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ORIGINAL ARTICLE

The role of ultrasound and preparation in first-year medical students' learning lumbar spine anatomy and diagnostic skills

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Abstract *Background:* Ultrasound as an educational tool in preclinical medical education needs to be examined because of its broad and increasing use in medicine and its potential in enhancing students' anatomical knowledge and diagnostic skills. This study examines the role of ultrasound and preparation in first-year medical students' learning to identify and palpate lumbar spine landmarks.
Methods: Surveys were collected from first-year medical students who attended the lumbar spine workshop. Students were randomly stratified into two groups: using ultrasound and not using ultrasound. Student-diagnosed lumbar spine somatic dysfunctions were assessed by two blinded physicians.
Results: Three hundred and eighteen first-year students completed the survey. Sixty six percent (n = 104) of the students in the ultrasound group stated that ultrasound improved their physical examination skills. No significant difference existed between the ultrasound and non-ultrasound groups in confidence level in palpation, engagement level in workshop, nor accurately diagnosing lumbar somatic dysfunction. A significantly greater proportion of prepared students, compared to unprepared students, responded that the workshop helped with diagnosing and was engaging, and that ultrasound did or would improve physical

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examination skills (all $p < 0.05$). No significant difference was found between ultrasound and non-ultrasound groups, as well as between prepared and non-prepared groups, in physician assessment of student diagnosis.
Conclusion: The study results can assist in the design of future studies and workshops on ultrasound in preclinical education. Our study suggests the need for further research exploring ultrasound's role in helping preclinical medical students acquire basic and advanced palpatory and diagnostic skills.

Implications for practice

- The majority of the first-year medical students believe that ultrasound would improve their physical examination skills.
- Students who sufficiently prepared for the workshop through online videos were more likely to believe that the workshop was helpful for diagnosing and was engaging and that ultrasound would improve their examination skills.
- No significant difference between ultrasound and non-ultrasound groups, as well as between prepared and non-prepared groups, existed in physician assessment of student diagnosis.
- The study results can aid in the design of future studies and how to better integrate ultrasound and preparation through online videos throughout preclinical osteopathic medical education.

Background

In the past few decades, with ultrasound technology becoming more portable and affordable, ultrasound imaging has been increasingly used by physicians across medical specialties to perform rapid bedside evaluation and interventional management of patients.[1] The Accreditation Council for Graduate Medical Education requires ultrasound education for residents in various specialties including internal medicine, obstetrics-gynecology, radiology, and emergency medicine.[2–5] While ultrasound use rapidly increases in the clinical setting, its role in undergraduate medical education remains uncertain.[6]

Because ultrasound imaging is a useful modality in imaging anatomical landmarks, it has been utilized in gross anatomy curriculum in medical schools.[7–9] The advantages of utilizing ultrasound imaging is its relatively low cost, its non-invasiveness, and its ability to capture dynamic anatomy. In the arena of medical education, students have found ultrasound an engaging and useful educational tool.[9,10]

The role of ultrasound has also shown potential in improving preclinical medical students' physical exam skills and accuracy.[11,12] The physical examination is a fundamental skill for all clinicians, and osteopathic physicians-in-training must also learn to competently perform an osteopathic structural exam. This examination emphasizes the neuromusculoskeletal system which includes a palpatory diagnosis for somatic dysfunctions. A somatic dysfunction is described as an "impaired or altered function of related components of the somatic (body framework) system: skeletal, arthrodial and myofascial structures, and their related vascular, lymphatic, and neural elements."[13] As future clinicians, medical students will apply their knowledge of anatomy while conducting a physical exam. Although diagnostic palpation is integral to clinical decision-making and medical school curriculum, it is also a challenging clinical skill to develop in and teach to medical students.[14]

While ultrasound has demonstrated benefit as an educational tool in preclinical medical education, the integration of ultrasound education in U.S. medical schools—allopathic and osteopathic—is nonetheless variable, with no published model ultrasound curriculum.[6] Therefore, the role of ultrasound as an educational tool in preclinical education and Osteopathic Manipulative Medicine (OMM) needs to be explored and closely examined because of its broad and increasing use in medical care and its potential to enhance students' learning anatomical landmarks and osteopathic palpation techniques.

This study seeks to understand the role of ultrasound as a tool for first-year medical students to improve their ability to identify and palpate lumbar spine anatomic landmarks. It also looks at the use of ultrasound to enhance students' palpation and diagnostic skills and their level of engagement

in OMM workshops. We sought to examine if ultrasound use, as well as pre-workshop preparation, would enhance students' overall osteopathic structural examination skills.

Methods

This study was approved by the New York Institute of Technology (NYIT) Institutional Review Board as an exempt study (NYIT IRB BHS#1090). This study was exempt as it was research conducted in an established educational setting involving the comparison of instructional techniques. Additionally, it was research involving the use of surveys, which requested no participant identifiers, such as name, date of birth or student ID numbers. At NYIT College of Osteopathic Medicine, 319 first-year medical students were randomly stratified into two groups for an OMM workshop: 158 students into one group using ultrasound pre-assessment and 160 students into another group not using ultrasound pre-assessment. As instructed in their class preparation guide, all students should have prepared for the workshop by (1) viewing a 1-h general lecture, available as a live or online video lecture, on ultrasound concepts and imaging and (2) watching a 3-min online video introducing ultrasound and imaging the lumbar spine. Students were asked to self-report whether they watched the pre-workshop videos and their level of preparation in the survey (Appendix A). The 1-h workshop took place on 1/7 and 1/8/2015, in the middle of the first-year medical school curriculum. The 1 h workshop consisted of students' reviewing the concepts of lumbar spine anatomy and somatic dysfunctions, pairing up with a classmate and practicing diagnosing lumbar spine dysfunctions on each other, reviewing ultrasound concepts and utilizing ultrasound to identify lumbar spine anatomy, such as the spinous process, transverse process and the erector spinae muscles, and physician assessment of student diagnoses. The ultrasounds utilized were SonoSite M-turbo models, each with a high frequency linear transducer, HFL50X/15-6 MHZ with a 6 cm scan depth, on the MSK exam type setting. Students were evaluated by two-components (1) a survey (Appendix A) composed of 7 Likert scale-based questions and 2 open-ended questions and (2) two osteopathic physicians in the OMM department of NYIT College of Osteopathic Medicine (NYIT-COM). Students were asked to note the one somatic dysfunction that they were most confident in having checked, similar to how they do on their OMM practical examinations. The two physicians who assessed each student diagnosis of a lumbar somatic dysfunction were blinded to the study and students' group allocation. They were involved in only the assessment portion of the workshop. If the two physicians disagreed on their assessment of the student diagnosis, they would have to reassess the student diagnosis, confer, and come to an agreement on their assessment. This study analyzes the data of 318 surveys. One participant's data was excluded due to missing responses.

In the survey, students were asked to indicate their degree of agreement on a 5-point Likert scale to 6 statements (Appendix A). Students remarked by checking 'strongly disagree', 'disagree', 'neutral', 'agree', or 'strongly agree'. Responses were regrouped in 'yes' if participants chose the affirmative response options of 'agree' or 'strongly agree', and 'no' if they chose 'strongly disagree', 'disagree', or 'neutral'. Because we sought to examine whether ultrasound was associated with student perception of enhancing their osteopathic structural examination skills, the "neutral" response was grouped with the non-affirmative responses of "disagree" or "strongly disagree" responses. Participants in the two groups were given the same items on the survey, with one exception. The ultrasound group received this 5-point Likert scale item: "Ultrasound imaging improved OMM structural examination skills", whereas the control group received "Ultrasound imaging would have improved OMM structural examination skills".

Statistical analysis was performed to compare the two arms, using IBM SPSS Statistics 22. Differences between groups were tested using a Chi-Square statistic for categorical variables. Odds ratios (ORs) and their 95% confidence intervals (CIs) were estimated using binary logistic regression models. Table 2 shows the ORs, unadjusted and preparation-adjusted, between ultrasound use and student beliefs and performances. Table 3 shows the unadjusted ORs between pre-workshop preparation and student beliefs and performances. Statistical significance was assessed using a two sided test at the alpha $= 0.05$ level.

Results

The study analyzes the data of 318 first-year medical students at NYIT-COM. The mean age of the first-year medical students is 26 years old, with 162 male and 156 female students (data not shown). Table 1 shows the survey responses from the study participants in both the ultrasound and control groups. The majority of participants

Table 1 Responses from first year medical students with respect to ultrasound use.

	Ultrasound N = 158	Control N = 160	*p*-Value
	N (%)		
Watched pre-workshop videos			0.05
Yes	134 (84.8)	122 (76.3)	
No	24 (15.2)	38 (23.7)	
Prepared sufficiently for ultrasound portion of workshop through pre-workshop videos			**0.00**
Agree	113 (71.5)	73 (45.6)	
Disagree	45 (28.5)	87 (54.4)	
Workshop improved confidence level in palpating lumbar spine landmarks			0.66
Agree	90 (57.0)	95 (59.4)	
Disagree	68 (43.0)	64 (40.0)	
Workshop improved understanding of lumbar spine anatomy			0.40
Agree	102 (64.6)	96 (60.0)	
Disagree	56 (35.4)	64 (40.0)	
Workshop helped with identification of lumbar spine landmarks			0.87
Agree	104 (65.8)	104 (65)	
Disagree	54 (34.2)	56 (35.0)	
Workshop helped with diagnosing lumbar spine somatic dysfunctions			0.16
Agree	104 (65.8)	117 (73.1)	
Disagree	54 (34.2)	43 (26.9)	
Felt engaged in workshop			0.62
Agree	129 (81.6)	134 (83.8)	
Disagree	29 (18.4)	26 (16.2)	
Ultrasound imaging (would have) improved OMM structural examination skills			0.19
Agree	104 (65.8)	94 (58.8)	
Disagree	54 (34.2)	66 (41.2)	
	Ultrasound N = 130	Control N = 123	*p*-Value
Physician agreement with student diagnosis			0.86
Agree	33 (25.4)	30 (24.4)	
Disagree	97 (74.6)	93 (75.6)	

Bolded values are significant ($p < 0.05$ or CI not including 1) and described in the text of results.

Table 2 Associations between ultrasound use and student beliefs and performance.

	Ultrasound vs. non-ultrasound OR (95% CI)	Ultrasound vs. non-ultrasound Preparation- adjusted-OR (95% CI)
Workshop improved confidence level in palpating lumbar spine landmarks.	0.91 (0.58—1.41)	0.87 (0.53—1.33)
Workshop improved understanding of lumbar spine anatomy.	1.21 (0.77—1.91)	1.09 (0.68—1.75)
Workshop helped with identification of lumbar spine landmarks.	1.04 (0.65—1.65)	0.94 (0.58—1.52)
Workshop helped with diagnosing lumbar spine somatic dysfunctions.	0.71 (0.44—1.14)	**0.57 (0.34—0.96)**
Felt engaged in workshop.	0.86 (0.48—1.55)	0.71 (0.38—1.30)
Ultrasound imaging (*would have*) improved OMM structural examination skills.	1.35 (0.86—2.13)	1.05 (0.65—1.70)
	N = 253	N = 253
Physician agreement with student diagnosis	0.95 (0.54—1.68)	0.94 (0.52—1.70)

Bolded values are significant ($p < 0.05$ or CI not including 1) and described in the text of results.

Table 3 Associations between pre-workshop preparation and student beliefs and performance.

	Prepared N = 186	Unprepared N = 132	*p*-Value	Prepared vs. unprepared OR (95% CI)
	N (%)			
Workshop improved confidence level in palpating lumbar spine landmarks			0.27	1.30 (0.82–2.02)
Agree	113 (60.8)	72 (54.5)		
Disagree	73 (39.2)	60 (45.5)		
Workshop improved understanding of lumbar spine anatomy			0.06	1.57 (0.99–2.48)
Agree	124 (66.7)	74 (56.1)		
Disagree	62 (33.3)	58 (43.9)		
Workshop helped with identification of lumbar spine landmarks			0.13	1.43 (0.90–2.29)
Agree	128 (68.8)	80 (60.6)		
Disagree	58 (31.2)	52 (39.4)		
Workshop helped with diagnosing lumbar spine somatic dysfunctions			**0.02**	**1.80 (1.11–2.92)**
Agree	139 (74.7)	82 (62.1)		
Disagree	47 (25.3)	50 (37.9)		
Felt engaged in workshop			**0.03**	**1.89 (1.05–3.40)**
Agree	161 (86.6)	102 (77.3)		
Disagree	25 (13.4)	30 (22.7)		
Ultrasound imaging (*would have*) improved OMM structural examination skills			**0.00**	**2.74 (1.72–4.37)**
Agree	134 (72.0)	64 (48.5)		
Disagree	52 (28.0)	68 (51.5)		
	Prepared N=142	Unprepared N=111	*p*-Value	N = 253
Physician agreement with student diagnosis			0.92	
Agree	35 (24.6)	28 (25.2)		0.97 (0.55–1.72)
Disagree	107 (75.4)	83 (74.8)		

Bolded values are significant ($p < 0.05$ or CI not including 1) and described in the text of results.

believed that ultrasound use did or would have improved their OMM structural examination skills, with 66% (n = 104) from the ultrasound group and 58.8% (n = 94) of the control group respectively ($p = 0.19$; OR = 1.35, 95% CI = 0.86–2.13 in Table 2). There was a significant difference between the two groups in self-reported pre-workshop preparation, with 71.5% (n = 113) of the ultrasound group and 45.6% (n = 73) of the control group preparing sufficiently for the ultrasound portion of the workshop through viewing pre-workshop videos ($p < 0.05$, OR = 3.00; 95% CI = 1.88–4.76, data not shown). No significant difference existed between the ultrasound and non-ultrasound groups in improving students' lumbar palpatory and diagnostic skills, anatomic knowledge, nor engagement level in workshop (all $p > 0.05$).

Odds ratios, including preparation-adjusted ORs, and 95% CIs comparing those who did or did not use ultrasound for items related to lumbar spine palpation, diagnosis, anatomy and engagement level are shown in Table 2. When adjusted for self-reported preparation, participants who used ultrasound were less likely to respond that the workshop helped their diagnosing lumbar spine dysfunctions (Preparation-adjusted OR = 0.57, 95% CI = 0.34–0.96; unadjusted OR = 0.71, 95% CI = 0.44–1.14). No other significant findings existed when comparing ultrasound versus non-ultrasound participants. There was no significant difference between the two groups in physician agreement with student diagnosis.

Table 3 presents the associations between sufficient pre-workshop preparation through viewing online videos and students' beliefs and performance. Prepared students were more likely to find the workshop helpful for diagnosing lumbar spine somatic dysfunctions (OR = 1.80, 95% CI = 1.11–2.92), engaging (OR = 1.89, 95% CI = 1.05–3.40), and that ultrasound would or did improve their osteopathic physical examination skills (OR = 2.74, CI = 1.72–4.37). No other significant associations were found in comparing prepared versus unprepared students. Of note, there was no signficiant difference between prepared and unprepared students with respect to

physician agreement with the student diagnosis (OR = 0.97, 95% CI = 0.55–1.72).

Discussion

Along with current literature, our results suggest that ultrasound as an educational tool could be more helpful to medical students if introduced later in the curriculum, after maturation of basic skills.[15,16] To underscore the importance of student preparatory work and acquisition of basic skills, Arroyo-Morales et al. highlighted that second-year physiotherapy students who received supplemental e-learning videos on palpation and ultrasound, compared to students with only texts, needed less time to palpate a musculoskeletal structure, were more able to obtain a reliable ultrasound image, and demonstrated more theoretical knowledge, determined by multiple choice exam.[16] While, in our study, the majority of first year students in both ultrasound and non-ultrasound groups believed that ultrasound would help their physical examination skills, there was no significant difference between the two groups in accurately diagnosing lumbar spine somatic dysfunctions. These findings could be explained by preclinical students' needing more ultrasound or palpatory exposure and experience to see an improvement in diagnostic skills, as well as the level of agreement between the assessing physicians and students. Similarly, our study showed that prepared students were significantly more likely than unprepared students to find the workshop helpful for diagnosing and that ultrasound would improve their physical examination skills. Yet, there was no significant difference between prepared and non-prepared students in accurately diagnosing the lumbar spine. Potentially ultrasound and preparation through online videos would be more helpful in second-year medical students, after more exposure and practice with ultrasound and palpating.

The strength of this study lies in its unique focus on ultrasound use in preclinical medical education, specifically in determining its role as an adjunct in teaching physical and osteopathic structural examination skills and whether there are any differences in exposed students' diagnostic skills as compared to their unexposed counterparts. It is interesting to note that Morris et al. demonstrates that visuohaptic training, compared to haptic or visual training alone, is more effective in teaching sensorimotor skills with force-sensitive components.[17] Our study offered students an opportunity through ultrasound to three-dimensionally visualize the anatomy they were palpating and subsequently diagnosing. Ultrasound provides additional and accurate visuohaptic feedback to an osteopathic student doctor in training and could potentially enhance student retention of anatomical structures, knowledge base and examination skills. Faculty could also use ultrasound imaging to corroborate and further review their assessment with students. It would thus be prudent to take the results of this study and further investigate if ultrasound indeed enhanced students' osteopathic examination skills in subsequent workshops after student acquisition of basic knowledge and skills. Additionally, the assessments tools used sought to prevent the introduction of bias into this study. The surveys do not ask students outright about ultrasound's effects on their knowledge or structural examination skills. The physicians who assessed students' diagnoses were blinded to the group allocation, had to agree on their assessment, and offered an additional assessment of students' palpatory and diagnostic skills, rather than solely the students' self-report.

It is important to view the results from our study in the context of certain limitations. Survey responses relied on students' self-reporting. Additionally, while we were able to analyze 99% of the first-year medical class at NYIT-COM, this study only analyzes medical students from one location. The workshop was also only 1 h in duration and once in the middle of their first year. Students likely needed more time and practice to proficiently learn both ultrasound and physical examination skills. After all, a recent 2015 study demonstrated that students exposed to an ultrasound curriculum of 8 half-hours sessions throughout their first year of medical school, compared to the year prior's unexposed first-year medical students, had a significant increase in their Objective Standardized Clinical Examination scores at the end of their first year.[18] Further studies can examine if integrating multiple ultrasound sessions into osteopathic workshops and laboratory sessions throughout the preclinical medical curriculum could improve the students' osteopathic structural examination skills and whether ultrasound use is more effective in teaching landmarks in the axial versus appendicular skeleton. Future studies should also adjust for age, gender, academic performance, and prior experiences with ultrasound use and manual therapy.

Results from our study can assist in the design of future studies on ultrasound in preclinical education and suggests the need for further research exploring ultrasound's role in teaching preclinical medical students basic and advanced

palpatory and diagnostic skills. Moreover this study could help aid in understanding ultrasound's role in teaching and assessing students' osteopathic knowledge and examination skills. Using these results as guidance, we will be examining the role of ultrasound and online videos as educational tools in additional workshops for future first-year medical students and how to better integrate these tools throughout their preclinical curriculum.

Conclusion

We found that the majority of first-year medical students believe that ultrasound would improve their physical examination skills. We also found that students who sufficiently prepared for the workshop were more likely to believe that the workshop was helpful for diagnosing and was engaging and that ultrasound would improve their examination skills. Still, no significant difference between ultrasound and non-ultrasound groups, as well as between prepared and non-prepared groups, existed in physician agreement with student diagnosis. The study results can aid in the design of future studies and how to best integrate ultrasound and preparation through online videos into preclinical medical education.

Conflict of interest statement

None declared.

Ethical approval

This study was approved by the NYIT Institutional Review Board as an exempt study. The privacy rights of participants has always been observed. Identifying information, including patients' images, names, initials, were never included in any collected documents.

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Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.ijosm.2016.10.001.

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