

Use of a Novel Assay to Measure Pre- to Posttraining Palpatory Skills of First-Year Osteopathic Medical Students

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Context: Although palpation is a central skill in the practice of osteopathic medicine, few data are available on factors affecting the development of palpatory skills.

Objective: To use a novel palpatory skills assay to assess the role of training and practice in the development of palpatory skills in an osteopathic medical student population.

Methods: The palpatory skills of first-year osteopathic medical students were assessed using a simple, objective palpation assay that consisted of locating a dime placed under sheets of copy paper at depths of 50, 100, 150, 200, 300, and 400 sheets. Two trials were performed at each depth. The assay was performed at the beginning and at the end of the students' first term. To determine whether practice with the assay impacted participant performance, a third assay was conducted to compare the performance of students who completed the assays at the beginning and at the end of the term with that of students who had never completed the assay.

Results: Sixty-three participants completed the assays at the beginning and end of the term. Fifty-seven of those 63 participants and 192 participants who had not previously completed the assay completed the third assay. A wide variability in number of correct responses per participant was observed at both the beginning (range, 0-11 correct) and the end (range, 2-12 correct) of the term. The mean (SD) number of correct responses per participant increased from the beginning (5.49 [2.78]) to the end (7.17 [2.27]) of the term. Analysis using the generalized estimating equation model demonstrated that both paper depth and experience (ie, beginning vs end of the term) were statistically significant determinants of the number of correct responses ($P < .001$). The Kaplan-Meier method indicated that the median paper depth at which participants first scored no correct responses increased from 200 sheets (95% CI, 171-229) at the beginning of the term to 300 sheets (95% CI, 232-367) at the end of the term ($P < .001$). In the third assay, no significant differences were noted in the performance of students who had completed the 2 previous assays vs participants who had not completed the previous assays ($P = .136$).

Conclusion: Participants' palpatory skills improved from the beginning to the end of the term. The range of participants' palpatory skills at the beginning of the term suggests that other factors in addition to training influenced participants' palpatory skill level. Additional research is needed to identify and investigate factors that influence the development of palpatory skills.

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Palpation is a skill that uses touch while applying various amounts of pressure to assess the condition of the tissues beneath the skin.¹ It can be used on every part of the body accessible to the examiner's fingers, including all external structures, bones, joints, fasciae, muscles, tendon sheaths, and ligaments, as well as solid abdominal viscera, solid contents of hollow viscera, and accumulations of body fluids such as pus or blood.² In addition to inspection, percussion, and auscultation, palpation is part of the routine physical examination of every patient. Palpation of the various joints and osseous structures is central to the neuromusculoskeletal assessment that is part of the integrated osteopathic structural examination. The aim of the palpation examination used in this context is to obtain additional information that is not immediately recognizable by the naked eye or by particular laboratory tests or other diagnostic means.³ Isaacs and Bookhout⁴ emphasized the need for physicians to develop adequate palpation skills through repeated practice:

One of the difficulties people have in understanding and applying manual medicine techniques is that both diagnosis and treatment require a palpation skill that is different from, and in some ways greater than, that used in other branches of medicine.

Despite the importance of palpation skills, consensus about what constitutes a competent level of palpation skills (eg, the ability to detect an object or surface temperature variations) is incomplete and not well specified. In addition, which factors affect acquisition of competent palpation skills is unknown.

Although novice practitioners may have difficulty developing palpation skills—partly because of the complex integration of factors being assessed (eg, tissue texture abnormality and asymmetry, assessment of position and tissue mass)—they may improve palpation skills with practice. Researchers have examined the role of training and practice in improving palpation skills of students and experienced practitioners using 2 primary approaches.

In the first approach, interrater reliability of palpation findings in a specific test participant or model system is determined and the reliability is correlated with rater experience level. Studies⁵⁻⁸ using this approach have yielded different results, with experience found to both correlate and not correlate with interrater reliability.

In the second approach, the effect of palpation skills practice and training in a specific model system on palpation skills performance in that model system is examined. Studies⁹⁻¹² using this approach have consistently reported that training and practice improved accuracy and sensitivity of palpation skills.

The studies that have used these 2 approaches have some limitations, however. First, the cited studies⁵⁻¹² were performed in the United States and in other countries. Differences in practitioner training might have affected the outcomes of these studies. Second, most of these studies^{7-9,11,12} focused on palpation of specific body parts or tissue levels rather than on palpation skills in general. Because of these limitations, the results of these studies cannot be extrapolated to the role of training and practice on basic palpation skills.

To focus directly on the acquisition of basic palpation skills, we developed a simple, objective, and easily reproducible assay system for assessing palpation skills. Using this assay system, we measured changes in the palpation skills of novice first-year osteopathic medical students from the beginning to the end of their first term, during which time they received formal training and possibly informal practice in palpation and other osteopathic manipulative treatment techniques. We hypothesized that student palpation skills would improve from the beginning to the end of the term.

Methods

The present study took place from September to December 2013 at the New York Institute of Technology College of Osteopathic Medicine (NYIT-COM). Participants were first-year NYIT-COM students who were re-

cruited by means of class announcements. Participation was voluntary, and no exclusion criteria were applied. The study was determined to be exempt by the New York Institute of Technology's institutional review board. Informed consent was not obtained from participants per institutional review board waiver.

Study Protocol

Each participant was assigned a random number at the beginning of the study. Results were identified only by participant number thereafter. Participants completed an identical assay at the beginning and at the end of their first term in medical school (ie, assay 1 and assay 2, respectively). During this period, the participants received 31 hours of formal osteopathic manipulative medicine (OMM) training. To determine whether practice with the assay impacted participant performance, a third assay (ie, assay 3) was conducted to compare the performance of participants who had completed both assay 1 and assay 2 with that of participants who had not previously completed the assay.

For each assay, a sheet of copy paper was divided into 9 sectors of equal area using a ruler and pen to mark the grid pattern. This grid was placed as the top sheet in a stack of 500 sheets of copy paper. Depths of copy paper were indicated at 50, 100, 150, 200, 300, and 400 sheets. A dime of standard diameter (17.91 mm), thickness (0.35 mm), and edge ridges (118 reeds) was used as the object to be palpated.

For each assay, the sector location of the dime was predetermined by a random number generator for integers 1 through 11. Numbers 1 through 9 corresponded with the 9 sectors and determined which sector the dime would be placed. Numbers 10 and 11 indicated that no dime was to be placed under the copy paper stack. The dime, when present, was placed in the center of the assigned sector.

Each palpation trial lasted 45 seconds. The participant performed a practice palpation trial with the dime placed at a depth of 50 sheets of copy paper. At the end of the

practice palpation trial, the participant was told whether he or she did or did not correctly locate the dime. If incorrect, the participant was told which sector the dime was located in and was allowed to palpate that sector to determine how the presence of the dime would feel.

The participant performed 2 trials per paper depth at increasing depths of paper from 50 sheets up to 400 sheets. To begin the assay, the person administering the assay placed the dime either at the designated sector location under a depth of 50 sheets of paper or the dime was not placed under the paper stack. Participants were blinded to the dime's placement. The participant palpated the top sheet of paper for up to 45 seconds and then wrote down the perceived sector location of the dime or, if no dime was detected, wrote "no dime" on his or her answer sheet.

The dime was placed in the next location using the same procedure, and the trials were completed at depths of 50, 100, 150, 200, 300, and 400 sheets of paper. To avoid potential bias introduced in subsequent trials, the participants were not told whether or not they correctly identified the dime's presence and location. No attempt was made to obscure the participant's view of the paper stack during the assay, but simple observation did not reveal any obvious deformation in the paper surface with the presence of a dime, even at a 50-sheet paper depth.

Statistical Analysis

Data were analyzed using Microsoft Excel 2010, SPSS statistical software (version 22; SPSS Inc), and SAS version 9.3 software (SAS Institute Inc). A paired *t* test was performed for comparisons between assay 1 and assay 2, with $P < .05$ defined as the threshold for statistical significance. Results from assay 1 were subdivided by participants who had 8 or more correct responses and those who had less than 8 correct responses. The change in performance from assay 1 to assay 2 in these 2 subpopulations was then compared. Statistical significance was determined by a paired *t* test. A generalized estimating equation model was

fitted to the data to study the main effects of experience (beginning vs end of the term), paper depth, and the interaction effect of the 2 factors. A polynomial contrast analysis was performed as a post hoc analysis to determine whether the specific nature of trends seen between paper depth and assay performance was linear, as linearity was a precursor for the subsequent Kaplan-Meier method.

The Kaplan-Meier method was used to estimate the median paper depth and 95% CIs at which participants first scored 0 correct responses in both trials. An associated log-rank test could not be calculated, as the time points for the 2 assays were correlated. To establish a *P* value for comparing the 2 time points and to generate a hazard ratio, a marginal Cox model was fitted to the correlated time-to-event data.¹³

Results

A total of 63 participants completed both assay 1 and assay 2. Fifty-seven of those 63 participants and 192 participants who had not previously completed an assay completed assay 3. Of those who completed assays 1 and 2, the range in the total number of correct responses per participant varied widely in assay 1 (range, 0-11 correct out of a maximum correct total of 12) and in assay 2 (range, 2-12) (*Figure 1*). The mean (SD) number of correct detections increased significantly ($P < .001$) from the beginning (5.49 [2.78]) to the end of the term (7.17 [2.27]).

In assay 1, 43 of 63 participants (68%) correctly located the dime in both trials at a depth of 50 sheets (ie, the lowest paper depth) (*Figure 2A*). The number of participants who correctly located the dime in the stack of paper in both trials at any sheet depth declined progressively as the number of sheets increased. Whereas a majority of participants located the dime correctly in both trials at a depth of 50 sheets, approximately equal numbers of participants located the dime correctly in 0, 1, or both trials at a depth of 150 sheets. At a depth of

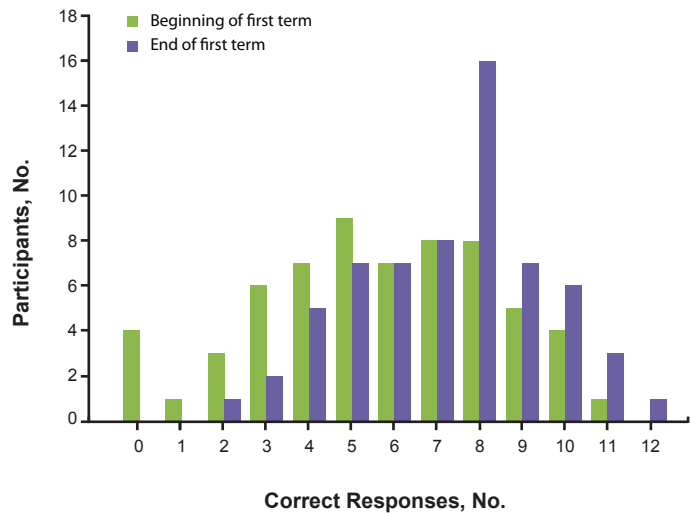


Figure 1.

The number of first-year osteopathic medical students ($n=63$) who correctly palpated the location of a dime in a stack of paper at the beginning and end of their first term. A wide variability in number of correct responses was observed at both the beginning (range, 0-11 correct) and the end (range, 2-12 correct) of the term. The mean (SD) total number of correct responses increased from 5.49 (2.78) at the beginning of the first term to 7.17 (2.27) at the end of the first term.

200 sheets, 49 participants (78%) located the dime correctly in either 0 trials or 1 trial. For the 2 largest paper depths, the majority of participants did not locate the dime correctly in either of the 2 trials (300 sheets, 34 participants [54%]; 400 sheets, 43 participants [68%]).

In assay 2, 56 of 63 participants (89%) located the dime correctly in both trials at a depth of 50 sheets (*Figure 2B*). Seven participants (11%) located the dime correctly in 1 of the 2 trials at this depth. All participants in assay 2 were able to locate the dime in at least 1 of the trials at a depth of 50 sheets, in contrast to the 5 participants (8%) in assay 1 who did not locate the dime correctly in either trial at this paper depth. As the paper depth increased, the number of participants locating the dime correctly in both trials decreased, and the number of participants unable to locate the dime correctly in either trial increased. A greater proportion of participants

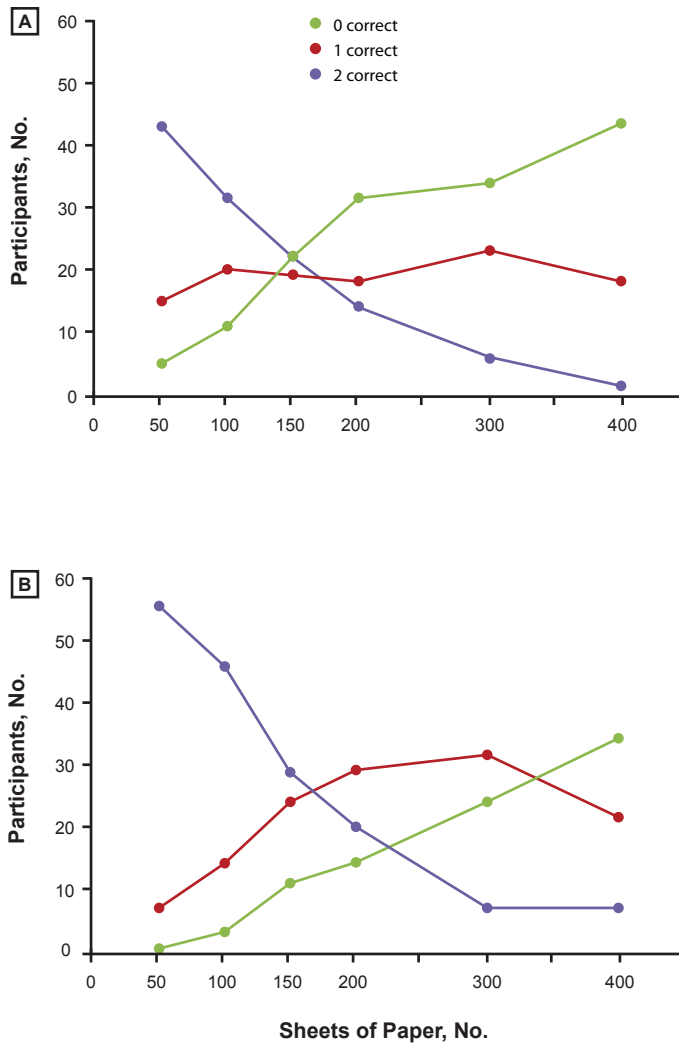


Figure 2. The number of first-year osteopathic medical students (n=63) who were able to correctly palpate the location of a dime in a stack of paper in 0, 1, or 2 trials by paper depth at the beginning of the first term (A) vs the end of the term (B). Students' ability to locate the dime progressively declined as paper depth increased both at the beginning and the end of the term. In the assay at the end of the term, a greater proportion of participants were able to locate the dime in at least 1 trial at the higher paper depths compared with the assay at the beginning of the term.

were able to locate the dime in at least 1 trial at higher paper depths in assay 2 than in assay 1. At a depth of 400 sheets, 29 participants (46%) in assay 2 were able to correctly locate the dime in at least 1 trial.

Generalized estimating equation analysis revealed a statistically significant relationship between time of assay administration (ie, beginning vs end of the term) and participants' performance (ie, ability to locate the dime correctly) ($P<.001$). Paper depth also demonstrated a significant effect on participants' responses ($P<.001$). The possibility that these 2 factors interacted in determining the probability of correct responses in the assay did not reach significance ($P=.08$). The post hoc polynomial contrast analysis showed a significant linear trend of decreasing mean number of correct responses with increasing paper depth (linear contrast estimate, -0.57 ; $SE=0.03$; $P<.001$).

Regardless of whether the dime was present or absent, the percentage of incorrect responses increased as paper depth increased. In assay 1, the percentage of incorrect responses when a dime was present increased with paper depth from 15 of 104 responses (14%) at a depth of 50 sheets to 91 of 108 responses (84%) at a depth of 400 sheets (Figure 3A). When no dime was present, the percentage of incorrect responses increased with paper depth from 10 of 22 responses (45%) at a depth of 50 sheets to 12 of 18 responses (67%) at a depth of 400 sheets. Similarly, in assay 2, the percentage of incorrect responses when a dime was present increased from 2 of 101 responses (2%) at a depth of 50 sheets to 77 of 104 responses (74%) at a depth of 400 sheets (Figure 3B). When no dime was present, the percentage of incorrect responses increased from 5 of 25 responses (20%) at a depth of 50 sheets to 12 of 22 responses (55%) at a depth of 400 sheets.

The percentage of incorrect responses in which a participant incorrectly answered that there was no dime present when a dime was present was relatively constant with paper depth and was consistently higher in assay 2 than in assay 1 (Figure 4). In assay 1, 4 of 15 total incorrect responses at a depth of 50 sheets were those in which a participant incorrectly answered "no dime." At a depth of 400 sheets, 25 of 91 incorrect responses (27%) were "no dime" responses. In assay 2, 1 of 2 incorrect responses at a depth of 50 sheets was a "no dime" response. At a depth of 400 sheets, 34 of 77 incorrect responses (44%) were "no dime" responses.

The Kaplan-Meier method revealed that the median paper depth at which participants first had 0 correct responses was 200 sheets (95% CI, 171-229) for assay 1 and 300 sheets (95% CI, 232-367) for assay 2 (Figure 5). Analysis with the marginal Cox model demonstrated that the rate at which participants failed to respond correctly in both trials at any paper depth decreased by approximately half from the beginning to the end of the term (hazard ratio, 0.56; 95% CI, 0.41-0.76; $P < .001$).

When the participant population was subdivided according to performance, the subgroup who had less than 8 correct responses on assay 1 had a positive mean (SD) score change of 2.91 (2.46) from assay 1 to assay 2. For the subgroup who had 8 or more correct responses, the mean (SD) change from assay 1 to assay 2 was -1.67 (1.53). Three of 45 participants (7%) in the subgroup with less than 8 correct responses declined in performance from assay 1 to assay 2. In contrast, 14 of 18 participants (78%) in the subgroup with 8 or more correct responses declined in performance from assay 1 to assay 2. Allowing for a variation of 1 response from assay 1 to assay 2, because some variability between repeated tests would be expected, 1 of 45 participants (2%) of those with less than 8 correct responses on assay 1 decreased in performance by greater than 1 response in assay 2, whereas 9 of 18 participants (50%) of those with 8 or more correct responses in assay 1 declined in performance by greater than 1 response in assay 2.

Compared with those participants who had not been previously exposed to the palpation assay (ie, those who completed assay 3 only; $n=192$), participants who had previously completed both assay 1 and assay 2 did not demonstrate significantly better performance in assay 3 ($n=57$), as assessed by total number of correct responses out of 12 trials (mean [SD] correct responses, 6.27 [2.13] and 6.75 [2.11], respectively; $P=.136$).

Discussion

The primary findings of our study were as follows: (1) the described assay yielded an objective and quantitative measure of basic palpation skills; (2) a substantial

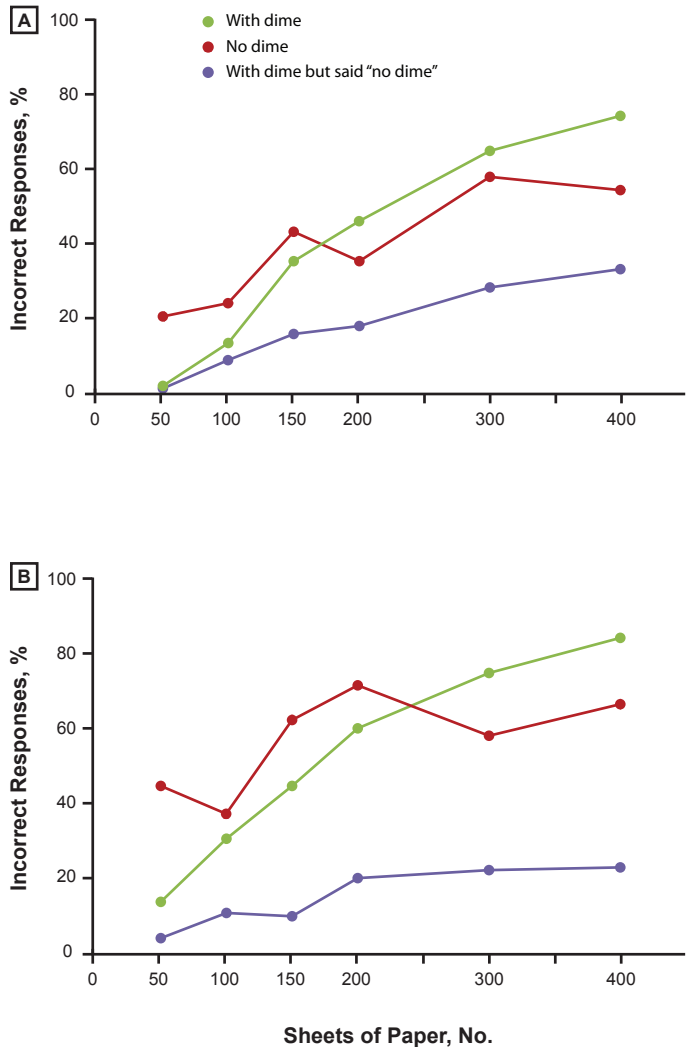


Figure 3.

The percent of incorrect responses by first-year osteopathic medical students ($n=63$) who attempted to palpate the location of a dime in a stack of paper at the beginning (A) or end (B) of the first term. Responses are presented according to whether a dime was present, a dime was not present, or a dime was present but the student reported that no dime was present. The percentage of participants who incorrectly answered that no dime was present when a dime was present was relatively constant throughout the range of sheet depths in both assays.

range of palpation skill was demonstrated by incoming first-year osteopathic medical students; (3) statistically significant improvement in performance was observed after a single academic term (approximately 3 months) of

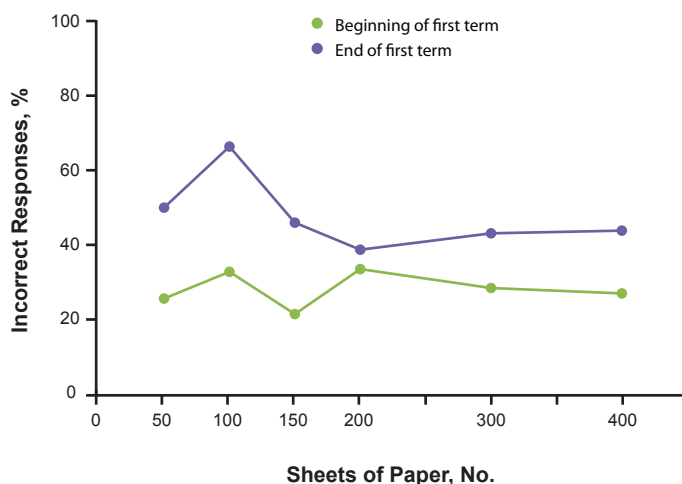


Figure 4. Percentage of incorrect responses by first-year osteopathic medical students (n=63) in which students stated that no dime was present in a stack of paper when a dime was present. Students attempted to palpate the location of a dime in a stack of paper at the beginning and end of the first term. Results are presented by paper depth. The relative proportion of responses in which students incorrectly stated that no dime was present remained relatively constant. The proportion was higher for participants in the assay at the end of the term than in the assay at the beginning of the term.

formal, osteopathic laboratory training; (4) participants exhibiting less developed palpatory skills (ie, poorer performance) at the beginning of the term demonstrated a statistically significant improvement in palpatory skills by the end of the term, whereas participants exhibiting more developed palpatory skills (ie, better performance) at the beginning of the term demonstrated a decline in palpatory skills by the end of the term; and (5) from the beginning to the end of the term, participants were more likely to indicate that they did not detect an object even when an object was present. The current study is, to our knowledge, the first to document improvement of basic palpatory skills during a period when students are receiving formal training in palpation and other osteopathic manipulative techniques.

The present study has several limitations. First, the relationship of performance in this assay with palpation accuracy in human participants is unknown. Our goal

was to develop a simple assay that measured some aspect of palpatory skills. We believe our assay achieves this goal and provides valuable insight into the ability of participants to identify the location of an object by manual palpation. Second, our study lacked a control group. An ideal control group would have been a parallel group that received the same medical education without palpation and OMM training. Our study, however, focused on the osteopathic medical profession. Future studies could compare the development of basic palpatory skills in the osteopathic medical student populations vs allopathic medical student populations.

We attempted to assess the role of practice with the palpation assay in improving palpation performance by comparing the results from participants who were previously exposed to 0 assays with those from participants who were previously exposed to 2 assays. Because participants were not told the results of their assays, knowledge of previous performance cannot be a factor influencing performance in the later assay. All participants received equivalent hours of formal, laboratory-based palpatory skills and other OMM training. These results indicated that practice with the assay did not significantly alter subsequent performance on the assay, which supports the argument that the observed improvement between the beginning and end of the term was not a result of previous exposure to the palpation assay. Third, the actual number of hours that participants spent practicing palpatory skills is unknown. Although we were able to quantitate the number of hours participants received in formal osteopathic laboratory training, we did not record any practice outside of the formal laboratory periods. In addition, we did not record participants' practice in basic physical examination skills, which likely included additional practice in palpation. Variation in these potential additional hours of palpatory skills practice could explain some of the individual variation in palpatory skills observed in our study. We are currently attempting to quantitate these informal and alternative training components and to determine how they impact development of basic palpatory skills for our future studies.

Previous studies have examined the acquisition of palpatory skills using assay systems targeted to specific body parts and areas. For example, Gerling et al¹¹ reported that training using a dynamic breast model improved the ability of medical students to detect breast lumps. In contrast, Lee et al¹⁴ reported that performance of medical students in a clinical breast examination test declined with increasing time in medical school. Lee et al¹⁴ attributed this progressive decline to lack of focus on training in palpatory skills. Several other studies^{9,10,12} by osteopathic researchers have reported that practice with palpation is associated with an improvement in palpatory skills in a specific model system. The consistency of our results with the results of studies^{9,10,12} by US-trained osteopathic physicians demonstrating an improvement in palpation skills with training might reflect the particular emphasis on the physical examination and, in particular, palpatory skills in standard osteopathic medical education curricula.

Multiple studies have investigated the interexaminer reliability for the use of palpation to detect specific body structures or abnormalities. Several studies^{7,8,15,16} examining palpation of the spinal and paraspinal area to detect specific structures or landmarks have reported poor agreement among examiners. Identification of lumbo-pelvic landmarks by palpation exhibited poor interexaminer reliability,¹⁷ as did detection of hepatomegaly by palpation.¹⁸ Several studies¹⁵⁻¹⁸ did not comment on the relative experience of the practitioners, thus making it impossible to assess the effect of experience and training on palpatory skills and interexaminer reliability in their findings.

Palpation is a complex process that involves the acquisition of a number of tactile sensations (eg, temperature, softness, tissue turgor, ease of compression). The practitioner integrates findings from these tactile stimuli to assess different structures in the living human being. The results of the present study suggest that training in palpation and other OMM techniques can improve a student's ability to integrate the variety of sensations and signals received during palpation into a conscious identification of an unseen object. These results support further investiga-

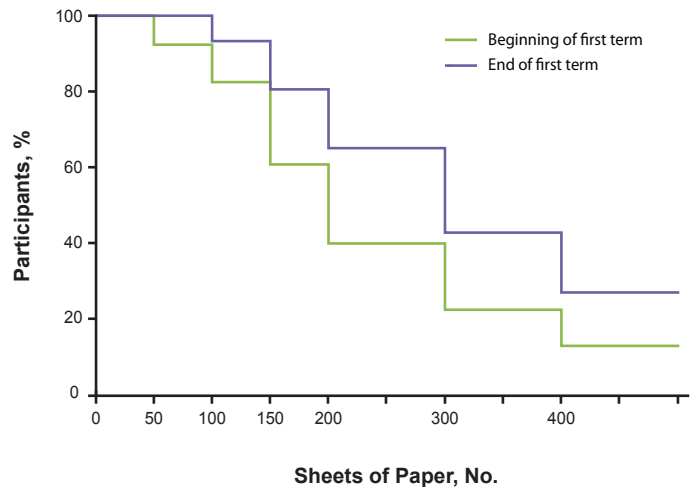


Figure 5.

Paper depth at which first-year osteopathic medical students (n=63) were first unable to palpate the location of a dime in a stack of paper in both trials. The median paper depth at which participants had 0 correct responses increased from the beginning to the end of the first term at 200 sheets (95% CI, 171-229) and 300 sheets (95% CI, 232-367), respectively.

tion into the effect of training and into the role of various factors in the acquisition of palpatory skills.

Conclusion

Using a novel assay, we demonstrated that the performance of first-year osteopathic medical students improved from the beginning to the end of their first term, a period during which the students are receiving intensive formal training in palpation and other OMM techniques. Although other factors may have contributed to this improvement, our results are consistent with previous studies that have shown practice in palpation is associated with improvement in basic palpatory skills.

Author Contributions

All authors provided substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; Student Doctor Loh, Dr Gilliar, Student Doctor Iacono, and Dr Amsler, drafted the article or revised it critically for important intellectual content; and all authors gave final approval of the version of the article to be published.

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