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Topics in Training

Assessment of a New Undergraduate Module in Musculoskeletal Medicine

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Background: Despite the high prevalence of musculoskeletal disorders seen by primary care physicians, numerous studies have demonstrated deficiencies in the adequacy of musculoskeletal education at multiple stages of medical education. The aim of this study was to assess a newly developed module in musculoskeletal medicine for use at European undergraduate level (i.e., the medical-school level).

Methods: A two-week module in musculoskeletal medicine was designed to cover common musculoskeletal disorders that are typically seen in primary care. The module incorporated an integrated approach, including core lectures, bedside clinical examination, and demonstration of basic practical procedures. A previously validated examination in musculoskeletal medicine was used to assess the cognitive knowledge of ninety-two students on completion of the module. A historical control group (seventy-two students) from a prior course was used for comparison.

Results: The new module group (2009) performed significantly better than the historical (2006) control group in terms of score (62.3% versus 54.3%, respectively; $p < 0.001$) and pass rate (38.4% versus 12.5%, respectively; $p = 0.0002$). In a subgroup analysis of the new module group, students who enrolled in the graduate entry program (an accelerated four-year curriculum consisting of students who have already completed an undergraduate university degree) were more likely to perform better in terms of average score (72.2% versus 57%, respectively; $p < 0.001$) and pass rates (70.9% versus 21.4%, respectively; $p < 0.001$) compared with students who had enrolled via the traditional undergraduate route. In terms of satisfaction rates, the new module group reported a significantly higher satisfaction rate than that reported by the historical control group (63% versus 15%, respectively; $p < 0.001$).

Conclusions: In conclusion, the musculoskeletal module described in this paper represents an educational advance at undergraduate (i.e., medical-school) level as demonstrated by the improvement in scores in a validated examination. As pressure on medical curricula grows to accommodate advancing medical knowledge, it is important to continue to improve, assess, and consolidate the position of musculoskeletal medicine in contemporary medical education.

Musculoskeletal disorders are common, particularly in primary care, where they are the second most common reason for consultation after presentation for a general medical examination with no specific complaint; such disorders account for 10% to 28% of all consultations across the United States and Europe[1-5]. In emergency departments, musculoskeletal disorders are the second most common reason for presentation after respiratory illness[6]. Despite the high prevalence of musculoskeletal disorders in primary care and emergency department settings, numerous studies have demonstrated deficiencies in

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the adequacy of musculoskeletal education at multiple stages of the medical educational process, from medical-school level both in the United States and Europe[6-9] to the level of primary care provider[5,8,10]. In recognition of this deficiency, at the beginning of the Bone and Joint Decade, an appeal was made for reform of education in musculoskeletal education[11]. Yet, at the end of this Decade, there is little evidence of an improvement in the education of musculoskeletal medicine[5,8,12], with only two studies demonstrating an improvement at undergraduate (i.e., medical-school) level[13,14]. Reform must begin at this undergraduate level. We have recently demonstrated deficiencies at undergraduate level, with 87.5% of medical students failing a validated musculoskeletal examination[8]; this finding is in agreement with those of previous studies[6,7]. The most likely cause of deficiencies at undergraduate level is a lack of dedicated formal teaching in musculoskeletal medicine. In a survey of medical schools in the U.S., only 20.5% (twenty-five) of 122 medical schools surveyed required a formal period of education in musculoskeletal medicine[15]. In medical schools in the United Kingdom, the average length of time spent in the study of musculoskeletal medicine is five weeks, with the majority of this time combined with training in other specialties[16].

Having demonstrated deficiencies in the adequacy of musculoskeletal education at undergraduate level in our institution, we subsequently designed an undergraduate module aimed at improving the competency of medical students in musculoskeletal medicine. This module, which was designed to cover the common orthopaedic disorders that are often seen by primary care providers or in patients who present with musculoskeletal medical emergencies, made use of an integrated approach that included core lectures, bedside clinical examination, and demonstration of basic practical procedures. Within this paper, we discuss the design and administration of the module. With use of a validated examination in musculoskeletal medicine that was specifically designed for undergraduate medical students, we assessed the level of competence achieved by medical students on completion of the module.

Materials and Methods

Module Design

The module was designed by faculty from the Department of Trauma and Orthopaedic Surgery of the Royal College of Surgeons in Ireland. The aim of the module was to provide students with a foundation in musculoskeletal medicine, with an emphasis on the common orthopaedic conditions seen in primary care and orthopaedic emergencies. Although there is considerable overlap between rheumatology and orthopaedic surgery, minimal focus was placed on rheumatological conditions because the students would be exposed to a second module in rheumatology later in the curriculum. At the end of the orthopaedic module, students were expected to have an understanding of common musculoskeletal disorders, to be able to perform a clinical examination of the musculoskeletal system, and to be able to perform basic procedures, such as joint injection and cast application. The module was delivered over a two-week period to groups of thirty students. A curriculum was developed whereby nine musculoskeletal topics were covered by means of an integrated approach of three fifty-minute lectures, clinical bedside demonstrations of physical examinations, demonstration of basic practical procedures, and small group-directed and/or student-directed learning activities, such as case presentations (Tables I and II). The final day consisted of student case presentations and an assessment that consisted of multiple-choice questions.

Module Administration

The module was delivered by a variety of educators from a variety of disciplines. Four lecturers (orthopaedic research fellows)

TABLE I Curriculum Overview*

Day	Core Topic	Clinical Examination	Procedure Demonstration
1	Hip	Yes	
2	Knee	Yes	Knee injection
3	Foot and ankle	Yes	
4	Upper limb I	Yes	Shoulder injection
5	Upper limb II	Yes	
6	Spine	Yes	Spinal immobilization
7	Trauma		Limb splinting
8	Sports medicine	Yes	
9	Musculoskeletal emergencies		Dislocated joint reduction
10	Case presentations and assessment with multiple-choice examination		

*The curriculum consisted of nine core topics, each being delivered on a different day. Clinical-examination teaching and procedure demonstrations were given where appropriate, as denoted. The final day consisted of students presenting an assigned core topic, including a case presentation from the wards, followed by a multiple-choice assessment.

TABLE II Example of a Core Topic (the Knee) and the Activities and Methodologies Used to Teach It

Day 1	Activity	Time *(hr)*	Teaching Methodology
AM	Lectures		
	Clinical anatomy of the knee		
	Common conditions seen in primary care		
	Knee osteoarthritis		
	The rheumatoid knee		
	The injured knee		
	Knee deformity	3	Didactic teaching, problem-based learning, and real-time assessment
	Clinical examination of knee		
	Knee aspiration and injection	1.5	Bedside demonstration (small group) and demonstration models
PM	Case preparation from ward: history, clinical examination, and preparation for presentation to peers	1	Self-directed learning
	Optional activity		
	Observation in orthotics and prosthetics		
	Observation in operating theater		
	Observation in outpatient clinic		
	Observation in occupational therapy	2	

were responsible for the overall running of the module. Lectures were delivered by consultant orthopaedic surgeons, lecturers, a physiotherapist, and a consultant radiologist. The lectures were available online on an Internet-based teaching platform as PowerPoint presentations (Microsoft, Redmond, Washington). Students were expected to have read the lectures prior to participating in the module. Each lecture was similarly structured so that relevant clinical anatomy was presented first, followed by a discussion of the pathology and management of common conditions. Lectures ended with a series of case discussions in a problem-based learning format. Lecture material was graded as being core content if it dealt with common conditions seen in the primary-care setting. Material that covered the more technical aspects of orthopaedic surgery was graded as optional and was available for students who had an interest in pursuing a career in orthopaedic surgery.

A different musculoskeletal region was covered each day with use of an integrated approach of lectures, clinical bedside teaching, practical procedure demonstrations, and student-directed learning activities. For example, the first day of the module covered the knee region (Table II). With use of a three-lecture format, relevant knee anatomy was discussed first, followed by a discussion of the pathology and management of common conditions seen in primary care, such as knee osteoarthritis. Problem-based learning, in which cases were presented for discussion by the students, was incorporated at the end of the lectures. The students formed small groups of six students each after the lectures, and each group was given a bedside demonstration of physical examination of the knee joint. These groups were then assigned to a patient for the purpose of taking a history and performing a physical examination. They were then expected to give a brief PowerPoint presentation to their fellow students to explain their findings and discuss the management of the underlying condition. The day concluded with a practical demonstration session of knee-injection techniques with use of synthetic knee demonstration models (Sawbones; Pacific Research Laboratories, Vashon, Washington). For the remainder of the day, optional observation activities were available in the operating room, in outpatient clinics, or in the occupational therapy or orthotics and prosthetics departments.

Student Assessment

Students were assessed at the end of the module with use of a multiple-choice questionnaire examination. Throughout the module, a real-time assessment system was used to provide students with real-time feedback on their performance. Multiple-choice questionnaires were interspersed throughout the lectures. Students made use of a remote handheld answering device, which they were given at the beginning of the module, to answer the multiple-choice questionnaires. After answering each multiple-choice questionnaire, they were given the correct answers along with a data set describing how they performed in comparison with their peers. This system allows students to identify how they are performing relative to their peers in real time and allows them to identify and correct their deficiencies as they go through the module rather than at the end of the module as occurs with traditional assessment methods.

TABLE III Mean Scores, Pass Rates, and Satisfaction Rates

	Score* (%)	Pass Rate (%)	Satisfaction Rate (%)
2009 group (n = 92)	62.3 ± 15.4	38.4	63
Undergraduate (n = 61)	57 ± 14.8	21.4	64
Graduate entry program (n = 31)	72.2 ± 11.8	70.9	61.3
2006 group (n = 72)	54.3 ± 11.9	12.5	15
P value†	<0.001	0.0002	<0.001
P value‡	<0.001	<0.001	

*Percentages are given as the mean value and the standard deviation. †P values for the comparison of the 2009 group and the 2006 group. ‡P values (where significant) for the comparison of the undergraduate group and the graduate entry program group.

Module Assessment

For this study, we used a previously validated examination[7] in musculoskeletal medicine that was designed specifically for medical students and had been used previously in studies in both the U.S.[5-7,13,17] and Europe[8,18]. The examination was administered to ninety-two students at the end of the two-week module. These students were in year four of a six-year course and had no previous formal education in musculoskeletal medicine. The group consisted of sixty-one undergraduate and thirty-one graduate entry students. (Undergraduate students enter a six-year medical school program after high school, whereas graduate entry students enter an accelerated four-year program after having previously completed an undergraduate degree, typically with a science background.) A historical control group was used for comparison and consisted of seventy-two undergraduate (year four of six) students who completed the examination in 2006 after taking a one-week course in orthopaedic surgery prior to the design of the current module. This group was used in a previous study from our institution[8]. Along with completing the examination, students in both groups also completed a questionnaire regarding their satisfaction with each respective course and their ability to perform a musculoskeletal clinical examination.

The examination used in this study is a validated examination that has been used in multiple previous studies[5-8,13,17,18]. It was validated by orthopaedic surgeons as well as internal medicine program directors in the U.S., who set a passing score of 70%[17]. It consisted of twenty-five short-answer, open-ended questions. On the basis of the validation process, a weighted marking system was used, with partial credit given for partially correct answers. To assess student satisfaction with the module, a demographic questionnaire was also administered with the examination. The mean scores of each group were compared with use of a two-tailed Student t test. Proportions were compared with use of the Pearson chi-square test. The level of significance was set at $p < 0.05$.

Source of Funding

No funding was received from any external group, company, or body for this study.

Results

When the mean scores were compared between the 2006 historical control group of students and the 2009 student group who took the new two-week module, the score for the 2009 group showed a significant improvement (62.3% for the 2009 group versus 54.3% for the 2006 group; $p < 0.001$). This translated to an improved pass rate (students who scored >70%) for the 2009 student group relative to the control 2006 group (38.4% versus 12.5%, respectively; $p = 0.0002$, Table III).

In a subgroup analysis in which students in the 2009 student group were analyzed according to whether they were undergraduate students or postgraduate students enrolled in the graduate entry program, the graduate entry students fared significantly better in terms of both their average score (72.2% for graduate entry students versus 57% for undergraduates; $p < 0.001$) and pass rate (70.9% for graduate entry students versus 21.4% for undergraduates; $p < 0.001$).

With regard to the satisfaction of the students with the musculoskeletal teaching, the satisfaction rate was 63% (fifty-eight of ninety-two students) in the 2009 group, which was significantly better than that of the 2006 group (15% or eleven of seventy-two students; $p < 0.001$) in the 2006 group. Regarding the students' perception of how comfortable they were at performing a basic musculoskeletal examination, 68.5% (sixty-three of ninety-two) of the 2009 student group was satisfied with their ability to perform a musculoskeletal examination, which was significantly better than the 19.4% (fourteen of seventy-two students; $p < 0.001$) rate of satisfaction that was expressed by the 2006 student group.

Discussion

Despite an appeal for reform in musculoskeletal medical education at the beginning of the Bone and Joint Decade[11], only two studies, published at the end of the Decade, have demonstrated an improvement in undergraduate education in musculoskeletal medicine[13,14]. This study demonstrates that a new module, developed to specifically address common disorders seen in primary care, results in a significant improvement in the mean score and pass rates of students taking a validated examination in musculoskeletal medicine. Even though the pass rate for the students taking the new module was only 38.4%, it

represents a significant improvement over the 12.5% pass rate achieved by the historical control group. This represents significant progress in educational terms and proves that appropriate curriculum design can address deficiencies in musculoskeletal medical education. Of note, the graduate entry group did significantly better than the undergraduate group did (70.9% versus 21.4% pass rates, respectively). The reason for this is unclear, although it may be due to the graduate entry students having developed better learning and study skills during their prior undergraduate teaching.

Williams et al. recently demonstrated a 6% improvement in student scores in a student group who took a newly designed seven-week course in musculoskeletal medicine, which covered both orthopaedic and rheumatological disorders[14]. The assessment tool they used was an internally compiled multiple-choice-question examination. The examination used in our study is a more powerful assessment tool because it was designed specifically for medical students, has been validated by more than 300 physicians, and has been used internationally, thereby enabling comparison among different educational systems. In the U.S., Bilderback et al. used the same validated examination as ours to assess a six-week course in musculoskeletal medicine[13]. In that study, the course was delivered to students during their preclinical years, combined basic science and clinical teaching, and was designed to cover both rheumatological and orthopaedic aspects of musculoskeletal medicine. The authors noted an improvement in score from 59.6% for a historical control group to 77.8% for the new student group. That score was significantly better than the 62% score achieved by the students in our two-week module and is probably due to the length of the course and the inclusion of rheumatology in their curriculum.

The findings of this study are important in the context of the design of medical-school curriculum. Education in musculoskeletal medicine has traditionally been delivered via basic-science teaching (e.g., anatomy and physiology) at undergraduate level, followed by clinical teaching in the clinical years. Clinical teaching has often been delivered within other specialties, such as internal medicine, general practice, pediatrics, and general surgery, with formal training in musculoskeletal medicine being minimal or nonexistent. One study in the U.S. found that only 20.5% of 122 medical schools had a formal period of education in musculoskeletal medicine[15]. Reform of education in musculoskeletal medicine must involve acquiring or consolidating curriculum time for formal teaching delivered by practitioners of musculoskeletal medicine. Evidence of improvements in teaching in musculoskeletal medicine at undergraduate level can be taken to the deans of medical schools and used as leverage to obtain curriculum time. Apart from acquiring curriculum time and to offset potentially reduced curriculum time, the quality of education must also improve. Our module was specifically designed to address the common musculoskeletal conditions seen in primary care. In terms of the quality of education, the module that we described utilizes modern teaching methodology, including small-group teaching, self-directed learning, problem-based learning, and real-time assessment during lectures.

Limitations to this study include the use of a historical control group consisting of an undergraduate class from 2006, which was before the new module was developed. This class received one week of formal teaching in musculoskeletal medicine, delivered via the traditional teaching methodology of large-group lectures and clinical-examination demonstrations. The two cohorts potentially differ in a number of respects. In particular, the preclinical undergraduate teaching may differ between the groups, as the new group may have received improved musculoskeletal teaching at the basic-science level. Having compared the overall preclinical curriculum structure between both groups, we found little difference between the preclinical teaching of the groups, although the more recent group did receive methodologically improved teaching, such as problem-based learning and enhanced electronic learning technology. A randomized controlled trial, which would better address this issue, would be difficult to conduct in the setting of medical education. Another limitation is that the examination tests cognitive knowledge only and does not address clinical history-taking or clinical examination skills. In conclusion, the musculoskeletal module that we describe in this paper represents an educational advance at undergraduate level, as demonstrated by the improvement in scores in a validated examination. Even though there remains room for further improvement, this module represents a promising start in addressing a chronic problem in medical education and can be used as evidence to consolidate precious musculoskeletal curriculum time as medical curricula come under pressure to accommodate advancing medical knowledge in all fields.

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