. For each model type and assessment, a threshold (80%,

90%, or 95%) was defined as the magnitude of asymmetry where the predicted probability of students correctly determining the direction of the asymmetry exceeded a specified amount (.80, .90, or .95).

Results

A total of 346 osteopathic medical students participated in the current study: 174 students from the ATSU-KCOM class of 2013 and 172 students from the ATSU-KCOM class of 2014 (205 [59%] men; mean [standard deviation] age, 25.1 [2.8] years). Of those, 346 participated in assessment 1, 343 participated in assessment 2, and 334 participated in assessment 3.

Using the uncovered block transverse process models, used only in assessment 1, the students were able to correctly identify the direction of asymmetry with .89 probability at 1 mm of asymmetry, with .94 probability at 2 mm, and with .95 probability at 3 mm (Table 1). The magnitude of the asymmetry had a significant effect on the probability of students correctly identifying the direction of asymmetry ($P<.001$). The probability of correctly identifying the direction of

asymmetry increased from 1 mm to 2 mm; changes in probability from 2 mm through 6 mm were not statistically significant. The thresholds for correctly identifying the direction of asymmetry were 1 mm to 3 mm for these models (Table 2).

For the covered block transverse process models, used during all 3 assessments, the magnitude of the asymmetry incrementally increased from 1 mm through 3 mm for assessments 1 and 3 and from 1 mm through 4 mm for assessment 2. As the asymmetry increased, the probability of students correctly identifying the direction of asymmetry significantly increased ($P<.001$ for all assessments) (Table 1). There were significant increases in the probability of students correctly identifying the direction of asymmetry from assessment 1 to assessment 2 at 2 mm to 4 mm of asymmetry, from assessment 1 to assessment 3 at 2 mm to 3 mm, and from assessment 2 to assessment 3 at 1 mm and 3 mm ($P=.03, P<.001, P<.001, P<.001$ for 1, 2, 3, and 4 mm of asymmetry, respectively). The 90% and 95% thresholds for students correctly identifying the direction of asymmetry improved from assessment 1 to assessment 2 and were unchanged from assessment 2 to assessment 3 (Table 2).

Table 1.
Predicted Probability of First-Year Osteopathic Medical Students Correctly Identifying the Direction of Asymmetry in Block Transverse Process and Lumbar Spine Models

Model Type	Assessment	Predicted Probability (95% CI) by Magnitude of Asymmetry					
		1 mm	2 mm	3 mm	4 mm	5 mm	6 mm
Block Transverse Process							
Uncovered	1	.89 (.86-.92)	.94 (.91-.95)	.95 (.93-.96)	.97 (.93-.99)	.96 (.92-.98)	.97 (.93-.99)
Covered	1	.80 (.75-.84)	.85 (.81-.89)	.91 (.88-.94)	.93 (.90-.96)	.96 (.93-.98)	.96 (.93-.97)
	2	.75 (.72-.78)	.92 (.91-.94)	.97 (.96-.97)	.99 (.98-.99)	NA	NA
	3	.80 (.76-.83)	.92 (.89-.93)	.98 (.97-.99)	NA	NA	NA
Lumbar Spine							
Uncovered	2	NA	.93 (.90-.95)	.95 (.93-.97)	.98 (.96-.99)	.97 (.95-.98)	.99 (.97-1.0)
Covered	2	NA	.74 (.69-.79)	.74 (.68-.78)	.91 (.88-.94)	.85 (.81-.88)	.84 (.80-.88)
	3	NA	.72 (.66-.77)	.59 (.53-.65)	.87 (.83-.90)	.88 (.84-.91)	.77 (.72-.82)

Abbreviations: CI, confidence interval; NA, not applicable.

Using the uncovered lumbar spine models, which were used only during assessment 2, the students were able to correctly identify the direction of asymmetry with .93 probability at 2 mm of asymmetry and with .95 probability at 3 mm (Table 1). The magnitude of the asymmetry had a significant effect on the probability of students correctly identifying the direction of asymmetry ($P < .001$): the probability was significantly lower at 2 mm than at 4 mm to 6 mm, at 3 mm than at 4 mm and 6 mm, and at 5 mm than at 6 mm. The thresholds for students correctly identifying the direction of asymmetry were 2 mm to 3 mm for these models (Table 2).

The covered lumbar spine models were used during assessments 2 and 3. For assessment 2, the probability of students correctly identifying the direction of asymmetry was highest at 4 mm and lowest at 2 mm to 3 mm ($P < .001$) (Table 1). For assessment 3, the probability of correctly identifying the direction of asymmetry was highest at 4 mm to 5 mm and lowest at 3 mm ($P < .001$). There were significant decreases in the probability of students correctly identifying the direction of asymmetry from assessment 2 to assessment 3 at 3 mm and 6 mm ($P < .001$ and $P = .02$, respectively). The 80% threshold for correctly identifying the direction of asymmetry was reached at 4 mm for the covered lumbar spine models for assessment 2 (Table 2). A 90% threshold for these models was not obtained because the probability of students correctly identifying the direction of asymmetry at 5 mm and 6 mm was below .90 (Table 1).

The probability of students correctly identifying the direction of asymmetry was higher for the uncovered block transverse process models than for the covered block transverse process models at assessment 1 for 1 mm to 4 mm of asymmetry ($P < .001$, Figure 3). The probability of students correctly identifying the direction of asymmetry was higher for the uncovered lumbar spine models than for the covered lumbar spine models at assessment 2 for all the magnitudes of asymmetry tested (2-6 mm, $P < .001$) (Figure 4). For all magnitudes of asymmetry used for both the covered block transverse process and covered lumbar spine models (assessment 2, 2-4 mm; assessment 3,

Table 2. Magnitudes of Asymmetry for Which the Probability of First-Year Osteopathic Medical Students Correctly Identifying the Direction of Asymmetry Exceeded a .80, .90, and .95 Threshold

Model Type	Assessment	Magnitude of Asymmetry (in mm) by Probability Threshold		
		.80	.90	.95
Block Transverse Process				
Uncovered	1	1	2	3
Covered	1	1	3	5
	2	2	2	3
	3	1	2	3
Lumbar Spine				
Uncovered	2	2	2	3
Covered	2	4	4 ^a	>6
	3	4 ^b	>6	>6

^a The probability for 4 mm of asymmetry was greater than .90, whereas the probabilities for 5 mm and 6 mm of asymmetry were less than .90.

^b The probabilities for 4 mm and 5 mm of asymmetry were greater than .80, whereas the probability for 6 mm of asymmetry was less than .80.

2-3 mm), the probability of students correctly identifying the direction of asymmetry was higher for the block transverse process models for both assessments ($P < .001$ and $P < .001$, respectively) (Figure 5).

Discussion

To our knowledge, the current study is the first to investigate the palpation accuracy thresholds for asymmetry in the transverse plane of a large number of osteopathic medical students over multiple assessments using models simulating lumbar transverse processes.

First-year osteopathic medical students improved their accuracy with the covered block transverse process model over the course of 3 assessments. These results suggest that skill development during the osteopathic theory and methods laboratory sessions may be transferable to palpation of the models.

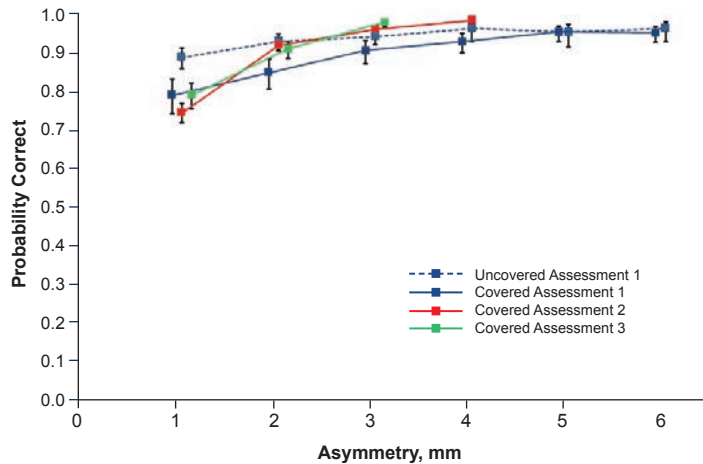


Figure 3. Probability of first-year osteopathic medical students identifying direction of asymmetry in uncovered and covered block transverse process models by magnitude of asymmetry. Error bars represent confidence intervals.

However, students' accuracy did not improve with the anatomically realistic covered lumbar spine model over the course of 2 assessments. Several factors may have influenced these results. First, the lack of improvement in accuracy with the lumbar spine models leads to questions about whether the current curricular design, which does not include immediate objective feedback about performance, is effective in the training of this skill set. Second, the models were available to the students for 2 weeks before testing, but we did not track whether students took advantage of this opportunity. Finally, a learning effect may have occurred from the repeated use of the models over the course of the 3 assessments for the block transverse process models that did not occur over the course of the 2 assessments for the lumbar spine models. Further study is necessary to determine what combination of these factors resulted in the inconsistent improvement in performance for the 2 models over time.

The students' accuracy was better with the uncovered models than with the covered models during the initial assessment for both model types. These

results suggest that direct visualization of the transverse processes increased their accuracy. After 3 assessments, the probability threshold for covered block transverse process models improved to the same threshold found with the initial uncovered model. These results may be explained by the students' development of tactile and proprioceptive skills during their osteopathic theory and methods laboratory sessions. However, this improvement was not observed for the lumbar spine models after 2 assessments.

Differences in student accuracy between the 2 models may be explained by the models' level of complexity. For the block transverse process models, the transverse processes were flat, rectangular, large, and equally spaced. The distal tips of the anatomical transverse processes of the lumbar spine models were ellipsoidal and had segmental variability in the distance of the transverse processes from the spinous processes. In addition, the thickness of upholstery foam for the covered block transverse process models was 16 mm and the thickness of upholstery foam for the covered lumbar spine models was 37 mm. This difference in thickness of foam is likely another factor that influenced palpatory accuracy.

For the covered lumbar spine models, the students' accuracy was unexpectedly lower at 5 mm to 6 mm of asymmetry than at 4 mm of asymmetry. It is likely that the students had difficulty correctly localizing the landmark rather than difficulty determining the direction of asymmetry. We suspect that with the larger asymmetries, the students mistakenly palpated the facet on the side of the anterior transverse process and compared it to the height of the posterior transverse process. We could potentially increase the range of the magnitude of asymmetry; however, if landmark localization (transverse process vs facet) is the confounding issue, student accuracy would continue to decrease as the magnitude of asymmetry increased. Another approach to address this issue would be to assess the accuracy of student landmark localization on the models and determine whether it is associated with palpation accuracy thresholds for asymmetry in the transverse plane.

Studies suggest that osteopathic manipulative treatment (OMT) is beneficial for those with low back pain.²⁶⁻²⁸ Further, landmark asymmetry has been shown to be different between people with and without low back pain,⁵ and OMT has been shown to change landmark asymmetry.²⁹ However, we have not determined whether accurate palpation of these models translates into accurate palpation of the human body. The first step in addressing this issue is to determine whether use of these lumbar models increases accuracy of localization of transverse processes in humans. The second step is to determine if these models increase accuracy of determining the presence and direction of asymmetry. The third step is to determine what magnitudes of asymmetries in the lumbar spine are clinically meaningful. Once thresholds for clinically meaningful asymmetry have been established, the level of palpatory accuracy that should be targeted in osteopathic medical education can be determined.

To our knowledge, convenient and cost-effective methodologies to determine landmark asymmetry in humans have not been developed. Consequently, having objective and inexpensive calibrated models approximating palpatory assessment in humans is valuable at this time. The model program described in the present study allows students to receive immediate objective feedback about their palpatory accuracy and allows for the assessment of their accuracy without instructor bias.

These lumbar models may also improve the quality of research studies that include palpatory assessment as a measure of the effect of OMT by providing a benchmark for determining the accuracy and reliability of the palpatory skills of the researchers.¹⁻⁴ However, many physicians rely more on segmental motion testing than landmark asymmetry in their diagnostic evaluations before performing OMT. Yet it is reasonable to assume that accurate segmental motion testing is dependent on the accurate localization of the transverse processes. Typically, objective models for teaching and assessing segmental motion testing are not used in the educational setting. Therefore, because accuracy in identifying landmark asymmetry is likely a precursor

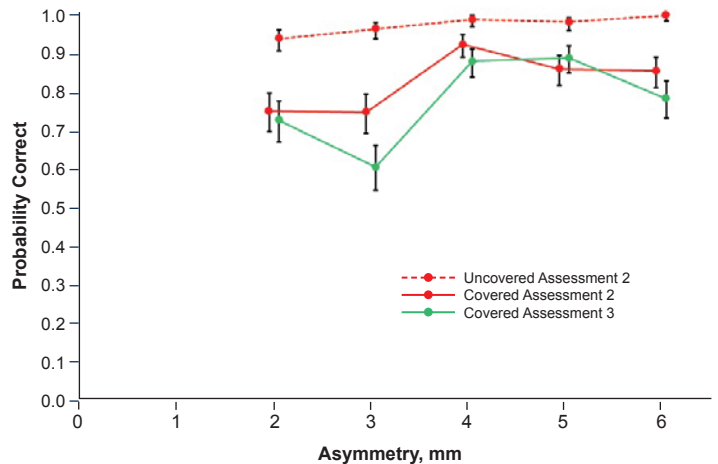


Figure 4. Probability of first-year osteopathic medical students identifying direction of asymmetry in uncovered and covered lumbar spine models by magnitude of asymmetry. Error bars represent confidence intervals.

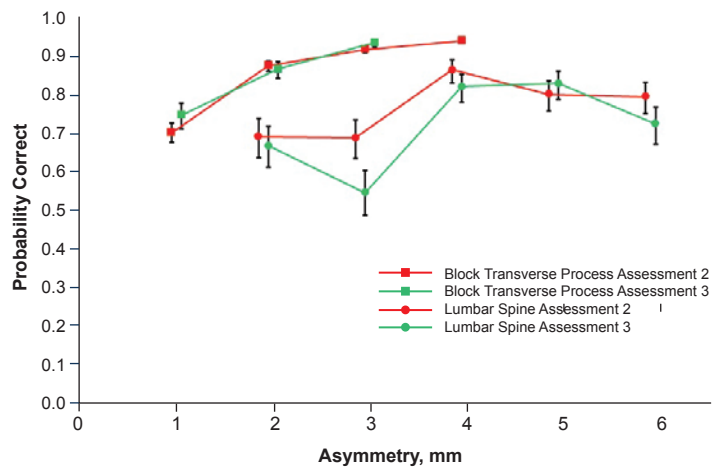


Figure 5. Probability of first-year osteopathic medical students identifying direction of asymmetry in covered block transverse process and covered lumbar spine models by magnitude of asymmetry. Error bars represent confidence intervals.

to accurate segmental motion testing, these lumbar models are also an important first step in teaching more complex palpatory skills.

Conclusion

In the current study, most first-year osteopathic medical students were able to determine the direction of positional asymmetry in the transverse plane on calibrated static models. However, as the models became more realistic, by using casted vertebrae, padding, and covering to mimic muscle and skin, the students' accuracy diminished. Although additional research is needed, these static models are an important first step for incorporating immediate objective feedback into osteopathic manipulative medicine education.

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