The Use of Teaching Associates for Knee and Shoulder Examination: A Comparative Effectiveness Analysis

Julian Zabel*, Dr. med., Jasmina Sterz*, Dr. med., Sebastian H. Hoefer†
Dr. med., Maria-Christina Stefanescu†, Marieke Lehmann*, Dennis K. Sakmen*,
Prof. Dr. med., Ingo Marzi* and Prof. Dr. med., Miriam Ruesseler*

*Department of Trauma, Hand and Reconstructive Surgery, University Hospital Frankfurt, Goethe University Frankfurt, Frankfurt, Germany; and †Centre of Surgery, University Hospital Frankfurt, Goethe University, Frankfurt, Germany

OBJECTIVE: Musculoskeletal diseases and injuries are the most common cause of long-term pain and physical disability. Thus, every medical graduate should be able to perform a structured examination of the musculoskeletal system. Besides the see-one-do-one principle, other teaching methods have been proposed to be effective. The use of teaching associates offers an established, proven pathway for teaching examination skills in urology and gynecology. During the patient experience method, students are examined first, thus giving them an opportunity to feel the examination before performing it themselves. The objective of this study was to compare the efficiency of 3 distinct teaching methods for both knee and shoulder examination.

DESIGN: The study took place during obligatory knee and shoulder examination training. Participants received basic training, including a demonstration of the structured examination by a specialist in trauma surgery. Afterward, group 1 examined each other under professional supervision; group 2 students examined the teaching associates, followed by mutual examinations; and group 3 students were each examined by the instructor, followed by mutual examinations. The acquired competence was assessed in 5-minute practical assessments directly after training and again 5 weeks later.

SETTING: The study was conducted at the medical faculty of Goethe University, Frankfurt, Germany.

PARTICIPANTS: Study participants were third-year undergraduate medical students completing their obligatory 3-week surgical training.

RESULTS: One hundred and forty-four students [group 1 (N = 53), group 2 (N = 46), and group 3 (N = 45)] participated in the first measurement, 92 students in the second measurement of the study. Directly after the training, group 2 and group 3 performed significantly better than group 1 regarding overall score ($p < 0.001$) and all 4 checklist parts ($p < 0.001$). At the second measurement, group 2 performed significantly better than group 1 regarding shoulder examination ($p = 0.003$) and significantly better than group 3 ($p = 0.025$) regarding knee examination.

CONCLUSIONS: The use of a teaching associate and the patient perspective can increase students' performance in knee and shoulder examinations. (J Surg Ed 76:1440−1449. © 2019 Published by Elsevier Inc. on behalf of Association of Program Directors in Surgery.)

KEY WORDS: knee examinations, shoulder examination, teaching associates, patient experience, see-one-do-one, checklist rating

COMPETENCIES: Patient Care, Medical Knowledge, Practice-Based Learning and Improvement

INTRODUCTION

Musculoskeletal disorders are a major cause of severe long-term pain and physical disability, affecting hundreds of millions of people globally.[1] The European Health Questionnaire, which was published in 2007, has shown that muscle, bone, and joint problems are the

Correspondence: Inquiries to Miriam Ruesseler, Department of Trauma, Hand and Reconstructive Surgery, University Hospital Frankfurt, Theodor-Stern-Kai 7, 60590 Frankfurt, Germany; e-mail: miriam.ruesseler@kgu.de

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second most common cause of long-term medical treatment. A fifth of the European population has or have had long-term musculoskeletal problems, which is among the most common of the interrogated diseases.[2] Joint diseases account for half of all chronic conditions in persons aged 65 years and older.[3,4] Moreover, the already high portion of healthcare expenses will further increase as the population becomes more aged.[4] Because of their high prevalence, doctors often have to deal with musculoskeletal patients irrespective of their specialization.[5] It is a common but mostly wrong notion that people affected by musculoskeletal disorders are often ignored and that their impairment is underestimated by doctors.[6]

With regard to its prevalence and importance, every future doctor should be able to perform a structured joint-examination.[5] Several studies have demonstrated that the amount of time spent on musculoskeletal examination courses in the curricula is limited.[7-9] To effectively use the existing training time, new instructional approaches are required, which might compensate for the limited teaching time available.

The instructional approach used to teach skills has a substantial influence on what is memorized and what will become part of a doctor's regular examination repertoire. However, the best didactical method requires further investigation for most learning objectives.[10] A commonly applied method is based on the demonstration of the examination method by a professional, followed by the students practicing their skills on each other (known as the see-one-do-one principle).

The use of teaching associates has been proven useful when imparting knowledge of various examination methods in multiple medical disciplines, such as gynecology or urology.[11-14] Teaching associates are trained simulation patients that can give immediate feedback to the students while they learn and practice their skills in the joint examination.[12,13]

Furthermore, experiencing an examination as a patient, where the examination is performed by a professional, might add another perspective to the learning process. Thus, such an approach might increase the acquired competences in comparison to acquiring the examination skills by practicing after watching an instructor's demonstration. To our knowledge, this teaching method has not been directly evaluated in the literature.

The aim of the present study was to compare the efficiency of 3 distinct teaching methods for both the knee and the shoulder examination directly after the training as well as 5 weeks after the training.

METHODS

Trial Design

This study has a prospective, comparative effectiveness design with 3 parallel study arms aiming to analyze the effect of 3 teaching methods on students' joint examination competencies of both the knee and the shoulder examination. The tested methods were using teaching associates, being examined by a professional before practicing the skills (patient perspective), and the common approach of see-one-do-one, all followed by mutual examination.

The study was conducted according to the ethical principles of the Helsinki Declaration (Ethical Principles for Medical Research Involving Human Subjects). According to the Ethics Board at Goethe University Medical School, no ethics approval was required for this study.

Participants

Study participants were third-year medical students of a 6-year program completing their 3 weeks of surgical training.[15] Participation in the study was voluntary after providing written informed consent, which participants could withdraw at any time. Basic data, such as age, sex, duration of the study, and previous experience, were acquired by an online questionnaire.

Study Protocol

During the first week of the 3-week training, the students take part in a preparatory course incorporating 12 training modules to acquire basic surgical competencies.[15]

The incorporated module influenced by our study focused on both knee examination and shoulder examination and was taught by a specialist for trauma surgery. A maximum of 7 students took part in a module at a time, and each module lasted 210 minutes.

After compiling the most important facts of taking a standard surgical history, based on their previous knowledge, which had been acquired in the surgical lecture, the students repeated and developed the most important steps of both knee examination and shoulder examination. After a demonstration of a structured examination by the instructor, the students practiced their examination skills according to the study arm they had been randomized to (about 50 minutes per examination).

Interventions

All students participating in their surgical training are assigned to a training group completing their week of training together (with a maximum of 7 students per group). The assignments were made before the

beginning of the surgical training weeks by the deanery using balanced, simple randomization, independent of the authors and independent of study participation.

These groups were randomly assigned to 1 of the 3 study arms, which we named the common approach, teaching associate, and patient experience groups.

Group 1 – A Common Approach

In the common approach group, the students practiced by examining each other under supervision and feedback from the instructor and student tutors (the see-one-do-one principle).

Group 2 – Teaching Associates

In the teaching associate-group, the students practiced the examination on a teaching associate first, receiving direct feedback on structure and performance by the teaching associate, and then practiced the acquired skills by examining each other under supervision and feedback from the instructor and student tutors.

Group 3 – Patient Experience

In the third group, participants should not only see and practice the examination, but also experience how a structured examination should feel when performed by a professional (the patient experience). Thus, each participant in this study group was first examined by the tutor before practicing the examination on each other under supervision, receiving feedback from the instructor and student tutors.

Standardization of Instructors

To guarantee that all students acquired the same competencies in shoulder and knee examination, the trauma surgery module was standardized before the present study. Therefore, a structured algorithm was generated for both shoulder examination and knee examinations. Great importance was given to the fact that the students should perform 1 specific test for each of the examined structures correctly using a clear structure. Based on this algorithm, an instruction manual describing the intended performance and structures was developed, as well as a Microsoft PowerPoint presentation. These included basic training, with repetition of the anatomical background and demonstrations of the structured examinations. All instructors, each a trauma surgery specialist, received an introduction to the algorithm, module structure, and standardization.

Training of the Teaching Associates

The teaching associates were 6 fourth- or fifth-year undergraduate students, which had already completed their surgical training. To acquire the necessary competencies, the teaching associates participated in a 3-hour training course consisting of a theoretical part taught by a trauma surgeon (MR). This training was intended to reactivate and amplify their knowledge of a structural shoulder and knee examination (e.g., anatomical structures), to allow the teaching associates to become accustomed to the structured algorithm for knee and shoulder examination, and to train the teaching associates how to give the students adequate feedback. Next, the teaching associates received practical training, in which 4 different trauma surgeons examined each teaching associate, 1 at a time, during which they got accustomed to the structured algorithm for the examination and how the different steps of the examination should feel when performed correctly. Thus, the teaching associates could not only give feedback about students' adherence to the algorithm structure but also whether each step was performed as it should be (e.g., regarding hand position, grip, and the direction of tension force). Afterward, the teaching associates examined each other, giving structured simultaneous feedback on structure and performance in the role as a teaching associate, as well as in the role as a student tutor under the supervision of the trauma surgeon (MR).

Measurement

To evaluate the acquired competencies in shoulder and knee examination, a structured checklist rating based on the objective structured clinical examination format (OSCE) was used.[5] This format is a valid and reliable tool to assess a student's clinical competence.[16] For the study measurement, the competencies were evaluated in a 5-minute assessment for each examination (shoulder and knee) at 2 time points.

The first assessment took place immediately after the training module, and the second assessment about 5 weeks later as part of a preparation training for the curricular surgical OSCE exam, which took place a further 1 week later.

At both measurements, the students were rated on a 4-part checklist assessing their competences in inspection, palpation, examination of mobility and range of motion, and special tests. Afterward, the students received a short feedback session regarding their performance, including suggestions for improvement.

Examiners were blinded to the study group and received examiner training before the assessment so that experience in the use of the checklist could be gained.

Statistical Methods

Statistical analyses were performed using SPSS Statistics (version 19, IBM, Armonk). If a Gaussian distribution was

not present in the data of a variable, then nonparametric test methods were applied. If a Gaussian distribution was present, then parametric test methods were applied. To test for significant mean differences, the averages of all included groups were analyzed by parametric analysis of variance or with the nonparametric Kruskal-Wallis test. When using the analysis of variance, the Tukey test was used as a post hoc test to analyze the comparisons between the single groups. If there is no variance homogeneity, the Games-Howell test is used. By using the Kruskal-Wallis test, pairwise comparisons were used to test the single groups. The Cohen's d effect size was calculated for the mean difference between the groups.

RESULTS

One hundred forty-four students completing their surgical training week consented to participate. At the second measurement, a total of 92 students participated. The characteristics of each study group are shown in Table 1.

The different teaching methods were all feasible, as envisaged within the given time frame of the curriculum.

Knee and Shoulder Examinations at the First Time Point

Regarding the overall score of the checklist, students who obtained the teaching associate or patient experience training performed significantly better than the common approach group ($p < 0.001$). Compared to the common approach group, the teaching associate and patient experience groups performed significantly better on all 4 checklist parts ($p < 0.001$). There were no significant differences between the teaching associate and patient experience groups. For the first measurement point, the checklist ratings regarding the competencies in shoulder examination were similar between the 3 groups. (Figs. 1a and 2a, Tables 2a and 3a)

Knee Examinations at the Second Time Point

The teaching associate group performed significantly better than the patient experience group regarding the overall score of the checklist ($p = 0.025$). Breaking down the overall score to the single checklist items, the teaching associate group performed significantly better than the patient experience group in the special tests item ($p = 0.031$). Otherwise, for knee examination, there were no significant differences between the 3 study groups at the second measurement point. (Fig. 1b, Table 2b)

Shoulder Examinations at the Second Time Point

The teaching associate group performed significantly better than the common approach group regarding the overall score of the checklist ($p = 0.003$).

Breaking down the overall score to the single checklist items, the teaching associate group performed significantly better than the common approach group when assessing mobility and range of motion ($p < 0.001$), as well as in the specific tests ($p = 0.04$). For shoulder examination, there were no other significant differences between the 3 study groups at the second time point. (Fig. 2b, Table 3b)

DISCUSSION

There are only a few studies that have addressed the use of teaching associates in practical clinical skills training for medical students. Most of those studies deal with manual skills in urogenital, anal or vaginal examination.[17] Studies investigating the use of teaching associates in other contexts are rare. Barley et al. investigated the use of teaching associates in various clinical contexts[12] but, in comparison to our study, their work did not contain any results regarding the long-term effects of the use of teaching associates. Regarding musculoskeletal examination, Perrig et al.

TABLE 1. Group Characteristics. For the Items "Age," "Duration of Study," and "Number of Previous OSCE" Data are Presented as Mean

	Point in Time 1			Point in Time 2		
Study Group	**Group 1**	**Group 2**	**Group 3**	**Group 1**	**Group 2**	**Group 3**
Participants [*n*]	53	46	45	34	30	28
Male [%]	35,8	34.78	33.33	38.20	30.00	39.30
Age [year]	24.1	23.4	23.3	23.7	23.1	23.5
Duration of study [year]	3.2	3.1	3.2	3.1	3.1	3.2
Previous OSCEs	1.08	1.07	1.04	1.06	1.03	1.07
Professional qualification as						
-Nurse	0	4	1	0	3	1
-Theatre nurse	0	0	0	0	0	0
-Other medical qualification (e.g., medical technical assistant)	2	2	0	0	0	0

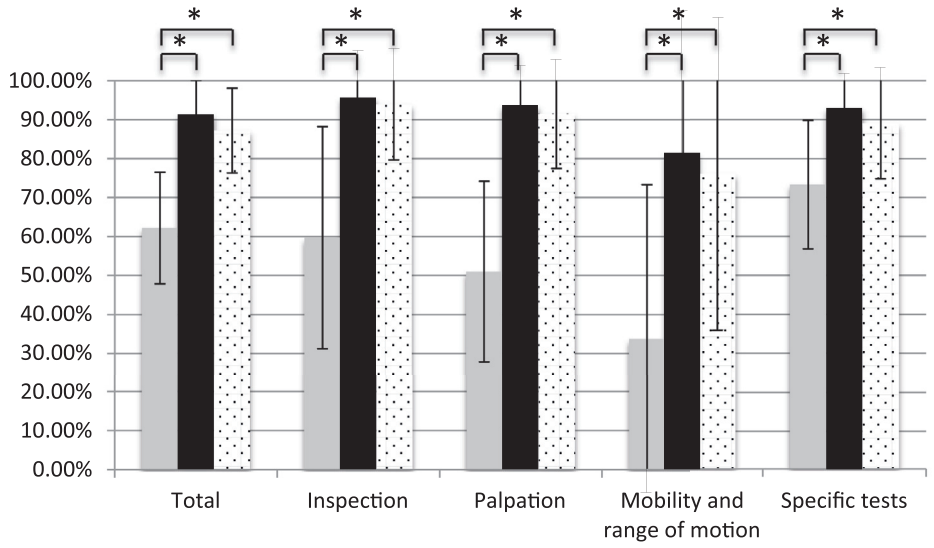

FIGURE 1A. Examination of the knee: checklist ratings. Point in time 1.
Results of the checklist rating in total and for each checklist part. Given are mean scores in % of the total score ± standard deviation. Results of group 1 are presented in light grey, group 2 in black, group 3 in dots.
Significance of improvement after intervention: *$p < 0.005$; $p < 0.05$; and n.s. = not significant.

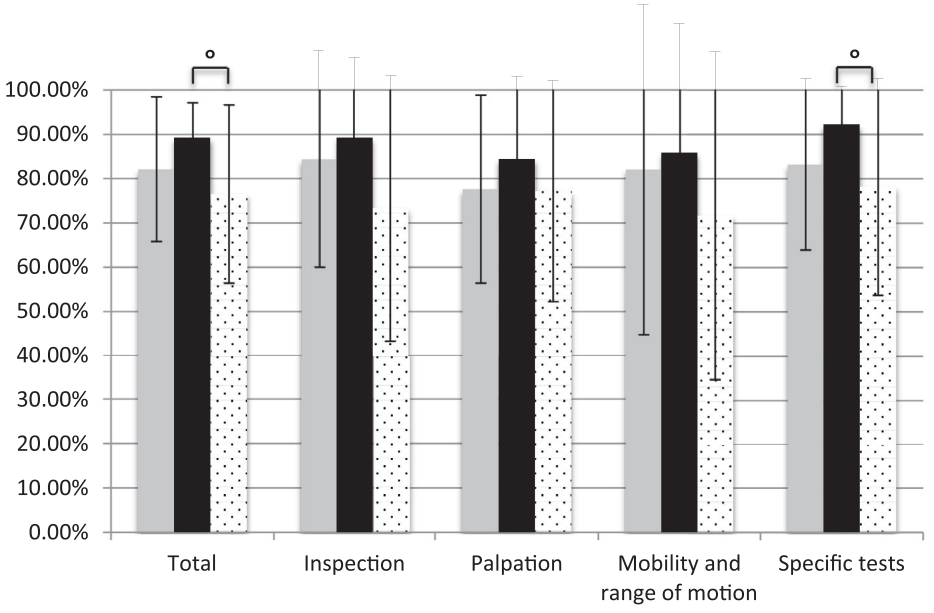

FIGURE 1B. Examination of the knee: checklist ratings. Point in time 2.
Results of the checklist rating in total and for each checklist part. Given are mean scores in % of the total score ± standard deviation.

addressed the positive effect of feedback on the long-term learning processes for medical students.[18] However, these authors had to implement an additional course into their medical clerkship period.

In the present study, we demonstrate that, in undergraduate training, teaching associates can be used within the existing curricular structures without restrictions or limitations. Furthermore, in comparison to the common see-one-do-one approach, we were able to demonstrate a significant improvement in the acquired skills when using teaching associates. The use of teaching associates combines the feedback of the patients' view with the immediate differentiated feedback of the performance after every step of the examination, which in this

TABLE 2A. Examination of the Knee: Differences and Educational Effect Sizes Between Study Groups. Point in Time 1

		Group 1 Vs. 2	Group 1 Vs. 3	Group 2 Vs. 3
Total	p	<0.001	<0.001	0.306
	d	2.47	1.97	0.42
Inspection	p	<0.001	<0.001	1.000
	d	1.64	1.52	0.13
Palpation	p	<0.001	<0.001	1.000
	d	2.39	2.11	0.19
Mobility and range of motion	p	<0.001	<0.001	1.000
	d	1.25	1.06	0.14
Specific tests	p	<0.001	<0.001	0.643
	d	1.46	1.00	0.33

TABLE 2B. Examination of the Knee: Differences and Educational Effect Sizes Between Study groups. Point in Time 2

		Group 1 Vs. 2	Group 1 Vs. 3	Group 2 Vs. 3
Total	p	0.520	1.000	0.025
	d	0.56	0.31	0.83
Inspection	p	1.000	0.711	0.223
	d	0.22	0.40	0.64
Palpation	p	1.000	1.000	1.000
	d	0.32	0.02	0.33
Mobility and range of motion	p	1.000	0.626	0.640
	d	0.11	0.28	0.43
Specific tests	p	0.312	1.000	0.031
	d	0.61	0.23	0.77

dimension cannot be given by the instructor, who only observes the examination and does not feel the performance. Teaching associates help the students to perform the examination more precisely as they can give feedback about where and how to put their hands to perform the test correctly. This observation underlies the thesis of multimodal (visual as well as auditory and haptic) feedback and its positive influence on motor learning. However, research in this area is still in its early phases and requires further investigation.[19]

As we trained fifth-year medical students to be our teaching associates and, simultaneously, student tutors, the students also benefited from peer-assisted learning. Burke et al. have shown that peer-assisted learning significantly improves the students' end-of-year musculoskeletal OSCE performance.[20] Similar results have been shown for other clinical contexts.[21,22] Cate et al. detected multiple benefits of peer-assisted learning in their review, including offering education to students on their cognitive level, creating a comfortable and safe educational environment, and improved learning

TABLE 3A. Examination of the Shoulder: Differences and Educational Effect Sizes Between Study Groups. Point in Time 1

		Group 1 Vs. 2	Group 1 Vs. 3	Group 2 Vs. 3
Total	p	<0.001	<0.001	0.186
	d	3.34	2.89	0.62
Inspection	p	<0.001	<0.001	0.584
	d	1.76	1.36	0.37
Palpation	p	<0.001	<0.001	1.000
	d	2.79	2.39	0.31
Mobility and range of motion	p	<0.001	<0.001	0.617
	d	2.57	2.27	0.36
Specific tests	p	<0.001	<0.001	1.000
	d	2.06	1.83	0.18

TABLE 3B. Examination of the Shoulder: Differences and Educational Effect Sizes Between Study Groups. Point in Time 2

		Group 1 Vs. 2	Group 1 Vs. 3	Group 2 Vs. 3
Total	p	0.003	0.906	0.348
	d	1.05	0.43	0.68
Inspection	p	0.132	0.781	1.000
	d	0.68	0.36	0.26
Palpation	p	0.516	1.000	0.996
	d	0.49	0.06	0.45
Mobility and range of motion	p	<0.001	1.000	0.123
	d	1.08	0.32	0.79
Specific tests	p	0.040	0.486	1.000
	d	0.76	0.50	0.29

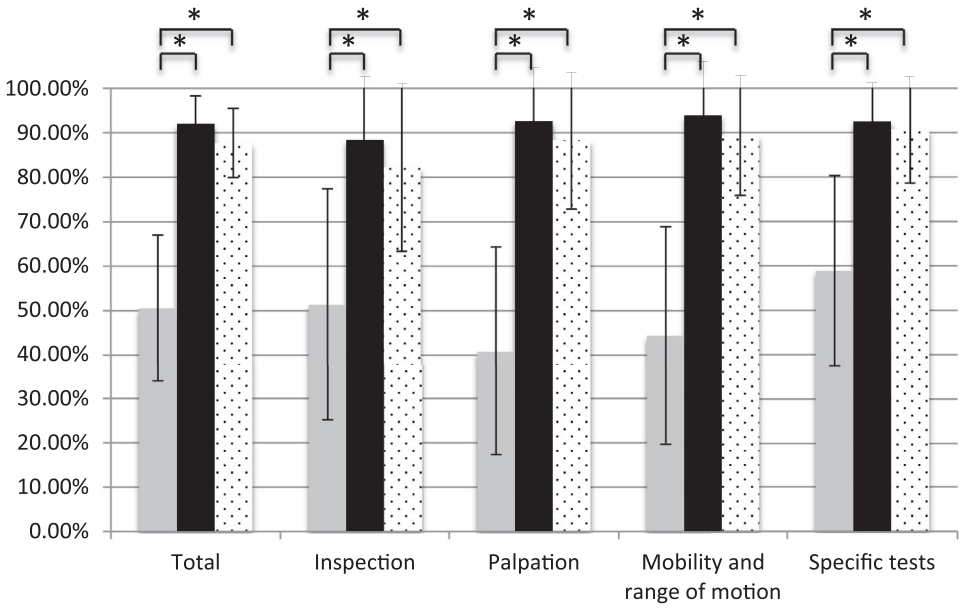

FIGURE 2A. Examination of the shoulder: checklist ratings. Point in time 1.
Results of the checklist rating in total and for each checklist part. Given are mean scores in % of the total score ± standard deviation.

efficiency.[23] Taken together, teaching associates, as deployed in the present study, provide training with simulation patients,[24] direct oral feedback,[25] multimodal feedback,[19] and peer learning/teaching,[20,22,23,26,27] which, in past studies, have been shown to have positive effects on the student learning process.

As hypothesized, we found that experiencing an examination on one's own as a "patient perspective," with the examination performed by a professional, can be an effective teaching method. The patient perspective gives the students an additional perspective in which they can feel the examination. In the following mutual examination, the students can give direct feedback regarding the performance's similarity to that of the teaching associates. Thus, even though the patient perspective approach is not as effective as the use of teaching associates, it includes similar benefits regarding the acquired competencies and how they are acquired.

Both the teaching associates and patient perspective methods can increase the acquired competences in comparison to the see-one-do-one principle. In the present study, we did not replace the professional trauma surgeon completely but instead included a further teaching aspect to the training. The advantage of this cooperation is that the specialist does not have to be present during the whole training but instead transmits his/her expertise to their peers. This approach will likely be advantageous under increasing economic pressure,[23] consolidation of working time with shorter wait time, increasing number of cases, and decreasing weekly workload due to working time laws. Another problem is that most patients ask to be treated by a specialist, which makes it

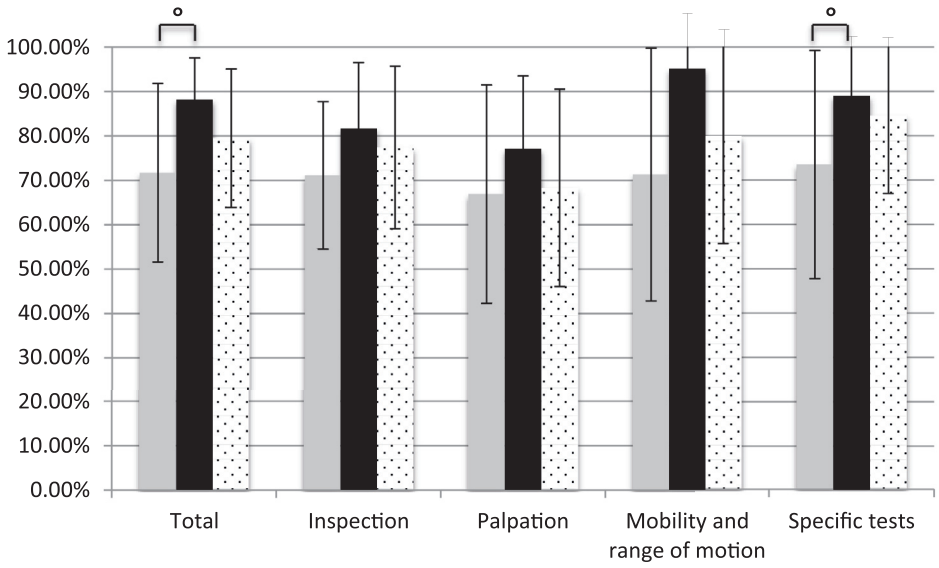

FIGURE 2B. Examination of the shoulder: checklist ratings. Point in time 2.
Results of the checklist rating in total and for each checklist part. Given are mean scores in % of the total score ± standard deviation.

increasingly difficult to integrate those specialists into clinical teaching.[28]

Finally, the economic importance of our findings should not be underrated. Even university hospitals are affected by cost pressures, especially when balancing teaching, patient care, and research.[28] With the use of teaching associates, which have been shown to provide a high training standard, up to 30% of costs can be saved. In our local remuneration structure, 2 students earn 15€ per hour each, in comparison to a faculty member earning approximately 50€ per hour.[14]

However, there are some limitations which have to be considered. The study was designed for a well-established curriculum at a single medical faculty within a single cohort of medical students. This might limit its external validity. In other countries and institutions, there might be different conditions that do not allow for a similar implementation in the current curriculum or the generalization of our findings to their students. Another limitation is that we did not include a global rating scale in addition to our checklist rating. Thus, we do not know if the different teaching methods had any effect on, for example, communicative competencies; though this has not been the focus of our study. An essential disadvantage was that the study was bound to the predefined curricular settings, such as training periods and number of students scheduled. For instance, individual randomization of those students willing to participate in the study was not possible, as students were assigned to 1 of the groups before their decision of whether to participate. Furthermore, the second measurement took place in students' preparation training for their surgical OSCE, which took place 1 week later. Thus, all students might have already been training on their own for this summative assessment, which might explain the similar checklist results in all 3 groups. Furthermore, we defined 5 weeks as a long-term interval. The choice of this time point was limited by the study design and data from a longer follow-up period might have been useful.

The strength of this study is its large sample size of 144 students and the reports of statistically significant findings. Another distinctive feature of the present study is that it was conducted directly within students' curricular and obligatory training (in vivo), rather than being an in vitro study with participants especially recruited for the study's purposes, presenting the direct usability of the methods in curricular training.

CONCLUSIONS

The implementation of the teaching methods "teaching associate" and/or "the patient perspective" can increase students' performance in shoulder and knee examinations in undergraduate skill training.

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SUPPLEMENTARY INFORMATION

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.jsurg.2019.03.006.