ABSTRACT

Context: In September of 2005, the Association of American Medical Colleges published a report on musculoskeletal medicine education expressing growing concern that physicians lack the skills necessary to recognize and treat the expected increase in musculoskeletal disorders. Recent studies have suggested that American and Canadian medical schools may not be effectively addressing musculoskeletal medicine in their curriculums.

Objectives: To assess the medical students’ attitude towards musculoskeletal medicine and the musculoskeletal curriculum and to measure their knowledge in this subject by using a validated instrument.

Design, Setting, and Participants: A cross-sectional volunteer survey study of first, third, and fourth year Harvard Medical School students was conducted during the 2005-2006 academic school year. Overall response rates were 101/165 (61%), 120/183 (65%), and 80/153 (52%) of first, third, and fourth year medical students respectively. Participants were recruited through various courses and also through USMLE Step II review sessions.

Main Outcome Measures: Perception towards impact of musculoskeletal education on future career, self-reported confidence in performing a physical examination, attitudes towards the current musculoskeletal curriculum, and basic knowledge in musculoskeletal medicine.

Results: The graduating class ranked musculoskeletal medicine as being of “major importance” (3.95/5, [95% confidence interval {CI}: 3.78-4.12]) towards their career but rated the required curriculum time spent on musculoskeletal medicine as “poor” (1.92/5, [95% confidence interval {CI}: 1.76-2.08]). Students who took clinical electives in the subject improved their confidence in examining the musculoskeletal system (electives: 2.04/5, no electives: 2.38/5, p<.001) and enhanced their performance on the competency exam (electives: 71.4%, no electives: 57.6%, p<.001). Only 25% (20/80) of the graduating class demonstrated competency in musculoskeletal medicine using a passing benchmark set by U.S. internal medicine residency program directors.

Conclusions: Medical students’ attitude and knowledge of musculoskeletal medicine indicate that the undergraduate medical institution may not be providing adequate training in this field to address the current and projected trends in musculoskeletal health care.

INTRODUCTION

The prevalence of musculoskeletal (MSK) symptoms seen in a wide spectrum of medical practice has drawn much attention to undergraduate MSK medicine education across American and Canadian medical schools within the past five years(1-8). MSK complaints and injuries comprise approximately 15-30% of primary care visits(5,9), 20% of emergency room visits(10), and 20% of non-routine pediatric visits(11). MSK symptoms have consistently accounted for the number one or two reason for patient visits to physicians’ office(9,12,13) and in 1995, resulted in 98.6 million office visits(13). In 2005, a Medical School Objectives Project (MSOP) report issued by the Association of American Medical Colleges (AAMC) suggested that because people in the United States are living longer, healthier lives, the prevalence of MSK conditions is increasing and will continue to rise over time(1). This trend poses a significant health problem to society due to the high impact that MSK disorders have on disability(14), the resulting productivity time lost in the workforce(15,16), and the subsequent cost to health care estimated at $200 billion annually(16,17).

Despite compelling sources of evidence pointing at the prevalence of MSK complaints in clinical practice, it is unclear whether American and Canadian medical schools are effectively educating medical students in this field(3-5,8). In 2001, a comprehensive study reviewing the curricula of all Canadian medical schools indicated that directors of undergraduate MSK programs felt dissatisfied with the current time devoted to MSK education(5). Also in the same year, survey responses by over 1,900 second-year residents in United States residency programs revealed that residents felt poorly or very poorly prepared.
in their training on examining various MSK body parts (6). In 2003, Freedman and Bernstein showed that 78% of all entering residents at the University of Pennsylvania School of Medicine failed to demonstrate basic competency in MSK medicine using a nationally validated basic competency exam in MSK medicine. The suggested passing criterion of the exam was determined by 58% of all internal medicine residency program directors across the United States based on what they felt all medical school graduates should know (2). The authors suggested that medical school education in MSK medicine is likely to be inadequate.

Few studies have directly evaluated the effectiveness of the medical students’ training in MSK medicine at the undergraduate medical institution. Our study addresses this issue by assessing the adequacy of the undergraduate MSK education curriculum at Harvard Medical School. The objectives of the study were: 1) to assess medical students’ attitude towards MSK medicine and the MSK curriculum, and 2) to examine the students’ knowledge in MSK medicine by using a validated competency exam.

**MATERIALS AND METHODS**

**Sample Selection and Administration**

Institutional Review Board approval was obtained from Harvard Medical School to anonymously survey all undergraduate medical students in the first, third, and fourth year classes during the 2005-2006 academic school year. First year students participated in the study during the first month of school and provided a baseline comparison in MSK knowledge and attitudes. The survey was administered online through the mandatory Human Body course. Third and fourth year students were recruited because both cohorts have taken the preclinical MSK block offered towards the end of their second year. Third year students were surveyed at the end of their mandatory general surgery rotation at three major teaching centers affiliated with Harvard Medical School: Massachusetts General Hospital, Brigham and Women’s Hospital, and Beth Israel Deaconess Medical Center. Fourth year students were recruited through a combination of clinical electives, USMLE Step II review sessions, and personal contacts.

**Population Subgroup**

In order to assess the required curriculum for all students as well as the impact of taking MSK electives, the composition for the participants of each class was divided between elective and non-elective takers. First year MSK electives, which were taken prior to medical school, include biomechanics focusing on MSK related injuries and anatomy and physiology. Third year MSK electives include two weeks of orthopedics during their general surgery rotation and a course on advanced clinical anatomy. Fourth year MSK electives include advanced clinical anatomy, advanced MSK physical diagnosis, and one month of adult or pediatric orthopedics.

**Survey Instrument**

All students filled out a two part instrument. The first part was an attitudes questionnaire designed for: 1) determining the students’ perception of the impact of MSK education on their future medical career, 2) measuring the students’ confidence in performing MSK physical examinations, and 3) gauging the students’ satisfaction of their undergraduate medical curriculum. The second part contained Freedman and Bernstein’s validated MSK basic competency exam (2) and was used to measure the students’ knowledge in MSK medicine. The exam consisted of 25 short answer questions, and the answer key and grading scheme used was identical to the one described in their 2002 study. First year students were asked to complete a shortened version of the survey instrument in order to minimize their potential frustration in taking a lengthy examination in which they had little prior knowledge or training. The shortened competency exam consisted of only five of the twenty-five original questions, four of which are among the easiest as determined by Freedman and Bernstein (2).

**Attitudes Questionnaire**

Students responded to a 5-category Likert scale (no, minor, average, major, and critical importance) that gauged their perceived importance of MSK education towards their future medical career, regardless of residency interest. For comparison, the same scale was used to measure the perceived importance of pulmonary education. Pulmonary medicine was chosen for comparison since MSK and respiratory symptoms comprise the top two reasons that patients seek medical attention (2,9,12). To guard against the tendency towards ranking all topics as being of major importance, the relative importance of MSK medicine was measured in relation to other major courses covered during the first two preclinical years at Harvard Medical School. Third and fourth year students were asked to rank MSK medicine along with seven other topics in the order of importance towards their future medical career. These topics included major human body systems and basic science courses all which have dedicated curriculum time greater than the amount of time devoted to MSK medicine. Clinical confidence was gauged by student responses to a 5-category Likert scale (none, low, adequate, high, complete) measuring their level of confidence in performing an overall MSK physical examination and in generating a differential diagnosis for pain. For comparison, the same scale was used to measure confidence in performing a respiratory examination. The third and fourth year student participants also rated the amount of curricular time spent on MSK pathophysiology and medicine at Harvard Medical School by responding to a 5-category Likert scale (inadequate, poor, adequate, good, excellent). They were also given the option of recommending changes (if any) to MSK education at Harvard Medical School.

**Statistical Analysis**

All analyses were conducted using SPSS version 13.0 (SPSS Inc, Chicago, Ill). Two-way analysis of variance (ANOVA) was used to characterize interactions of students’ importance ratings of MSK and pulmonary education in each class. Paired t-tests were used to compare importance ratings of MSK education to pulmonary education. Student’s t-tests were used to compare self-reported clinical confidence between elective and non-elective takers, self-reported clinical confidence between the MSK and pulmonary systems, and competency exam scores...
between elective and non-elective takers. The Mann-Whitney test was used to compare student importance rankings of the eight topics. Statistical significance was assessed at p<.05 throughout.

RESULTS

STUDY POPULATION

Overall response rates for the first, third, and fourth year classes were 101/165 (61.2%), 120/184 (65.2%), and 80/153 (52.3%) respectively. Each class’s participation was divided between elective and non-elective takers. Of the first, third, and fourth year class, four (4%), sixty-five (54%), and twenty-five (32%) of responding students had taken MSK electives. Twenty-four out of the 120 third year students had already seen Freedman and Bernstein’s competency exam and so only their responses to the attitudes questionnaire were included in analysis.

STUDENT ATTITUDES

On average, medical students estimated that MSK problems comprise between 40% and 45% of all primary care visits (1st year: 44±18%, 3rd year: 41±19%, 4th year: 45±18%). First year medical students did not indicate that there was a significant difference in importance between MSK and pulmonary education (p=.566), while third and fourth year students deemed pulmonary education as being more important than MSK education towards their future medical career (p<.001 for both groups, Figure 1). However, the ratings of both categories indicated that students in each year attributed both MSK and pulmonary education to be of “major importance” (score of 4/5). A two-way analysis of variance of academic year by topic revealed that as students progress into their clinical years, they feel that the relative importance of pulmonary education increases with respect to MSK education. When asked to rank 8 different preclinical curriculum topics, 3rd and 4th year students ranked MSK medicine as being the third most important topic to their future medical career, behind only cardiovascular and pulmonary medicine (Figure 2).

Third and fourth year medical students who have taken MSK electives felt significantly more confident in performing an MSK physical examination (3rd year: p<.05, 4th year: p<.001) and in generating a differential diagnosis (3rd year: p<.01, 4th year: p<.001) than those who have not taken any electives (Figure 3). A comparison between confidence in examining the MSK and pulmonary systems shows that while third and fourth year students generally felt a “high” (score of 4/5) level of confidence in examining the pulmonary system, the same students felt a “low” to “average” (score of 2/5 to 3/5) level of confidence in examining the MSK system (p<.001 for both years, Figure 4). Likewise, the students’ confidence levels were significantly higher in generating a differential diagnosis for pain for the respiratory system (p<.001 for both years). Both third and fourth year students ranked the amount of curriculum time spent on MSK medicine as “poor” (score of 2/5), and 76% of these students recommended “more time” as a way to change the current MSK curriculum (Table 1).

COMPETENCY EXAM RESULTS

Both third and fourth year students who have taken MSK related electives performed significantly better on the competency test than those who have just taken the required MSK curriculum (p≤.001 for both groups, Figure 5). Overall fourth year performance was not statistically different but was slightly higher than the overall score of the entering residents in Freedman and Bernstein’s study (4th Years: 62.0±13.4; Residents: 59.6±12.0; p>.20). The overall passing rate on this validated competency exam was 0%, 9.4%, and 25% for first, third, and fourth years respectively (Table 2).

DISCUSSION

Despite the growing prevalence of MSK conditions and the impact they have world-wide, these conditions have traditionally suffered from a lack of attention because they are perceived as being “less serious” than other disorders such as heart disease, AIDS, and cancer. The designation of the years 2000 to 2010 as “The Bone and Joint Decade” was a global response to their future medical career, behind only cardiovascular and pulmonary medicine (Figure 2).
Note: * Indicates significant difference between the two groups as determined by Student’s t-test. From left to right, p = .028, p = .007, p < .001, p < .001. Abbreviations: PE = Physical Examination, DDx = Differential Diagnosis

### Table 1: Self-Reported Confidence in Performing Physical Examination and Generating Differential Diagnoses in the Musculoskeletal System Among Elective and Non-Elective Takers for Third and Fourth Year Medical Students

<table>
<thead>
<tr>
<th>Third Year</th>
<th>Fourth Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE DDx</td>
<td>PE DDx</td>
</tr>
<tr>
<td>Adequate</td>
<td>4</td>
</tr>
<tr>
<td>Low</td>
<td>2</td>
</tr>
<tr>
<td>None</td>
<td>1</td>
</tr>
</tbody>
</table>

Note: * Indicates significant difference between the two groups as determined by Student’s t-test. P < .001 for each pair.

### Table 2: Competency Exam Results for First, Third, and Fourth Year Medical Students

<table>
<thead>
<tr>
<th>Academic School Year</th>
<th>1st Year</th>
<th>2nd Year</th>
<th>3rd Year</th>
<th>4th Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Score in Percentages (SD)</td>
<td>7.5±9</td>
<td>28±10</td>
<td>54±11</td>
<td>54±12</td>
</tr>
</tbody>
</table>

Note: * Indicates significant difference between the two groups as determined by Student’s t-test. P < .001 for each pair.

by the World Health Organization to outline strategies and goals to address this lack of attention(19). The United States adopted the National Bone and Joint Decade in 2002 as part of this global initiative with the ultimate goal of reducing societal burden arising from MSK conditions(20). Extending the collective effort to the medical school level, the AAMC issued a MSOP report in 2005 outlining MSK learning objectives in order to assist medical schools in their efforts to improve education about MSK conditions(1). However, there has been little direct evidence supporting the need for MSK education reform at the undergraduate level.

Previous studies have suggested that the discrepancy between the magnitude of MSK problems and physician competency in MSK medicine likely stems from educational deficiencies at the medical school level(2,6-8). In 1998, Freedman and Bernstein administered a basic MSK competency exam to all 85 entering residents at the University of Pennsylvania School of Medicine. According to a passing standard set by one hundred and twenty four (81%) of all 154 orthopedic residency program directors across the United States, seventy (82%) of these first-year residents failed to demonstrate basic competency in MSK medicine as expected from medical school graduates. A limitation of this study was the potential bias of having orthopedic residency directors set the passing criterion. In 2002, the authors addressed this limitation by re-validating the basic competency exam, and a different passing score was suggested by two hundred and forty (58%) of all 417 internal medicine residency program directors in the United States. Using these new passing standards, however, Freedman and Bernstein still found that sixty-six (78%) of the entering residents failed to demonstrate competency in MSK medicine. From these results, the authors suggested that undergraduate medical education in MSK medicine is insufficient. Results from our study, which directly evaluated medical student competency, validate their conclusion, as 75% of our graduating class failed to demonstrate competency using the passing standard set by the internal medicine residency program directors.

The first direct attempt at testing Freedman and Bernstein’s hypothesis at the undergraduate medical school level was in 2005. Investigators from the University of Washington Medical Center administered modified versions of Freedman and Bernstein’s validated exam to the medical students. The study divided the competency exam into two shorter versions in part to increase response rate. However, they attained responses from only 22% of the third year and 29% of the fourth year class(3). Results of their study indicated that the graduating class exhibited a passing rate of 43%, which is noticeably higher than the corresponding 25% at our institution. A limitation of the University of Washington study was the low response rate from their third and fourth year medical students. Our study at Harvard Medical School used the entire validated version of the basic competency exam and recruited over 60% and 50% of the third and fourth year students respectively.

In addition to directly evaluating the medical students’ knowledge in MSK medicine, we also examined the attitudes and perceptions of medical students toward MSK medicine and the MSK curriculum. The responses suggest that medical students are aware of the prevalence of MSK conditions and of the relative importance of MSK education. They ranked MSK medicine as being the third most important topic (tied with neural and renal medicine) to their future medical career out
of eight topics. Furthermore, while students felt on average that MSK medicine is of “major importance” towards their future career, they also felt that the amount of curriculum time devoted to MSK medicine was “poor”, with 76% of third and fourth years recommending that more curriculum time be devoted to the area.

One way that students can remediate their deficiency in this area is by taking MSK electives. Our results demonstrated that both 3rd and 4th year students who had taken MSK electives in their clinical years perform significantly better on the competency exam and are significantly more confident in examining the MSK system than those who had taken just the required MSK curriculum. Despite that fact that most students from our study seem to be aware of the importance and prevalence of MSK conditions, however, only 54% of third years and 32% of fourth years chose to take MSK electives. This data would suggest that medical students themselves play a role in their relative lack of competence and confidence in MSK medicine(4).

Nevertheless, as suggested by the AAMC MSOP report, more attention needs to be devoted to the MSK curriculum at the medical school institution itself. The students’ performance in the competency exam along with their relative dissatisfaction with the amount of curriculum time dedicated to this area provide evidence of the need to re-examine the undergraduate MSK medicine curriculum at Harvard Medical School.

**RELEVANCE TO OTHER MEDICAL INSTITUTIONS**

Harvard Medical School requires two weeks of preclinical instruction focused on MSK medicine in the second year and does not require a MSK clerkship during the clinical years. Of the 122 medical schools in the continental United States and Hawaii, fifty-seven schools (47%) do not require preclinical nor clinical instruction in MSK medicine and fifty-four schools (44%) require either preclinical or clinical instruction(4). Out of the 16 Canadian medical schools, 11 (68%) do not require MSK education in the clinical setting(5). Thus approximately 90% of United States and 70% of Canadian medical schools devote a similar amount of time to MSK medicine as does Harvard Medical School(4,5). Although individual institution’s MSK curriculums vary in effectiveness, it may still be reasonable to infer that the majority of United States and Canadian medical school face a similar degree of deficiency in MSK medicine education.

**LIMITATIONS**

Results from the study should be interpreted within the context of several limitations. First, there may be selection bias among the fourth year class, as 23 out of the 80 students surveyed participated by attending an optional Step II MSK boards review session. These participants may have volunteered because of their self-perceived lack of knowledge in MSK medicine and would therefore perform worse on the exam. Student’s t-tests between those who took the survey during the board review sessions and those who took the survey elsewhere reveal no statistical difference in exam scores (Boards: 58.7±14.6; Others: 63.4±12.1; p=0.146). There was, however, a significant difference in the confidence level in performing a physical examination on the MSK system (Boards: 2.25±0.44; Others: 2.75±0.68; p<0.005). Second, MSK elective-takers may have performed better on the competency exam not because they took MSK electives, but because they have a higher level of interest in MSK medicine. To address this issue, we looked at the top residency choice for all twenty-five 4th year elective takers and found that 7 out of the 25 medical students listed orthopedics as their first residency choice. When competency exam scores of the 7 students interested in orthopedics were compared to the other 18 students, we found no statistical difference between the two groups’ scores as shown by Student’s t-test (Orthopedics: 73.2±10; Others: 70.6±12; p=0.617). This data suggests that the increase in MSK medicine competency is more strongly correlated to taking MSK electives than to interest alone. Third, this study is limited to a single institution; however, results are likely generalizable to other medical schools because of the similar required time dedicated to the MSK curriculums in over 90% of all United States medical institutions(4).

**FUTURE DIRECTION**

Harvard Medical School is currently in the midst of a major undergraduate medical education reform. Instead of estimating what adjustments are needed, the institution is in favor of first assessing the effectiveness of the current MSK curriculum before embarking on specific changes. As the AAMC suggested in their MSOP guidelines, medical schools can better address
MSK education by striving to “integrate learning experiences relevant to MSK medicine throughout the curriculum in ways that explicitly identify the material as part of a coherent curriculum component”. A four-year MSK curriculum can aid in the organization of the curriculum design and link together parts of the MSK curriculum into various course blocks so that students obtain a more comprehensive understanding and cohesive view of MSK medicine. Results from our study as well as the one at the University of Washington would support requiring MSK training during the clinical years, as competency in MSK medicine significantly increased when students were exposed to the MSK clinical electives during their third and fourth years.

In conclusion, our study adds to the previous literature by not only providing direct measurement of the effectiveness of the undergraduate MSK education, but also by presenting the medical students’ perspective towards MSK medicine and the MSK curriculum. The increasing burden of MSK problems on individuals and society mandates more focus on MSK medicine, and a four year integrated MSK curriculum with dedicated time spent in both preclinical and clinical years is one way that medical schools can address this problem so that “young physicians entering their residencies will feel as well prepared to deal with such conditions as they are prepared to deal with problems found in other body systems”.

References