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ORIGINAL RESEARCH ARTICLE

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The status of ultrasound imaging education in Doctor of Physical Therapy program curricula: results of a national survey

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Abstract

Background This investigation evaluated the state of ultrasound imaging (USI) education in entry-level Doctor of Physical Therapy (DPT) program curricula in the USA, including faculty perceptions and qualifications regarding USI and identification of potential barriers to inclusion or expansion of USI education. A review of published literature reveals that the inclusion of USI education in entry-level DPT program curricula has not been systematically investigated and is largely unknown.

Methods Investigators created an online survey developed in Qualtrics[XM] and distributed through email an electronic link to the program chair/director at all 258 accredited entry-level DPT programs in the USA with instructions to complete and or share with faculty.

Results The overall response rate was 24% (65/269) and represented 54 programs from 28 of the 50 states; 70% reported including USI education in their program's curriculum, with 91% spending < 10 h on instruction throughout their curriculum; 44% reported plans to expand USI education in their curriculum, with 85% citing expanding scope of practice and curriculum as primary reasons; 79% cited the lack of qualified instructors, lack of knowledge/training, and equipment cost as the largest barriers to the inclusion of USI education in their program's curriculum. Whether USI is an entry-level skill was evenly split among respondents.

Conclusions Respondents from a representative sample of entry-level DPT programs across the USA provided survey responses. Despite most respondents being knowledgeable about USI, most do not use this point-of-care imaging modality in clinical practice. Based on the results of this survey, overcoming perceived barriers is necessary to expand USI education in entry-level DPT program curricula, namely, lack of qualified instructors, lack of knowledge/training, and cost of equipment. This national survey provides original data that may stimulate discussion about innovative ways to include USI education in entry-level DPT program curricula to meet the emerging needs of our profession.

Keywords Curricular design, Physical therapy education, Point-of-care imaging, Sonography

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Background

Point-of-care ultrasound imaging (USI) is a safe, inexpensive, and portable tool allowing for real-time imaging and evaluation of the neuromusculoskeletal system, including dynamic assessment of various joints and soft tissues during movement [1–3]. Diagnostic application of USI extends the clinical examination, aiding physical therapists in the differential diagnosis for various movement-related disorders or soft tissue injuries. In contrast to traditional medical management, USI allows for on-site evaluation, avoiding need for external imaging referrals which can be problematic when interpreted outside of a patient's symptoms and clinical examination [4–6]. Procedural USI informs physical therapy interventions, enhancing treatment effectiveness through biofeedback, neuromuscular re-education, and real-time monitoring of soft tissue changes, healing, and remodeling, and identification of target tissues for manual therapy or biophysical agents including needle guidance [3, 7–14]. Despite the demonstrated clinical value of USI, the status of USI education in entry-level Doctor of Physical Therapy (DPT) program curricula has not been systematically investigated.

With the increasing affordability and accessibility of USI equipment, there is a growing need to assess the state of USI education in entry-level DPT program curricula, particularly when considering the need to prepare physical therapists as primary-care providers [15, 16]. The definition of USI education includes both lecture- and laboratory-based instruction, incorporating live scanning on students, volunteers, or patients. Technological advances, such as portable hand-held and laptop-based USI devices [1, 17], have made it practical to introduce didactic USI content early in an entry-level DPT program's curriculum, alongside other imaging modalities [2, 3, 18–22]. Although the inclusion of laboratory-based USI instruction may be perceived as time and resource-intensive, successful *vertical*incorporation in medical school curricula suggests its potential benefit for learning anatomy, arthrokinematics, joint and soft tissue palpation, and clinical examination and intervention skills with favorable reception by students [19–22].

No published studies have detailed USI education in entry-level DPT program curricula; however, a national survey of medical school administrators revealed that only 62% of schools in the USA offered USI education in their curriculum, citing space in curriculum, lack of financial support, lack of equipment, and lack of trained faculty as barriers [18, 21, 23]. It is currently not known if similar or additional barriers exist in physical therapy education, which is influenced by state-specific Physical Therapy Practice Act restrictions [24]. In addition, despite the *Commission for the Accreditation of Physical Therapy Education*(CAPTE) listing "diagnostic imaging" as a required curricular element, no accepted standard exists recommending an appropriate depth and breadth of USI education in contemporary entry-level DPT program curricula [2, 25].

Despite the proven benefits of point-of-care USI in clinical practice, its integration in entry-level DPT program curricula in the USA remains largely unknown. This investigation evaluated the state of USI education in entry-level DPT program curricula in the USA, including faculty perceptions and qualifications regarding USI and identification of potential barriers to inclusion or expansion of USI education. We hypothesized that most entry-level DPT programs would report including didactic USI education in their curriculum with a minority of programs reporting inclusion of live scanning, citing similar barriers reported by medical education programs [18, 21, 23].

Methods

Participants

Study eligibility included current faculty members in entry-level DPT programs accredited by CAPTE within the USA. Investigators obtained the list of entry-level DPT programs ($n=258$) and their program chair/director from the CAPTE website (capteonline.org) in December 2022. Researchers solicited potential survey participants through email. Each program chair/director of an accredited entry-level DPT program received an email invitation including information about the study and an electronic link to the survey instrument with instructions to complete the survey and/or forward it to the appropriate faculty members based on their area of expertise (e.g., faculty teaching courses or content in diagnostic imaging, musculoskeletal/orthopedic physical therapy, etc.) with the understanding that a single program may provide more than one survey response.

The investigators utilized a cross-sectional study design. Winston-Salem State University Institutional Review Board (IRB-FY2023-31) approved this investigation, granting an exempted status because of the minimal risk posed to human subjects. Collected survey responses included no individually identifiable data, and all participants provided informed consent before accessing the full survey instrument for completion. Solicitation of survey responses began on January 2, 2023, and ended on June 30, 2023. Researchers sent periodic email reminders (roughly every 2–3 weeks) to unresponsive program chairs/directors to improve the overall survey response rate.

Survey instrument

Investigators created an online survey that was developed in Qualtrics[XM]. Pilot testing was conducted of the survey instrument by sending to a handful of colleagues and incorporating their feedback about clarity and flow of the questions. The finalized survey was distributed through email an electronic link to the program chair/director with instructions to complete and/or share with appropriate faculty. The survey consisted of an initial 14 questions with a branching option that accounted for a *maximum* of 34 questions or a *minimum* of 24 questions for a particular survey respondent based on their answer to the 14th question. The survey instrument included quantitative (Likert scale) and qualitative (short answer) questions. After providing informed consent, all survey respondents answered the first 14 questions, followed by ten unique questions for those respondents indicating that their program currently includes USI education in their entry-level DPT program curriculum. All survey respondents completed the final ten survey questions (Fig. 1). The survey questions fell into one of three general categories: (1) demographics and characteristics of the survey respondents; (2) demographics and characteristics of the entry-level DPT programs represented by the survey respondents; and (3) general perceptions of the survey respondents about USI education.

Statistical analysis

Investigators performed descriptive statistics on all survey questions and utilized Qualtrics[XM] for data analysis calculation to identify response frequencies and relative percentages for each survey question. Geographic representation of each entry-level DPT program was categorized based on the six *Council of Higher Education Accreditation*regions, namely, New England, Middle States, North Central, Southern, Western, and Northwest [26].

Results

The survey response rate was 24% (65 of 269) and represented 54 programs from 28 of the 50 states. The survey respondents' demographic information and other characteristics are found in Table 1. The survey respondents represented entry-level DPT programs from across the USA. The North Central, Southern, and Middle States regions had the greatest percentage of participating programs, providing 34%, 32%, and 19% of the survey responses, respectively. Programs from the following states provided the highest percentage of survey responses: New York (11%), California (8%), Pennsylvania (8%), Georgia (6%), and North Carolina (6%). Demographic information and other characteristics of the entry-level DPT programs represented by the survey respondents are found in Table 2.

Survey results revealed 70% of respondents reported that their entry-level DPT program includes USI education in their curriculum, with 91% reporting that their program spends *less than* 10 h on instruction throughout their entire curriculum; 84% of respondents reported that USI content is taught by a core faculty member, with 84% reporting inclusion of USI content during the first or second program year and 61% reporting that their program includes USI content in diagnostic imaging and/or orthopedics/musculoskeletal course. Regarding entry-level DPT programs that include USI education in their program's curriculum, 61% of

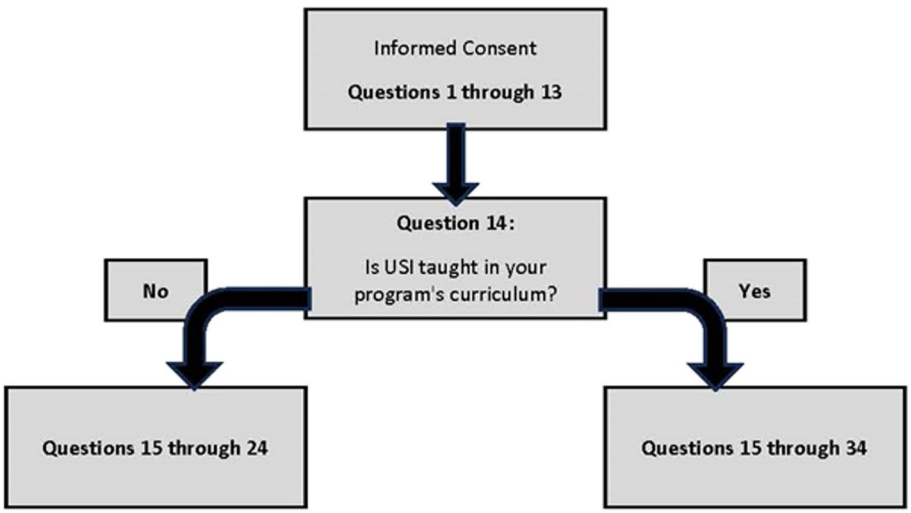

Fig. 1 Survey flow for each respondent. USI: ultrasound imaging

Table 1 Demographics and characteristics of survey respondents

Survey questions	Response choices	No. of respondents	% of Respondents
Which of the following best describes your role in your DPT program? (*n* = 65)	Core Faculty	35	53.8%
	Associated/Adjunct Faculty	1	1.5%
	Program Chair/Director	25	38.5%
	Clinical Faculty	4	6.2%
What is the highest academic degree you have earned? (*n* = 64)	Clinical Doctorate	19	29.7%
	Academic Doctorate	45	70.3%
Are you a licensed physical therapist? (*n* = 64)	Yes	63	98.4%
	No	1	1.6%
Are you a board-certified specialist? (*n* = 70)	Yes, ABPTS	32	45.7%
	Yes, non-ABPTS	10	14.3%
	No	28	40.0%
How many years of clinical experience do you have? (*n* = 64)	0–5 Years	2	3.1%
	6–10 Years	4	6.3%
	11–15 Years	8	12.5%
	16–20 Years	9	14.1%
	21 + Years	41	64.1%
How many years of full- or part-time academic experience do you have? (*n* = 64)	0–5 Years	8	12.5%
	6–10 Years	9	14.1%
	11–15 Years	13	20.3%
	16–20 Years	8	12.5%
	21 + Years	26	40.6%
What is your age? (*n* = 64)	25–34 Years	2	3.1%
	35–44 Years	10	15.6%
	45–54 Years	14	21.9%
	55–64 Years	29	45.3%
	65 + Years	9	14.1%

DPT Doctor of Physical Therapy, *ABPTS* American Board of Physical Therapy Specialties, *USI* ultrasound imaging

respondents reported that the primary instructor delivering USI content had received training through continuing education courses, 22% received formal training or completed a certification, and 13% had received no formal training; 72% of respondents reported that stated learning objectives related to USI are included in the applicable course syllabi. Regarding reasons for the inclusion of USI education in their program's curriculum, 26% of respondents reported "Description of imaging modality," 24% reported "Diagnostic imaging as extension of the clinical examination," 18% reported "Diagnostic or interventional biofeedback," with the remainder reporting supplemental learning of anatomy or clinical examination and intervention skills as the primary objectives; 65% of respondents reported their entry-level DPT program utilizes a lecture and laboratory delivery format, with 64% reporting that their students perform live USI scanning; 91% of respondents reported that their program owns or has access to USI equipment, with 34% reporting that their program uses a hand-held device (i.e., a device that connects to a tablet or phone); 44% of respondents reported that their program plans to expand USI education in their curriculum, with 85% citing the expanding scope of Physical Therapy Practice and the expansion of entry-level DPT program curricula as the primary reasons.

Survey respondents identified potential barriers to the inclusion of USI education in entry-level DPT program curricula; 79% of respondents cited the lack of qualified instructors, knowledge/training, and equipment cost as the largest barriers preventing them from including USI education in their program's curriculum; 53% of respondents estimated the cost of USI equipment exceeding $10 K, with 9% of those respondents estimating the cost of USI equipment exceeding $30 K. Whether the performance and interpretation of USI is an entry-level DPT skill was evenly split among respondents, with 73% reporting that training and education in USI should occur in post-graduate or continuing education settings. Survey respondents' general perceptions about including

Table 2 Demographics and characteristics of the entry-level Doctor of Physical Therapy programs represented by survey respondents

Survey questions	Response choices	No. of respondents	% of Respondents
Does your academic institution receive public or state-supported funding? (*n* = 64)	Yes	28	43.8%
	No	30	46.9%
	Not sure	6	9.4%
Which of the following best describes your program's accreditation status? (*n* = 64)	Fully accredited	64	100%
How many students does your program accept in each cohort? (*n* = 64)	21–30 Students	9	14.1%
	31–40 Students	24	37.5%
	41–50 Students	19	29.7%
	51 + Students	12	18.8%
How many cohorts does your program accept per academic year? (*n* = 64)	1 Cohort	60	93.8%
	2 Cohorts	1	1.6%
	3 Cohorts	3	4.7%
What is the total length, in months, of your program's curriculum? (*n* = 64)	25–36 Months	61	95.3%
	37 + Months	3	4.7%
Do any faculty in your department utilize USI in their research? (*n* = 62)	Yes	36	58.1%
	No	24	38.7%
	Not sure	2	3.2%
Is your program planning to *expand* USI education in its curriculum? (*n* = 62)	Yes	27	43.5%
	No	16	25.8%
	Not sure	19	30.6%
Is your program planning on *adding* USI education to its curriculum? (*n* = 19)	Yes	5	26.3%
	No	5	26.3%
	Not sure	9	47.4%

USI ultrasound imaging

USI education in entry-level DPT program curricula are found in Table 3.

In addition, 32% of respondents reported personally using USI in clinical practice, with 70% of those respondents considering themselves either "Confident" or "Expert" in the performance and interpretation of USI. Among respondents reporting that they *do not* personally use USI in clinical practice, 64% reported that they consider themselves either "Somewhat" or "Very" knowledgeable about USI. Respondents reporting that their

Table 3 General perceptions of respondents about ultrasound imaging education

Survey questions	Response choices	No. of respondents	% of Respondents
Is the performance and interpretation of USI within the scope of physical therapy practice in your state? (*n* = 62)	Yes	34	54.8%
	No	17	27.4%
	Not sure	11	17.7%
Do you view the performance and interpretation of USI as an entry-level DPT skill? (*n* = 62)	Yes	31	50.0%
	No	31	50.0%
Since you view USI as an entry-level skill, how should entry-level DPT programs incorporate USI content? (*n* = 77)	Diagnostic	28	36.4%
	Assist learning	23	29.9%
	Biofeedback	23	29.9%
	Other	3	3.9%
Since you *do not* view USI as an entry-level DPT skill, when is USI content indicated? (*n* = 68)	Elective course	18	26.5%
	Post-graduate training	28	41.2%
	Continuing education	22	32.4%

USI ultrasound imaging, *DPT* Doctor of Physical Therapy

entry-level DPT program *does not* currently incorporate USI education in their program's curriculum were evenly split (26% "Yes" and 26% "No") on whether their program is planning to add USI education in the future (47% of respondents reporting that they were "Not sure"); 69% of respondents reported that *onboard* training modules (i.e., training modules contained in the USI equipment, which allows students to learn while scanning along) would be useful as primary or secondary instructional tools, with 72% reporting the same about *online* training modules.

Discussion

The results of this national survey provide original data about the state of USI education in entry-level DPT program curricula in the USA. Respondents from a representative sample of programs across the USA provided survey responses. Notably, only 70% of respondents reported that their program's curriculum includes USI education. However, many respondents reported that their program does plan to expand USI education in their curriculum based on the expanding scope of Physical Therapy Practice and the expansion of entry-level DPT program curricula. Despite most survey respondents reporting that they are knowledgeable about USI, most of these educators do not currently utilize this point-of-care imaging modality in clinical practice. Based on the results of this survey, overcoming real and perceived barriers to inclusion of USI education is necessary to expand its use in entry-level DPT program curricula, with the primary barriers identified as the lack of qualified instructors, the lack of knowledge/training, and the high cost of equipment.

Our national survey are generally consistent with those found in surveys of medical schools, which found that only about 62% of programs in the USA offer USI education in their curriculum [23]. Similarly, the barriers identified in our investigation are consistent with prior studies evaluating USI education in medical schools, including the lack of space in the curriculum, the lack of financial support, the lack of equipment, and the lack of trained faculty [18, 21, 23]. A unique and potentially problematic finding in our investigation is that only 50% of respondents view the performance and interpretation of USI as an entry-level skill for DPT students. This finding may pose a significant barrier to the expansion of USI education in entry-level DPT program curricula. Considering the future of contemporary Physical Therapy Practice, which has placed increased emphasis on developing primary-care providers, one can envision the need for entry-level DPT students to achieve basic competency in the performance and interpretation of USI like other physical therapy tests and measures (e.g., goniometry or manual muscle testing).

Developing competence in the performance and interpretation of USI depends on two fundamental skills, namely, the ability to acquire quality images and then properly interpret those images in the context of the physical therapy examination and evaluation. USI is a powerful tool and a natural fit for physical therapists already recognized as experts in movement-related disorders and whose training and expertise rely heavily on the development of manual examination and intervention skills [16]. Contemporary healthcare systems in the USA increasingly recognize physical therapists as primary-care providers for the care and prevention of a variety of movement-related conditions [15]; therefore, it is incumbent on faculty and administrators to ensure that entry-level DPT program curricula evolve to meet the emerging needs of our profession. The *American Physical Therapy Association*at the state and national levels currently advocates for an expansion of Physical Therapy Practice Acts to allow physical therapists to order diagnostic imaging [24]. While the ability to order diagnostic imaging is important, it should be recognized that USI is the only imaging modality that physical therapists can *perform*, *interpret*, and receive third-party reimbursement [27]. Growth of USI applications in Physical Therapy Practice and related research is desirable for a variety of reasons, not the least of which is increased provider expertise improving the diagnosis and treatment of patients and the continued expansion of the role that physical therapists play as primary-care providers becoming less reliant on outside referral to obtain necessary diagnostic imaging [15]. Laboratory-based USI education requires a device, a qualified instructor, a student, and a live or simulated patient model. After the introduction of the fundamentals of image acquisition and interpretation, including appearance of clinically meaningful neuromusculoskeletal tissues and structures, USI education can be incorporated vertically throughout an entry-level DPT program curriculum as an adjunctive tool supporting the learning of anatomy and various clinical examination and intervention skills [19, 20]. While most laboratory-based courses utilize fellow students as models, the safety and portability of USI equipment provide opportunities to use human or animal cadavers or community volunteers, all of which can enhance student learning through exposure to a variety of anatomic variations and soft tissue pathologies [2]. In addition, expanded use of USI by physical therapists in clinical practice provides opportunities for interested students to be paired with appropriately trained clinical instructors to enhance their understanding of clinical application while reinforcing clinical reasoning and differential diagnostic skills [2].

This investigation sought to determine the state of USI education in accredited entry-level DPT program

curricula in the USA. The primary limitation of our study findings includes a relatively low response rate, despite strategies known to enhance response rate such as reasonably short survey instruments and several reminders for respondents to complete, with only 65 respondents from 54 CAPTE-accredited entry-level DPT programs completing the instrument. However, our response rate was only slightly lower and generally consistent with recent studies quantifying "survey fatigue" in the COVID-19 era and lower education-related research survey response rates, which ranged from 35 to 44% [28, 29]. While the authors hoped for a more robust survey response, the data collected does represent more than half of the USA and all six *Council of Higher Education Accreditation* regions, which improves the generalizability of our results and provides a valuable first step in furthering the conversation about the role of USI education in entry-level DPT program curricula. As with all survey data, response bias is a concern, and the impact of additional respondents would have on the data set is unknown. Therefore, the authors suggest caution and interpretation of the results within the context of these potential limitations.

Conclusions

Despite most respondents being knowledgeable about USI, most entry-level DPT program faculty are not currently utilizing this imaging modality in clinical practice. Based on the results of this survey, overcoming real and perceived barriers to inclusion of USI education is necessary to expand its use in entry-level DPT program curricula, namely, the lack of qualified instructors, the lack of knowledge/training, and the high equipment cost. Importantly, only half of respondents in this survey view USI as an entry-level skill for DPT students, which is problematic given that point-of-care USI is recognized by the *American Physical Therapy Association*as an emerging skill for contemporary Physical Therapy Practice [2, 25]. The results of this national survey provide original data that the authors hope will stimulate further discussion among faculty and administrators about the role and potential value of including USI education in contemporary entry-level DPT program curricula to meet the emerging needs of our profession.

Appendix

Survey questions

- Which of the following best describes your role in your DPT program?
- What is the highest academic degree you have earned?
- Are you a licensed physical therapist?
  - o • What is your professional licensure?
- Are you a board-certified specialist?
- How many years of clinical experience do you have?
- How many years of full or part-time academic experience do you have?
- What is your age?
- Does your academic institution receive public or state-supported funding?
- In which state is your program's main campus located?
- Which of the following best describes your program's accreditation status?
- How many students does your program accept in each cohort?
- How many cohorts does your program accept per academic year?
- What is the total length, in months, of your program's curriculum?
- ***Is ultrasound imaging taught in your program's curriculum?***
- Is your program planning on adding instruction in ultrasound imaging to its curriculum?
- In which program year are your students first introduced to instruction in ultrasound imaging?
- How is the ultrasound imaging content delivered in your program? (Select all that apply)
- Do students in your program perform live ultrasound scanning?
- Which of the following course(s) in your program is ultrasound imaging content delivered? (Select all that apply)
- For the course(s) that deliver ultrasound imaging content, are stated learning objectives related to ultrasound imaging contained in the course syllabi?
- What is your best estimate of the total number of hours of instruction (lecture and/or lab) in ultrasound imaging provided throughout your program's curriculum?
- Which of the following best represents your program's objectives for including ultrasound imaging content in your curriculum? (Select all that apply)
- Is the performance and interpretation of ultrasound imaging within the scope of physical therapy practice in your state?
- Do any faculty in your department utilize ultrasound imaging in their research?
- Do you personally utilize ultrasound imaging in clinical practice?
- o Despite not using in clinical practice, which of the following best describes your level of knowledge or understanding of ultrasound imaging?
- o Which of the following best describes your comfort level performing and interpreting ultrasound imaging?
- Does your department own or have access to an ultrasound imaging device?
- o Which of the following best describes your comfort level performing and interpreting ultrasound imaging?
- o What kind of ultrasound imaging device does your department utilize? (Select all that apply)
- Which of the following best describes the role of the primary instructor who delivers the ultrasound imaging content in your curriculum?
- Is your program planning to expand the use of ultrasound in its curriculum?
- o Which of the following factors influenced your program's decision to EXPAND ultrasound imaging content in your curriculum?
- o Which of the following factors influenced your program's decision to NOT EXPAND ultrasound imaging content in your curriculum?
- Thinking of the primary instructor delivering ultrasound imaging content, what specific training and/or certification in ultrasound imaging do they have? (Select all that apply)
- Which of the following do you perceive as potential barriers to incorporating ultrasound imaging content in your curriculum? (Select all that apply)
- What is your best estimate (in dollars) of the cost of an ultrasound imaging device that would meet the needs of your program's curriculum?
- Do you view the performance and interpretation of ultrasound imaging as an entry-level DPT skill?
- o Since you view ultrasound imaging as an entry-level skill, how should DPT programs incorporate ultrasound imaging content? (Select all that apply)
- o Since you do not view ultrasound imaging as an entry-level skill, when is ultrasound imaging content indicated? (Select all that apply)
- Would the availability of ONBOARD training modules (pre-programmed, machine-based, scan-along modules) be helpful for adding or expanding the use of ultrasound imaging in your curriculum?

• Would access to ONLINE training modules (internet-based training modules) be helpful for adding or expanding the use of ultrasound imaging in your curriculum?

Authors' contributions
NS, NH, and MC developed the survey, disseminated the survey, and analyzed and interpreted the data regarding the survey responses. All authors read and approved of the final manuscript.

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Availability of data and materials
All data generated or analyzed during this study are included in this published article.

Declarations

Ethics approval and consent to participate
Winston-Salem State University Institutional Review Board (IRB-FY2023-31) approved this investigation, granting an exempted status because of the minimal risk posed to human subjects.

Competing interests
The authors declare no competing interests.

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References
1. Jacobson JA. Fundamentals of musculoskeletal ultrasound. In: Fundamentals of radiology series. 3rd ed. United States: Elsevier; 2018.
2. Academy of Orthopaedic Physical Therapy ISIG, American Physical Therapy Association. Imaging Education Manual for Doctor of Physical Therapy Professional Degree Programs. https://www.orthopt.org/uploads/content_files/ISIG/IMAGING_EDUCATION_MANUAL_FINAL_4.15.15..pdf
3. Whittaker JL, Ellis R, Hodges PW, et al. Imaging with ultrasound in physical therapy: what is the PT's scope of practice? A competency-based educational model and training recommendations. Br J Sports Med. 2019;53(23):1447–53. https://doi.org/10.1136/bjsports-2018-100193.
4. Brinjikji W, Luetmer PH, Comstock B, et al. Systematic literature review of imaging features of spinal degeneration in asymptomatic populations. AJNR Am J Neuroradiol. 2015;36(4):811–6. https://doi.org/10.3174/ajnr.A4173.
5. Lawrence RL, Moutzouros V, Bey MJ. Asymptomatic rotator cuff tears. JBJS Rev. 2019;7(6):e9. https://doi.org/10.2106/JBJS.RVW.18.00149.
6. Culvenor AG, Øiestad BE, Hart HF, Stefanik JJ, Guermazi A, Crossley KM. Prevalence of knee osteoarthritis features on magnetic resonance imaging in asymptomatic uninjured adults: a systematic review and meta-analysis. Br J Sports Med. 2019;53(20):1268–78. https://doi.org/10.1136/bjsports-2018-099257.
7. Kasehagen B, Ellis R, Pope R, Russell N, Hing W. Assessing the reliability of ultrasound imaging to examine peripheral nerve excursion: a systematic literature review. Ultrasound Med Biol. 2018;44(1):1–13. https://doi.org/10.1016/j.ultrasmedbio.2017.08.1886.
8. Lee D, Hodges PW. Behavior of the linea alba during a curl-up task in diastasis rectus abdominis: an observational study. J Orthop Sports Phys Ther. 2016;46(7):580–9. https://doi.org/10.2519/jospt.2016.6536.
9. Hides JA, Stanton WR. Predicting football injuries using size and ratio of the multifidus and quadratus lumborum muscles. Scand J Med Sci Sports. 2017;27(4):440–7. https://doi.org/10.1111/sms.12643.
10. Chen L, Luo D, Yu X, Jin M, Cai W. Predicting stress urinary incontinence during pregnancy: combination of pelvic floor ultrasound parameters and clinical factors. Acta Obstet Gynecol Scand. 2018;97(8):966–75. https://doi.org/10.1111/aogs.13368.
11. Bailey LB, Beattie PF, Shanley E, Seitz AL, Thigpen CA. Current rehabilitation applications for shoulder ultrasound imaging. J Orthop Sports Phys Ther. 2015;45(5):394–405. https://doi.org/10.2519/jospt.2015.4232.
12. Heales LJ, Tucker K, Vicenzino B, Hodges PW, MacDonald DA. A comparison of fine wire insertion techniques for deep finger flexor muscle electromyography. J Electromyogr Kinesiol. 2018;41:77–81. https://doi.org/10.1016/j.jelekin.2018.05.003.
13. Stafford RE, van den Hoorn W, Coughlin G, Hodges PW. Postprostatectomy incontinence is related to pelvic floor displacements observed with trans-perineal ultrasound imaging. Neurourol Urodyn. 2018;37(2):658–65. https://doi.org/10.1002/nau.23371.
14. ShahAli S, Shanbehzadeh S, Ebrahimi TI. Application of ultrasonography in the assessment of abdominal and lumbar trunk muscle activity in participants with and without low back pain: a systematic review. J Manipulative Physiol Ther. 2019;42(7):541–50. https://doi.org/10.1016/j.jmpt.2019.05.003.
15. Bornhöft L, Larsson ME, Nordeman L, Eggertsen R, Thorn J. Health effects of direct triaging to physiotherapists in primary care for patients with musculoskeletal disorders: a pragmatic randomized controlled trial. Ther Adv Musculoskelet Dis. 2019;11:1759720X19827504. https://doi.org/10.1177/1759720X19827504.
16. Timmerberg JF, Chesbro SB, Jensen GM, Dole RL, Jette DU. Competency-based education and practice in physical therapy: it's time to act! Phys Ther. 2022;102(5). https://doi.org/10.1093/ptj/pzac018
17. Falkowski AL, Jacobson JA, Freehill MT, Kalia V. Hand-held portable versus conventional cart-based ultrasound in musculoskeletal imaging. Orthop J Sports Med. 2020;8(2):2325967119901017. https://doi.org/10.1177/2325967119901017.
18. Nicholas E, Ly AA, Prince AM, Klawitter PF, Gaskin K, Prince LA. The current status of ultrasound education in United States medical schools. J Ultrasound Med. 2021;40(11):2459–65. https://doi.org/10.1002/jum.15633.
19. Rempell JS, Saldana F, DiSalvo D, et al. Pilot point-of-care ultrasound curriculum at Harvard Medical School: early experience. West J Emerg Med. 2016;17(6):734–40. https://doi.org/10.5811/westjem.2016.8.31387.
20. So S, Patel RM, Orebaugh SL. Ultrasound imaging in medical student education: impact on learning anatomy and physical diagnosis. Anat Sci Educ. 2017;10(2):176–89. https://doi.org/10.1002/ase.1630.
21. Tarique U, Tang B, Singh M, Kulasegaram KM, Ailon J. Ultrasound curricula in undergraduate medical education: a scoping review. J Ultrasound Med. 2018;37(1):69–82. https://doi.org/10.1002/jum.14333.
22. Dinh VA, Frederick J, Bartos R, Shankel TM, Werner L. Effects of ultrasound implementation on physical examination learning and teaching during the first year of medical education. J Ultrasound Med. 2015;34(1):43–50. https://doi.org/10.7863/ultra.34.1.43.
23. Dinh VA, Fu JY, Lu S, Chiem A, Fox JC, Blaivas M. Integration of ultrasound in medical education at United States medical schools: a national survey of directors' experiences. J Ultrasound Med. 2016;35(2):413–9. https://doi.org/10.7863/ultra.15.05073.
24. Academy of Orthopaedic Physical Therapy APTA. State Acts and Regulations on Imaging Referral in Physical Therapist Practice. Academy of Orthopaedic Physical Therapy, American Physical Therapy Association. Updated 2021–07–16. https://www.orthopt.org/content/special-interest-groups/imaging/state-acts-and-regulations-on-imaging-referral-in-physical-therapist-practice
25. Accreditation Handbook. https://www.capteonline.org/faculty-and-program-resources/resource_documents/accreditation-handbook
26. Regional Accrediting Organizations | Council for Higher Education Accreditation. https://www.chea.org/regional-accrediting-organizations-accreditor-type

27. American Physical Therapy Association OS. Diagnostic and Procedural Imaging in Physical Therapist Practice. Updated 2020–12–02. https://www.orthopt.org/content/special-interest-groups/imaging
28. de Koning R, Egiz A, Kotecha J, et al. Survey fatigue during the COVID-19 pandemic: an analysis of neurosurgery survey response rates. Front Surg. 2021;8:690680. https://doi.org/10.3389/fsurg.2021.690680.
29. Wilson AB, Brooks WS, Edwards DN, et al. Survey response rates in health sciences education research: a 10-year meta-analysis. Anat Sci Educ Jan-Feb. 2024;17(1):11–23. https://doi.org/10.1002/ase.2345.

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