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Advancing skills and confidence in ultrasound-guided injection techniques: the impact of a cadaveric workshop

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Abstract

Background Ultrasound-guided injections have become increasingly popular in musculoskeletal practice due to their precision and minimally invasive nature. Cadaveric musculoskeletal ultrasound-guided injection workshops offer unique hands-on training, allowing physicians to refine their skills and improve procedural confidence in a realistic anatomical context. This study evaluates the effectiveness of such workshops in enhancing participants' confidence in performing musculoskeletal ultrasound-guided injections.

Methods A prospective cross-sectional study was conducted with 109 participants attending three one-day workshops. The workshops included theoretical sessions and hands-on practice on ultrasound-guided injections of the hip, knee, and ankle joints using cadaveric specimens. Participants completed pre- and post-workshop surveys assessing their self-reported confidence in performing injections. Changes in confidence were analyzed by comparing pre- and post-course responses to evaluate the effectiveness of the training.

Results Participants showed significant improvements in confidence for all three joints, with the largest gain observed in hip injections. Residents exhibited lower pre- and post-course confidence but demonstrated greater improvement compared to specialists. Prior exposure to ultrasound training was associated with higher pre-course confidence but not post-course; implying that those who had not attended previous ultrasonography courses showed greater improvement and that cadaveric courses compensate for the lack of previous courses. Access to ultrasound equipment during residency was positively correlated with higher confidence levels.

Conclusion Cadaveric musculoskeletal ultrasound-guided injection workshops significantly enhance procedural confidence among physicians, particularly for hip and ankle joint injections. These workshops are valuable enough tools to make up for missed preceding ultrasound program attendance, and it could thus call for a reevaluation of how educational resources are distributed to optimize procedural competence and patient safety.

Keywords Ultrasound-guided injections, Cadaveric training, Musculoskeletal ultrasonography, Medical education

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Introduction

Ultrasound imaging has revolutionized the diagnosis and treatment of musculoskeletal (MSK) disorders in recent years because of its non-radiative nature, portability, real-time visualization, and multimodal diagnostic capabilities [1]. Unlike static imaging techniques such as radiography, and magnetic resonance imaging, which are at times inadequate for assessing movement-dependent issues, ultrasonography (USG) enables dynamic evaluations. This capability is crucial in musculoskeletal physical examination, where mechanical symptoms often emerge only during specific movements. Therefore, by capturing real-time changes in anatomical structures, USG bridges an important gap in understanding functional impairments and mechanical pathologies [2, 3].

In addition to diagnostic imaging, ultrasound-guided injections have also become more appealing thanks to the advantages in accuracy and safety of treatments aimed at joints, tendons, and nerves. In the center of the knowledge transfer between physicians are MSK USG workshops, offering practical tools to improve procedural outcomes and diagnostic accuracy [4–6]. These courses equip inexperienced physicians with the skills necessary for accurate probe and needle placement and targeted therapeutic delivery, minimizing complications and maximizing patient comfort. With the growing demand for precise and minimally invasive treatments, the popularity of these training programs has surged in recent years. Trainers are continuously innovating to enhance learning, incorporating new teaching methods such as simulated models, interactive sessions, and hands-on practice [7–9].

Among these training programs, cadaveric injection courses provide a unique advantage by offering realistic, hands-on training that enable the physicians to refine both sonoanatomical knowledge and procedural confidence in a controlled environment. Unlike synthetic models or theoretical instruction alone, cadaveric courses closely mimic live tissue characteristics, allowing trainees to practice needle placement, apply correct angulation, and assess tactile feedback in actual anatomical contexts [8]. As procedural accuracy in ultrasound-guided injections is highly dependent on anatomical familiarity and confidence with needle techniques, cadaveric workshops have become a valuable educational tool for overcoming the operator-dependent challenges in ultrasound-guided injections [10, 11].

Given these advantages, this study seeks to evaluate the effectiveness of a cadaveric MSK ultrasound-guided injection workshop. By reviewing pre- and post-workshop responses, the aim is to explore the perceived usefulness of the cadaveric course in improving injection skills and anatomical understanding, whether participants report increased confidence in ultrasound-guided injections following the training, and if variations in perceived confidence and skill acquisition are associated with different sections of the course.

Materials and methods

This study employed a prospective cross-sectional design. Three one-day-long workshops on USG and ultrasound-guided injections covering three lower extremity joints, hip, knee, and ankle, were held. A team of experienced physical medicine and rehabilitation specialists with over a decade of combined expertise served as instructors. The study was approved by the Ethics Committee of Koc University on 03/10/2024 (Document ID: 2024.326.IRB3.135). Informed consent was obtained from each participant before the workshop. Data collection and analysis were conducted anonymously to ensure participant confidentiality and reduce bias. This study was registered at ClinicalTrials.gov (Identifier: NCT06851455). The study was carried out in accordance with the principles outlined in the Declaration of Helsinki.

Workshop plan

The workshop was divided into two main parts. The first part covered theoretical instructional sessions covering basic concepts and information on USG, standard examination positions and regional anatomy, probe and needle placement, ultrasonographic findings of both normal and pathological joints, and specific ultrasound-guided injection techniques for each joint. The imaging examination and guided injections to cover were determined using the EURO-MUSCULUS/USPRM and European Society of Musculoskeletal Radiology scanning and ultrasound-guided injection protocols [12–14].

In the second part, hands-on practice to improve scanning and ultrasound-guided injection skills was carried out in four stations, three of them representing the anterior and lateral aspects of the major joints— hip, knee, and ankle— and one station for the posterior aspect of all joints. To ensure the best possible practice environment for skill development, each station had a high-resolution ultrasound device, a cadaver, one instructor, and a maximum of ten participants. Following demonstrations of the scanning and injection techniques for each joint by the instructors, participants practiced under their supervision to refine their skills. Needle positions were not documented via imaging or dissection due to ethical and logistical constraints, as the study focused on self-reported confidence rather than objective procedural accuracy.

All cadavers were preserved using a formalin-based solution to maintain tissue integrity for ultrasound imaging and injection practice. Each cadaver was screened for infectious diseases (e.g., HIV, hepatitis B and C, and tuberculosis) prior to use, following standard protocols

to ensure participant safety. Participants were required to wear personal protective equipment, including disposable gloves, gowns, and protective eyewear, during hands-on sessions. Surgical masks were provided, but ventilators were not required as the formalin concentration was minimized through proper cadaver preparation. The workshop venues were well-ventilated, with high-efficiency particulate air (HEPA) filtration systems to reduce exposure to preservative vapors and fluid droplets. Cadavers were sourced through a donation program compliant with national ethical guidelines.

No needle stick injuries or sensitivity reactions (e.g., skin or respiratory irritation) were reported by participants during or after the workshops, as monitored by onsite staff.

Assessment

All participants filled out a pre-workshop survey (Additional File 1) prior to the lectures, which contained question items about their age, sex, academic and professional experience in medicine and physiatry, prior exposure to MSK USG and injections, current access to ultrasound equipment, prior attendance at other ultrasound training programs, frequency of ultrasound-guided injections done in a week, and self-confidence regarding hip, knee and ankle ultrasound-guided injections using a 5-point Likert scale, with 0 denoting the least confidence and 4 denoting the highest.

Following the two sessions, participants filled out a post-workshop survey (Additional File 2) to assess their self-confidence in MSK ultrasound-guided injections regarding the three joints and the perceived value of the course. In addition, the usefulness of the course and contentment of participants about the materials used and quality of context were also measured using a 5-point Likert scale, where 0 indicated the least content and 4 the most content. At last, participants were invited to suggest regions, subjects and techniques they would like to have covered in upcoming ultrasonography seminars.

Statistical analysis

Descriptive statistics were used to analyze the demographic information of the study population. The Chi-Square Test was used to measure any associations between categorical variables and the Mann-Whitney U Test was used to compare reported scores between groups. Comparison of reported confidence scores were done using Wilcoxon signed-rank test. Correlations between continuous variables (e.g., years of experience) and confidence scores were assessed using Pearson's correlation. ANOVA was used for categorical variables (e.g., academic level).

Statistical analyses were conducted using Python 3 (Python Software Foundation, Wilmington, Delaware USA 2009) with Pandas and SciPy Statistics Libraries [15, 16]. Visualizations were created using the MatPlotLib and Seaborn libraries [17, 18]. A p-value < 0.05 was considered statistically significant.

Results

A total of 109 attendees were present across three sessions. The basic demographic variables of participants are summarized in Table 1. Although some participants had previously attended a MSK USG or ultrasound-guided injection course, none had previously attended a cadaver course.

There was no statistically significant bias towards access to USG during residency based on the institution type of the residency (Chi-Square = 2.37, P-Value = 0.124, Degrees of Freedom = 1) across all participants. Subgroup analysis of academic levels revealed that current residents are more likely to have access to USG than specialists, associate professors, and professors did during their training (Chi-Square = 10.34, P-Value = 0.016, Degrees of Freedom = 3).

However, there was a significant association between current institution type and current access to USG (Chi-Square = 26.88, P-Value < 0.001, Degrees of Freedom = 4). Detailed results based on USG availability are shown in Table 2. Overall, Participants who were currently working at University Hospitals reported the highest percentage of an available USG (%95) followed by Teaching and Research Hospitals (%79).

Pre- versus post-course confidence scores were significantly improved for hip (mean 2.12 points, P-value < 0.001), knee (mean 1.24 points, P-value < 0.001), and ankle (mean 1.87 points, P-value < 0.001) joints (Table 3).

The comparison of pre-course and post-course confidence scores, as well as improvements in confidence, between specialists and residents revealed that residents had significantly lower confidence both before and after the course but showed significantly greater improvement overall, except in ankle improvement and post-hip confidence (Table 4).

Self-reported pre- and post-course confidence reporting revealed that participants were more confident in knee injections (p-value = 0 for both knee versus hip and knee versus ankle, hip versus ankle p-value = 0.64). No correlation was observed between residency type and pre-, post-course, or improvement in confidence across all injection sites.

Across all three joints, participants who attended previous courses consistently showed higher pre-course scores (p-value < 0.001 for all joints), this difference is most pronounced in knee injections (Fig. 1 top).

Post course confidence scores showed no statistically significant superiority over one group for hip

Table 1 Summary of demographics and professional background

Participant Characteristics	
Gender	Female: 61 (56.0%) Male 48 (44.0%)
Age (years)	Mean: 33.3 Median 31 IQR 28–36
Academic Level	Resident: 47 (43.1%) Specialist: 60 (55.0%) Associate Professor: 1 (0.9%) Professor: 1 (0.9%)
Professional Experience	
Years in Medicine	Mean: 8.88 Median: 7 IQR: 3–12
Years in Physiatry	Mean: 7.11 Median: 6 IQR: 3–10
Non-Physiatry Residency	Count: 14 Mean: 2.82 years Median: 2.5 years IQR: 1.25–3.88 years
Institutional Affiliations	
Current Institution Type	University Hospital: 39 (35.8%) State Hospital: 29 (26.6%) Training and Research Hospital: 28 (25.7%) Private Hospital: 10 (9.2%) Private Center: 3 (2.8%)
Residency Institution Type	University Hospital: 75 (68.8%) Training and Research Hospital: 34 (31.2%)
Training and Equipment	
Owns Personal Ultrasound Device	Yes: 16 (14.7%) No: 93 (85.3%)
Previous MSK USG Course Attendance	Yes: 62 (56.9%) No: 47 (43.1%)
Previous Cadaver Course Attendance	No: 109 (100%)

IQR: Interquartile Range, MSK USG: Musculoskeletal Ultrasonography

Table 2 Participants' reported availability of USG devices at their current institution

Institution Type	USG Device Available	% of USG Device Availability	USG Device not Available	% of USG Device not Available	Total
Private Center	1	33%	2	66%	3
Private Hospital	6	60%	4	40%	10
State Hospital	12	41%	17	49%	29
Teaching and Research Hospital	22	79%	6	21%	28
University Hospital	37	95%	2	5%	39

USG: Ultrasonography

Table 3 Comparison of pre- versus post-course confidence scores across all participants based on joint locations

Joint	Pre-course Confidence Mean	Post-course Confidence Mean	Mean difference	*P*-value
Hip	1.00	3.10	2.10	0
Knee	1.98	3.50	1.51	0
Ankle	1.31	3.20	1.89	0

(p-value = 0.067), knee (p-value = 0.05), and ankle (p-value = 0.085) joint injections (Fig. 1 middle).

Statistically superior improvements were observed in those who did not attend a previous course over those that did for hip (p-value = 0.005) and ankle (p-value = 0.003) but not for knee injections (p-value = 8.81) (Fig. 1 bottom).

Our findings further show a moderate positive correlation between years of musculoskeletal USG experience and pre-course confidence in joint injections across the hip ($r = 0.529$, $p < 0.01$), knee ($r = 0.500$, $p < 0.01$), and ankle

Table 4 Comparison of pre-course, post-course confidence, and improvements in confidence scores stratified between residents and specialists

Confidence Scores	Resident Mean	Specialist Mean	*P*-Value
Pre-Course Hip	0.617	1.2167	0.0018
Pre-Course Knee	1.4468	2.4167	0
Pre-Course Ankle	0.6383	1.25	0.0038
Hip Improvement	2.2979	1.9	0.01
Knee Improvement	1.9574	1.3	0.0001
Ankle Improvement	2.2979	1.9667	0.0814
Post-Course Hip	2.9149	3.1167	0.1044
Post- Course Knee	3.4043	3.7167	0.0091
Post- Course Ankle	2.9362	3.2167	0.0397

($r = 0.542$, $p < 0.01$) joints. A weaker yet similar correlation was also observed in post-course confidence scores across all hip ($r = 0.223$, $p = 0.02$), knee ($r = 0.330$, $p < 0.01$), and ankle ($r = 0.229$, $p = 0.017$) joints. Similarly, a meaningful yet negative correlation was observed in terms of improvement scores across hip (r=-0.422, $p < 0.01$), knee (r=-0.373, $p < 0.01$), and ankle (r=-0.424, $p < 0.01$) joints.

There was a moderate correlation between reported weekly number of injections and pre-course confidence scores (hip $r = 0.548$, knee $r = 0.594$, ankle $r = 0.605$). A weaker correlation was also observed for post-course scores (hip $r = 0.318$, knee $r = 0.376$, ankle $r = 0.417$). As logically expected, there was a weak to moderate negative correlation between reported weekly injections and improvement in reported scores (hip r=-0.400, knee r=-0.465, ankle r=-0.384).

All participants reported a course satisfaction greater than 4 on the category for course content and quality (11 votes for 4, 98 votes for 5 on the Likert scale). In terms of satisfaction on course material and applications, 97 participants voted a score of 5, 11 voted a score of 4, and a single participant voted a 3.

Discussion

This study aimed to evaluate the effectiveness of a cadaveric MSK ultrasound-guided injection workshop, focusing on participants' confidence levels in performing ultrasound-guided injections of the hip, knee, and ankle joints. The findings highlight significant improvements in participants' confidence levels post-workshop, emphasizing the value of hands-on cadaveric training enhancing procedural confidence.

Participants demonstrated a statistically significant increase in self-reported confidence for all three joints following the workshop. This aligns with the objectives of cadaveric training workshops, which aim to provide hands-on experience in realistic anatomical contexts to enhance both technical and diagnostic skills, consistent with prior literature emphasizing the value of hands-on cadaveric workshops in boosting procedural confidence and anatomical understanding [19–21]. The immersive experience provided by cadaveric dissection allows participants to engage with human anatomy in a way that is not possible through traditional learning methods or even some novelistic methods such as virtual reality training programs [22, 23].

The results of this study also highlight the impact of prior experience on workshop outcomes. Years of MSK USG experience showed a positive correlation with pre- and post-course confidence levels but a negative correlation with improvement scores. In line with earlier research, these findings suggest that these hands-on cadaveric workshops are particularly beneficial for not only the residents and early-career specialists but also more established specialists who are recently acquainted with ultrasound; allowing them to rapidly acquire foundational skills and bridge confidence gaps as it equips them with the necessary skills and confidence to perform complex procedures [21, 24].

In addition, participants with previous exposure to USG courses reported significantly higher pre-course confidence levels for all joints, consistent with the cumulative nature of ultrasound proficiency [25, 26]. However, those without prior training demonstrated greater confidence improvements post-workshop, particularly for hip and ankle joints. On top of that, in terms of self-reported confidence scores, post-course scores showed no significant difference between participants who had previously attended a non-cadaver MSK USG course of the lower limbs versus those that did not. This implies that a single cadaver course was enough to compensate for the absence of previous course attendance and may therefore necessitate a revision of educational resource allocation.

Notably, the participants reported the highest pre- and post-workshop confidence levels for knee joint injections, which might reflect greater prior familiarity with knee injections or simpler sonoanatomy compared to hip and ankle joints [27, 28]. In contrast, the hip joint demonstrated the largest improvement in confidence, reflecting the greater technical challenges and anatomical complexity associated with hip injections [29]. Ankle injections also showed significant improvement, underscoring the workshop's comprehensive approach to addressing anatomical and procedural difficulties across different joints [30].

Interestingly, no significant association was found between the type of institution where Physical Medicine and Rehabilitation specialization training was given to participants (university hospitals versus training and research hospitals) and pre-, post-course, or improvement in confidence levels. However, current institutional access to ultrasound equipment was strongly associated with higher pre- and post-course confidence levels. This highlights the importance of integrating ultrasound

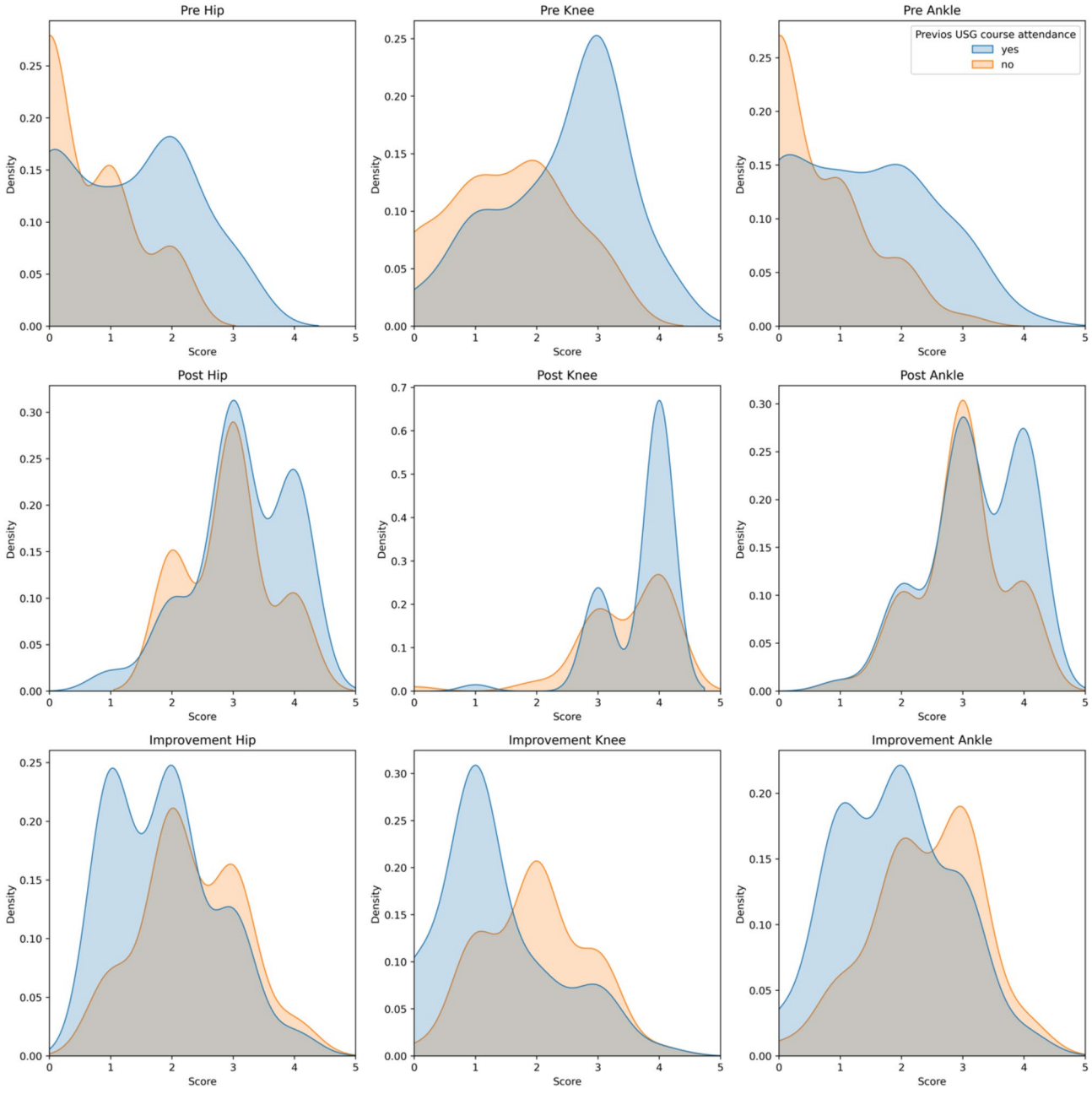


Fig. 1 Density distributions for each joint based on pre-course self-reported confidence (top), post-course self-reported confidence (middle), and improvements in self-reported confidence (bottom)

training into residency programs and providing ongoing access to equipment, as consistent exposure facilitates skill retention and procedural fluency. Additionally, residents who have consistent opportunities to practice ultrasound techniques report higher confidence levels in their abilities, underlining the psychological impact of ongoing access to ultrasound training [31–33]. In this study, participants currently working in university hospitals reported the highest access rates to ultrasound devices, reflecting resource disparities across healthcare institutions. Addressing such disparities is crucial to ensuring equitable training opportunities and skill development.

While this study provides valuable insights, a few limitations are worth considering. First, the reliance on self-reported confidence measures may introduce response bias. Objective assessments of technical skills, such as imaging-based verification of needle placement, were not feasible due to ethical and logistical constraints, limiting the ability to evaluate technical proficiency. Second, the

study's cross-sectional design limits the ability to assess the maintenance of skills and confidence over the long run. Future studies could involve follow-up evaluations to determine the durability of workshop benefits. Third, the workshop was not a mandatory workshop and a selection bias towards participants who were already interested in MSK USG may be present.

Additionally, the study exclusively targeted physiatrists, limiting generalizability to other specialties, such as orthopedics or rheumatology, that may also rely on ultrasound-guided interventions. Expanding the participant pool in future workshops could provide broader insights into the applicability of cadaveric training across specialties. Finally, the workshop focused on three lower extremity joints; future sessions could include upper extremity joints or peripheral nerves based on participant feedback.

Despite these limitations, the study has several strengths. It is among the few to evaluate the impact of cadaveric workshops on ultrasound-guided injections, providing a realistic and high-fidelity training environment that bridges the gap between theoretical knowledge and clinical practice. The large sample size and inclusion of participants with varying levels of prior experience enhance the generalizability of the findings within the physiatry community. Additionally, the systematic evaluation of confidence levels across multiple joints provides a nuanced understanding of the workshop's effectiveness.

Conclusion

This study indicates the effectiveness of cadaveric MSK USG workshops in enhancing self-reported procedural confidence among physicians. By providing hands-on, anatomically realistic training, such workshops play a crucial role in addressing operator-dependent challenges in ultrasound-guided interventions. The findings emphasize the importance of integrating cadaveric training into medical education and continuing professional development programs to improve patient outcomes and procedural safety. Future research should focus on long-term skill retention, objective assessments of competency, cost-effectiveness of cadaveric workshops over other workshops, and the development of standardized curricula to further optimize training methodologies.

Abbreviations

MSK	Musculoskeletal
USG	Ultrasonography
EURO-MUSCULUS	European Musculoskeletal Ultrasound Study Group in Physical and Rehabilitation Medicine/Ultrasound Study Group of the International Society of Physical and Rehabilitation Medicine
HIV	Human Immunodeficiency Virus
HEPA	High-efficiency Particulate Air

Supplementary Information

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Supplementary Material 1

Supplementary Material 2

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Author contributions

All authors have read and approved the final manuscript. MT and DD made critical revisions to the manuscript and contributed to study supervision. MZ and MT conceived and designed the study. DS performed the analysis and interpretation of the data, MZ, EE, and DS wrote the draft; MZ, MT, EE and SS recruited the study subjects, and are responsible for the acquisition, analysis, and interpretation of the data.

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Data availability

The datasets used and analysed during the current study are available from the corresponding author on reasonable request. Contact Mert Zure via mertzure@gmail.com.

Declarations

Ethics approval and consent to participate

Ethical approval was obtained from Ethics Committee of Koc University on 03/10/2024 (Document ID: 2024.326.IRB3.135). Informed consent to participate and for publication was acquired from each participant before the workshop. Data collection and analysis were conducted anonymously to ensure participant confidentiality and reduce bias. The study was carried out in accordance with the principles outlined in the Declaration of Helsinki.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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