

RESEARCH

Open Access



An online training and feedback module enhances the musculoskeletal examination performance of medical interns

Matías Arteaga¹, Catalina Vidal¹, Cristián Ruz¹, Raúl Zilleruelo¹, Ernesto Pino¹, Javier Dauvergne¹, Pablo Besa¹ and Sebastián Irarrázaval^{1*}

Abstract

Background Pathologies of the locomotor system are frequent and can cause disability and impact the quality of life of the people affected. In recent years, online training and feedback have emerged as learning tools in many fields of medicine.

Objective This study aims to evaluate medical interns' musculoskeletal examination performance after completing an online training and feedback module.

Methods This study employed a quasi-experimental design. Medical interns were invited to complete a 4-week musculoskeletal physical examination training and feedback module via an e-learning platform. The course included written and audiovisual content pertaining to medical history, physical examination, and specific tests for the diagnosis of the most common knee, spine, shoulder, ankle, and foot conditions. Before and after completing the module, their ability to perform the physical examination was evaluated using an objective structured clinical examination (OSCE) with simulated patients that took place face-to-face. A control group of experts was assessed using the OSCE, and their performance was compared to that of the interns before and after the training. At the end of the module feedback on the OSCE was provided to participants through the platform asynchronously and two evaluation questions about the user experience were conducted at the end of the study.

Results A total of 35 subjects were assessed using the OSCE, including 29 interns and 6 experts. At the beginning of the training module, the group of interns obtained an average score of 50.6 ± 15.1 . At the end of the module, 18 interns retook the OSCE, and their performance increased significantly to an average of 76.6 ± 12.8 ($p < 0.01$). Prior to the training, the experts performed significantly better than the interns (71.2 vs. 50.6 ; $p = 0.01$). After the interns received the training and feedback, there were no significant differences between the two groups (71.2 vs. 76.6 ; $p = 0.43$). Two evaluation questions were conducted at the end of the study, revealing that 93% of the participants affirm that the training module will be useful in their clinical practice, and 100% of the participants would recommend the training module to a colleague.

*Correspondence:
Sebastián Irarrázaval
sirraz@uc.cl

Full list of author information is available at the end of the article



© The Author(s) 2024. **Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>. The Creative Commons Public Domain Dedication waiver (<http://creativecommons.org/publicdomain/zero/1.0/>) applies to the data made available in this article, unless otherwise stated in a credit line to the data.

Conclusion The online training and feedback module enhances the musculoskeletal examination performance of medical interns.

Keywords Medical education, Physical examination, Undergraduate, Distance learning, Musculoskeletal diseases

Background

Pathologies of the locomotor system are frequent and can cause disability and impact the quality of life of the people affected. In the United States, 50% of people over 18 years old and 75% of people 65 years of age and over suffer from a musculoskeletal disorder [1]. In addition, as many as 25–50% of visits to general practitioners are related to musculoskeletal syndromes, spine and knee pain are among the most common causes of health care visits [2, 3].

Physical examination is key with regard to musculoskeletal conditions [4]. Every general practitioner should perform a thorough physical examination to diagnose frequent and urgent musculoskeletal disorders when providing initial medical care [5, 6]. However, current evidence suggests that general practitioners do not perform adequate physical examinations, and they report feeling insecure when diagnosing or treating patients with these disorders [7, 8]. Accordingly, a high proportion of conditions that could be diagnosed and managed by general physicians are instead referred to orthopedic specialists. Furthermore, some studies have shown that as many as 42% of trauma referrals are unnecessary leading to increased wait times, system costs, and reduced efficiency [9, 10].

In recent years, online training and feedback have emerged as learning tools in many fields of medical education. In fact, undergraduate students and residents report achieving similar or superior results with respect to the acquisition of clinical skills from online training than from traditional methods as well as higher satisfaction rates [11, 12]. As students' curricular time is limited and increasing clinical requirements reduce the time available for in-person learning of patient care [13, 14], it is essential to rethink traditional teaching methods. New approaches should focus on learning that combines diverse activities and includes effective feedback that can also adapt to the limited time of teachers. With this goal in mind, the present study aims to evaluate medical interns' musculoskeletal examination performance after they complete an online training and feedback module.

Methods

This study was conducted in 2021 and featured a quasi-experimental design. Medical interns from a single university program were invited to participate. Interns are final-year medical students who have completed all their theoretical courses but have not yet done their undergraduate clinical practice. The inclusion criteria were

that the participants were required to be regular last-year medical students and to voluntarily sign an informed consent form prior to the start of the study. The exclusion criteria were having taken additional courses or elective training in musculoskeletal examination that were not included in the standard medical curriculum.

Using an experiential learning platform (C1Do1[®], 15), a musculoskeletal examination training module was created (Fig. 1). The course included written and audiovisual content pertaining to medical history, physical examination, and specific tests for the diagnosis of the most common knee, spine, shoulder, ankle, and foot conditions (Fig. 2). The module was created and reviewed by a panel of experts consisting of eight orthopedic surgeons, including two surgeons per subspecialty. Priority pathologies, clinical cases (low back pain, patellofemoral pain, meniscal tear, ankle sprain, plantar fasciitis, rotator cuff injury), and evaluation guidelines were jointly agreed upon and reviewed twice by each specialist. Each module covers the anatomy, physiology, clinical presentation, physical examination, and specific tests for each joint through 5 videos of around 5–6 min each.

The four-week training module assessed interns' physical examination skills using the objective structured clinical examination (OSCE) with simulated patients before and after completion took place face-to-face. Six clinical cases representing common musculoskeletal pathologies in primary care were created: SET A (Lumbar pain, meniscal tear, plantar fasciitis) and SET B (Ankle sprain, rotator cuff syndrome, patellofemoral pain). Participants randomly performed cases from SET A or SET B in the first OSCE and completed the remaining cases in the second OSCE. Three professional actors each simulated two clinical cases for a total of six cases, representing patients with these pathologies. All students encountered the same cases, differing only in their order of presentation across the two OSCEs, and examined the same three actors (Fig. 3).

The OSCEs were recorded, and the students were required to submit their videos via the online platform (C1Do1[®]). Six teachers, who were also orthopedic specialists, with at least 5 years of experience as an orthopedic surgeon, provided feedback during the following two weeks through written comments, audio recordings, and drawings (Fig. 4). They also completed a checklist created for each pathology. These checklists consisted of milestones that must be met for each musculoskeletal condition; possible scores ranged from 0 to 100%.

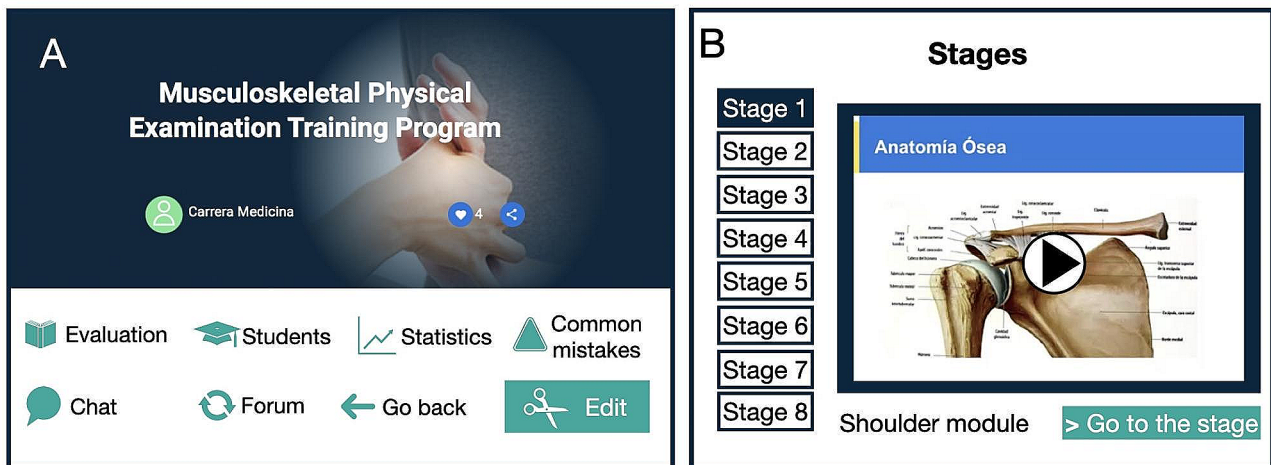


Fig. 1 Musculoskeletal examination training module. **A:** Home Page, **B:** The prelude to the eight stages of the training module

CIDOI
SOMOS C1D01

CREAR CURSO

Knee training module

Here's what you need to learn how to perform a shoulder physical exam and then apply it in the clinical setting.

Shoulder anatomy

- ▶ Knee anatomy
- ▶ **Physical examination**
- ▶ Specific test for meniscal injury
- ▶ Specific tests for patellofemoral syndrome

Fig. 2 C1Do1 content. Lecture videos on anatomy, medical history, physical examination, and specific tests for common knee conditions

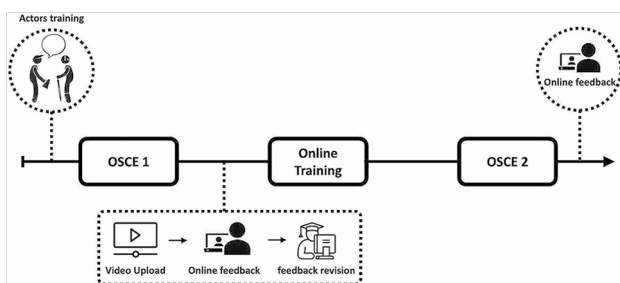


Fig. 3 Musculoskeletal examination course methodology. Online training and feedback using an experiential learning platform (C1Do1®)

A control group of orthopedic specialists and senior residents were assessed using the OSCE, and their performance was compared with that of the interns before and after the training. At the conclusion of the study module and evaluations via the OSCEs, participants were queried as to their belief regarding the utility of the training module in their clinical practice and whether they would recommend the training module to a colleague.

Categorical variables are summarized in terms of absolute and relative frequencies, while numerical variables are shown as means and standard deviations. The normality of the data was determined using the

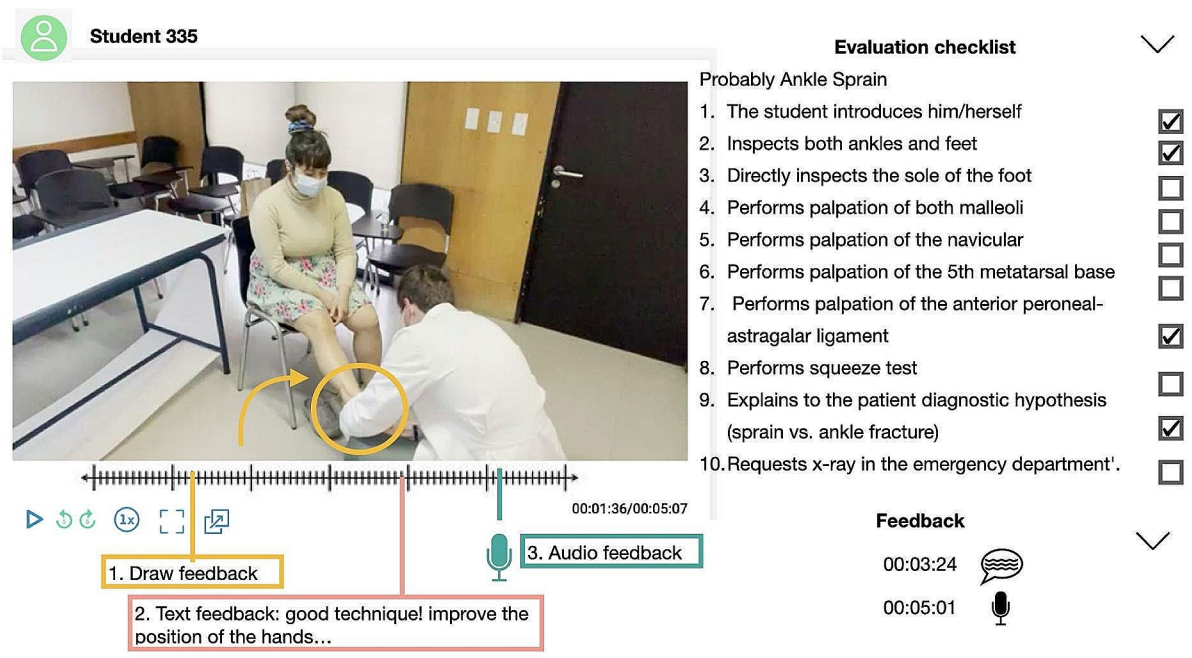


Fig. 4 C1Do1 online platform. Teachers provide feedback of the student’s OSCE physical examination performance through audio, written commentary and/or drawings on the video image. Evaluation checklists were available to teachers for grading the student’s performance

Shapiro–Wilk test. In the inferential analysis, paired T tests were performed to compare the means obtained by the students in the OSCE before and after completing the training module. T tests and Mann–Whitney tests were conducted to compare the students’ baseline performance and the control group as well as the final performance with the control group. Stata software (v.16) was used to conduct statistical analysis, and $p < 0.05$ was considered to indicate statistical significance.

Results

A total of 35 subjects participated in the first OSCE, including 29 interns and 6 experts. About 62% [15] of the interns were male and the median age was 24 (23–34). Of the experts, all were male, and the median age was 35 (32–58). At the end of the training module, 18 interns completed the second OSCE and 11 interns dropped out of the study. Teachers reviewed a total of 135 videos, including 85 videos from the first OSCE and 50 videos from the second OSCE. Four interns’ videos were excluded due to poor video quality.

The group of interns obtained a mean score of 50.6 ± 15.1 on the OSCE administered prior to the start of the module. This score increased significantly after the training to an average of 76.6 ± 12.8 , $p < 0.01$.

Untrained interns performed significantly worse than the expert group (71.2 vs. 50.6; $p < 0.01$). After receiving training and feedback, no significant differences were

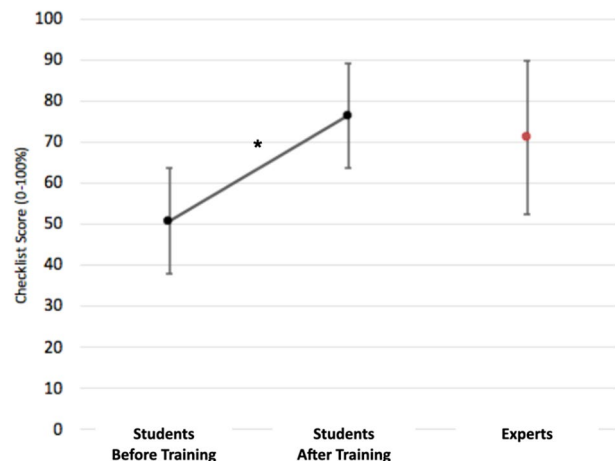


Fig. 5 Students and expert performance before and after the online training module. *Statistically significant differences

found between experts and the trained interns (71.2 vs. 76.6; $p = 0.43$) (Fig. 5).

Two evaluation questions were conducted at the end of the study, revealing that 93% of the participants affirm that the training module will be useful in their clinical practice, and 100% of the participants would recommend the training module to a colleague.

Discussion

This study aimed to assess medical interns' acquisition of musculoskeletal examination skills through their use of an online training and feedback tool. The results indicate that the online training and feedback module can enhance the musculoskeletal examination performance of medical interns. Clinical experience and scientific evidence have emphasized the importance of physical examination in the diagnosis of musculoskeletal disorders (4). However, it has been reported that the training of general practitioners is insufficient [7, 8]. Our online training and feedback module enhances the musculoskeletal examination performance of medical interns and allows them to achieve significant improvements in their OSCE scores.

Several educational techniques for teaching musculoskeletal examinations have been developed. E-learning, a methodology that has gained prominence in recent years, has been shown to lead to similar or even superior results that those associated with traditional teaching methods [16]. In this study, the e-learning methodology was used to teach interns the necessary knowledge of the main musculoskeletal disorders over a short period of time.

Other studies have focused on different online platforms that make it possible to share audiovisual material, such as videos or podcasts, as well as to provide feedback on videos uploaded by students. In the study published in 2012 by Dr. Varas and his group, it was published how a laparoscopy training program and asynchronous feedback significantly improved laparoscopic skills in the simulation laboratory. Additionally, in their study published in 2017, it was demonstrated how these acquired skills were transferred to the operating room. There were 25 first-year residents who received both virtual and in-person feedback after training sessions or evaluations. [15, 17]. To foster the development of effective skills, this study integrated both e-learning and online feedback tools. On our platform, students can review the audiovisual material as many times as they need and pause video playback to memorize or take notes on fundamental concepts. Additionally, after each OSCE, they can review the feedback given by the teachers multiple times regarding their performance in each of the clinical scenarios.

The face-to-face OSCE sessions facilitated the assessment of physical examination performance as well as the inclusion of nontechnical aspects. These aspects play an important role in the learning process associated with the development of doctor-patient communication in clinical practice [18]. It has been proven that nontechnical skills are trainable [19] and can benefit the acquisition of technical skills [20], so including the former in the learning context is nearly mandatory. The incorporation of a practice session with trained actors makes it possible to conduct a face-to-face evaluation of clinical skills in a protected environment as well as in an academic context.

The OSCE showed that the differences between students and experts prior to students' completion of the training module could be overcome by training. Students began with a low average performance score during the initial session, revealing their lack of practice and training in physical examination. Following the completion of the training module and a comprehensive analysis of feedback provided by experts regarding the physical examination conducted during the initial OSCE, interns exhibited a notable improvement in their scores during the subsequent OSCE. Regardless of the method of feedback, the literature consistently notes that students who receive feedback learn more than their peers who train without it and require less practice time to achieve similar performance [21]."

This novel methodology is one of the strengths of this study, which proved that the online training and feedback module improves student performance. This module could be a useful and time-efficient tool for teaching clinical skills pertaining to physical examination without compromising patient safety or requiring teacher-student synchronization.

However, it is important to note that the study outcomes were based solely on OSCE scores evaluated through actor simulations. Future studies should consider incorporating feedback from real patients and comparing the validity of real case diagnoses with expert evaluations to better reflect true clinical utility and outcomes.

The study had limitations including the absence of a control group of interns using traditional teaching methods, although their initial evaluation reflected their knowledge at that stage. Other limitations included participant numbers and dropout rates. Major reasons for dropout and non-completion of the second OSCE were academic evaluations, rotations at other healthcare centers, and emergency department shifts. While the participant number was sufficient for analysis, it was limited in a university context. Efforts were made to contact participants and reschedule, but this was unsuccessful due to scheduling conflicts.

Conclusion

The online training and feedback module significantly enhances the musculoskeletal examination performance of medical interns, leading to marked improvements in their OSCE scores. This study could be used as a starting point for the application of online training and feedback in multiple areas of medicine, specifically in the context of physical orthopedic examinations.

Abbreviations

OSCE Objective structured clinical examination

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12909-024-05683-w>.

Supplementary Material 1

Acknowledgements

Simulation and Experimental Surgery Center, School of Medicine, Pontifical Catholic University of Chile.

Author contributions

MA has made substantial contributions to the design of the article, the analysis and interpretation of data, has drafted the article, approved the submitted version, agreed to be personally accountable for the author's contributions, and ensure the accuracy and integrity of any part of the work. CV has made substantial contributions to the analysis and interpretation of data, revised the article, approved the submitted version, agreed to be personally accountable for the author's contributions, and ensure the accuracy and integrity of any part of the work. CR has made substantial contributions to data interpretation, substantively revised the work, approved the submitted version, agreed to be personally accountable for the author's contributions, and ensure the accuracy and integrity of any part of the work. RZ has made substantial contributions to the design of the article, analysis, and interpretation of data, approved the submitted version, agreed to be personally accountable for the author's contributions, and ensure the accuracy and integrity of any part of the work. EP has made substantial contributions to the acquisition and interpretation of data, approved the submitted version, agreed to be personally accountable for the author's contributions, and ensure the accuracy and integrity of any part of the work. JD has made substantial contributions to the acquisition and interpretation of data, approved the submitted version, agreed to be personally accountable for the author's contributions, and ensure the accuracy and integrity of any part of the work. PB has made substantial contributions to the drafted article, approved the submitted version, agreed to be personally accountable for the author's contributions, and ensure the accuracy and integrity of any part of the work. SI has made substantial contributions to the conception and design of the article, interpretation of data, substantively revised the draft, approved the submitted version, agreed to be personally accountable for the author's contributions, and ensure the accuracy and integrity of any part of the work.

Funding

Not applicable.

Data availability

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval

We obtained institutional board approval from the Scientific Ethics Committee of the Faculty of Medicine of the Pontificia Universidad Católica de Chile (number 201,006,002).

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Author details

¹Orthopedics Department, School of Medicine, Pontificia Universidad Católica de Chile, Diagonal Paraguay #362, Santiago 8330077, Chile

Received: 20 January 2024 / Accepted: 20 June 2024

Published online: 23 August 2024

References

1. Watkins-Castillo S, Andersson G, United States Bone and Joint Initiative. The Burden of Musculoskeletal Diseases in the United States (BMUS) [Internet]. The Burden of Musculoskeletal Diseases in the United States. 2014. <http://www.boneandjointburden.org>.
2. Wiitavaara B, Fahlström M, Djupsjöbacka M. Prevalence, diagnostics and management of musculoskeletal disorders in primary health care in Sweden - an investigation of 2000 randomly selected patient records. *J Eval Clin Pract*. 2017;23(2):325–32.
3. Haas R, Gorelik A, Busija L, O'Connor D, Pearce C, Mazza D, Buchbinder R. Prevalence and characteristics of musculoskeletal complaints in primary care: an analysis from the population level and analysis reporting (POLAR) database. *BMC Prim Care*. 2023;24(1):40.
4. Feddock CA. The lost art of clinical skills. *Am J Med*. 2007;120(4):374–8.
5. Brekke KR, Nuscheler R, Straume OR. Gatekeeping in health care. *J Health Econ*. 2007;26(1):149–70. <https://doi.org/10.1016/j.jhealeco.2006.04.004>.
6. van den Bogaart EHA, Spreeuwenberg MD, Kroese M, van den Boogaart MW, Boymans T, Ruwaard D. Referral decisions and its predictors related to orthopaedic care. A retrospective study in a novel primary care setting. *PLoS ONE*. 2020;15(1):e0227863.
7. Telias N, Alberto, Innocenti D, Piero, Orrego G, Francisca, Oliver C, Nicolás, Huidobro D, Bárbara, Orrego L M. Evaluación de percepción de conocimientos y destrezas de alumno de medicina en traumatología y ortopedia. *Rev Chil Ortop y Traumatol* [Internet]. 2011;52:63–70. <https://www.schot.cl/wp-content/uploads/revista/52-2.pdf>.
8. Myers A, McDonagh JE, Gupta K, Hull R, Barker D, Kay LJ et al. More cries from the joints: assessment of the musculoskeletal system is poorly documented in routine paediatric clerking. *Rheumatology* [Internet]. 2004;43:1045–9. <https://academic.oup.com/rheumatology/article/43/8/1045/2899193>.
9. Speed CA, Crisp AJ. Referrals to hospital-based rheumatology and orthopaedic services: seeking direction. *Rheumatology* (Oxford). 2005;44(4):469–71.
10. Roland MO, Porter RW, Matthews JG, Redden JF, Simonds GW, Bewley B. Improving care: a study of orthopaedic outpatient referrals. *BMJ*. 1991;302(6785):1124–8.
11. Tarpada SP, Morris MT, Burton DA. E-learning in orthopedic surgery training: a systematic review. *J Orthop*. 2016;13(4):425–30.
12. McNulty JA, Sonntag B, Sinacore JM. Evaluation of computer-aided instruction in a gross anatomy course: a six-year study. *Anat Sci Educ*. 2009;2(1):2–8.
13. DiCaprio MR, Covey A, Bernstein J. Curricular requirements for musculoskeletal medicine in American medical schools. *J Bone Joint Surg Am*. 2003;85(3):565–7.
14. Oswald AE, Bell MJ, Snell L, Wiseman J. The current state of musculoskeletal clinical skills teaching for preclerkship medical students. *J Rheumatol*. 2008;35(12):2419–26.
15. Ranjan P, Kumari A, Chakrawarty A. How can doctors improve their communication skills? *J Clin Diagn Res*. 2015;9(3):Je01–4.
16. Orientale E Jr, Kosowicz L, Alerte A, Pfeiffer C, Harrington K, Palley J, et al. Using web-based video to enhance physical examination skills in medical students. *Fam Med*. 2008;40(7):471–6.
17. Berner JE, Ewertz E. The importance of non-technical skills in modern surgical practice. *Cir Esp (Engl Ed)*. 2019;97(4):190–5.
18. Ruz C, Irrázaval S, Besa P, Vidal C, Nazar C, Varas J, et al. High-fidelity hybrid simulation not only optimizes skills acquisition but improves nontechnical skills. *Global Surg Educ - J Association Surg Educ*. 2022;1(1):29.
19. Boza C, León F, Buckel E, Riquelme A, Crovari F, Martínez J, et al. Simulation-trained junior residents perform better than general surgeons on advanced laparoscopic cases. *Surg Endosc*. 2017;31(1):135–41.
20. Varas J, Mejía R, Riquelme A, Maluenda F, Buckel E, Salinas J, et al. Significant transfer of surgical skills obtained with an advanced laparoscopic training program to a laparoscopic jejunostomy in a live porcine model: feasibility of learning advanced laparoscopy in a general surgery residency and other interventional techniques. *Surg Endosc*. 2012;26:3486–94.
21. O'Dunn-Orto A, Hartling L, Campbell S, Oswald AE. Teaching musculoskeletal clinical skills to medical trainees and physicians: a best evidence in Medical Education systematic review of strategies and their effectiveness: BEME Guide 18. *Med Teach*. 2012;34(2):93–102.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.