

The Adequacy of Medical School Education in Musculoskeletal Medicine^{*†}

BY KEVIN B. FREEDMAN, M.D.‡, AND JOSEPH BERNSTEIN, M.D., M.S.‡, PHILADELPHIA, PENNSYLVANIA

Investigation performed at the University of Pennsylvania School of Medicine, Philadelphia

ABSTRACT: A basic familiarity with musculoskeletal disorders is essential for all medical school graduates. The purpose of the current study was to test a group of recent medical school graduates on basic topics in musculoskeletal medicine in order to assess the adequacy of their preparation in this area.

A basic-competency examination in musculoskeletal medicine was developed and validated. The examination was sent to all 157 chairpersons of orthopaedic residency programs in the United States, who were asked to rate each question for importance and to suggest a passing score. To assess the criterion validity, the examination was administered to eight chief residents in orthopaedic surgery. The study population comprised all eighty-five residents who were in their first postgraduate year at our institution; the examination was administered on their first day of residency.

One hundred and twenty-four (81 per cent) of the 154 orthopaedic residency-program chairpersons who received the survey responded to it. The chairpersons rated twenty-four of the twenty-five questions as at least important. The mean passing score (and standard deviation) that they recommended for the assessment of basic competency was 73.1 ± 6.8 per cent. The mean score for the eight orthopaedic chief residents was 98.5 ± 1.07 per cent, and that for the eighty-five residents in their first postgraduate year was 59.6 ± 12 per cent. Seventy (82 per cent) of the eighty-five residents failed to demonstrate basic competency on the examination according to the chairpersons' criterion. The residents who had taken an elective course in orthopaedic surgery in medical school scored higher on the examination (mean score, 68.4 per cent) than did those who had taken only a required course in orthopaedic surgery (mean score, 57.9 per cent) and those who had taken no rotation in orthopaedic surgery (mean score, 55.9

per cent) ($p = 0.005$ and $p = 0.001$, respectively).

In summary, seventy (82 per cent) of eighty-five medical school graduates failed a valid musculoskeletal competency examination. We therefore believe that medical school preparation in musculoskeletal medicine is inadequate.

Second only to upper respiratory illness, musculoskeletal symptoms are the most common reason that patients seek medical attention^{12,16}, accounting for approximately 20 per cent of both primary-care and emergency-room visits^{5,6,8,11,15}. Musculoskeletal problems were reported as the reason for 525 (23 per cent) of 2285 visits by patients to a family physician¹¹, and musculoskeletal injuries accounted for 1539 (20 per cent) of 7840 visits to the emergency room⁶. The delivery of musculoskeletal care is spread across a spectrum of practitioners, including not only orthopaedic surgeons but also internists, family physicians, and pediatricians, among others. Moreover, under the so-called gatekeeper model that is prevalent in managed-care systems, physicians other than orthopaedic surgeons will provide an expanding share of this musculoskeletal care. Mastery of the basic issues in musculoskeletal medicine is therefore essential for all medical school graduates.

Despite the imperative for education, there may be a marked disparity between the frequency of musculoskeletal problems seen in medical practice and the adequacy of preparation in musculoskeletal medicine. In one study, 129 (51 per cent) of 255 family-practice physicians subjectively reported that their training in orthopaedics had been inadequate for their current practice¹⁷. In another survey, pediatric residents identified orthopaedics as first among the areas in which they believed that their education had been inadequate³. Several studies also have identified deficiencies in the orthopaedic physical-examination skills of medical students and primary-care physicians^{2,4,7,9}. Fowler and Regan found that only three (6 per cent) of forty-nine patients who had a chronic tear of the anterior cruciate ligament had been diagnosed properly by their primary-care physician. Ahern et al. reported that only seventeen (10 per cent) of 166 medical inpatients had had a musculoskeletal examination despite the fact that sixty-seven (40 per cent) had had a documented history of musculoskeletal symptoms on admission. These findings suggest that general practitioners may be inappropriately manag-

*No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article. Funds were received in total or partial support of the research or clinical study presented in this article. The funding source was the Office of the Dean for Health Services Research, University of Pennsylvania School of Medicine.

†Read in part at the Annual Meeting of the Academic Orthopaedic Society, Washington, D.C., November 1, 1997.

‡Department of Orthopaedic Surgery (K. B. F. and J. B.) and Center for Clinical Epidemiology and Biostatistics (K. B. F.), 424 Stemmler Hall, University of Pennsylvania, Philadelphia, Pennsylvania 19104-6081. E-mail address: orthodoc@mail.med.upenn.edu (for Dr. Bernstein).

TABLE I
BASIC-COMPETENCY EXAMINATION IN MUSCULOSKELETAL MEDICINE*

Question	Answer	Residents' Mean Score (per cent)	Chairpersons' Importance Score† (points)
1. What common problem must all newborns be examined for?	Congenital dislocation of the hip (CDH, dislocation, subluxation also accepted): 1 point	99	9.1
2. What is a compartment syndrome?	Increased pressure in a closed fascial space: 1 point	95	9.0
3. Acute septic arthritis of the knee may be differentiated from inflammatory arthritis by which laboratory test?	Any analysis of fluid from aspiration (cell count, gram stain, culture): 1 point	76	8.5
4. A patient dislocates his knee in a car accident. What structure(s) is/are at risk for injury and therefore must be evaluated?	Must mention popliteal artery: 1 point	70	8.4
5. A patient punches his companion in the face and sustains a fracture of the 5th metacarpal and a 3-mm break in the skin over the fracture. What is the correct treatment, and why?	Irrigation and débridement; risk of infection: 1/2 point each	54	8.4
6. A patient comes to the office complaining of low-back pain that wakes him up from sleep. What two diagnoses are you concerned about?	Tumor and infection: 1/2 point each	33	8.0
7. How is compartment syndrome treated?	Fasciotomy (surgery also accepted): 1 point	94	7.9
8. A patient lands on his hand and is tender to palpation in the "snuff box" (the space between the thumb extensor and abductor tendons). Initial radiographs do not show a fracture. What diagnosis must be considered?	Scaphoid fracture (carpal bone fracture also accepted): 1 point	54	7.8
9. A 25-year-old male is involved in a motor-vehicle accident. His left limb is in a position of flexion at the knee and hip, with internal rotation and adduction of the hip. What is the most likely diagnosis?	Hip dislocation: 1 point	35	7.6
10. What nerve is compressed in carpal tunnel syndrome?	Median nerve: 1 point	94	7.4
11. A patient has a disc herniation pressing on the 5th lumbar nerve root. How is motor function of the 5th lumbar nerve root tested?	Dorsiflexion of the great toe (toe extensors also accepted): 1 point	20	7.2
12. How is motor function of the median nerve tested in the hand?	Any median function (metacarpophalangeal finger flexion; thumb opposition, flexion, or abduction): 1 point	75	7.0
13. A 12-year-old boy severely twists his ankle. Radiographs show only soft-tissue swelling. He is tender at the distal aspect of the fibula. What are 2 possible diagnoses?	Ligament sprain and Salter-Harris I fracture (sprain, fracture also accepted): 1/2 point each	67	7.0
14. A patient presents with new-onset low-back pain. Under what conditions are plain radiographs indicated? Please name 5 (example: history of trauma).	Age >50; neurological deficit; bowel or bladder changes; history of cancer, pregnancy, drug use, or steroid use; systemic symptoms (night pain, fever); pediatric population: 1/4 point each, full credit for 4 correct responses	50	7.0
15. A patient has a displaced fracture near the fibular neck. What structure is at risk for injury?	Common peroneal nerve (peroneal nerve also accepted): 1 point	62	6.8
16. A 20-year-old injured his knee while playing football. You see him on the same day, and he has a knee effusion. An aspiration shows frank blood. What are the three most common diagnoses?	Ligament tear, fracture, peripheral meniscal tear (capsular tear, patellar dislocation also accepted): 1/2 point each, full credit for 2 correct responses	44	6.8

TABLE 1 (continued)
BASIC-COMPETENCY EXAMINATION IN MUSCULOSKELETAL MEDICINE*

Question	Answer	Residents' Mean Score (per cent)	Chairpersons' Importance Score† (points)
17. What are the five most common sources of cancer metastatic to bone?	Breast, prostate, lung, kidney, thyroid: 1/4 point each, full credit for 4 correct responses	86	6.7
18. Name two differences between rheumatoid arthritis and osteoarthritis.	Any two correct statements (i.e., inflammatory vs. degenerative, proximal interphalangeal joint vs. distal interphalangeal joint, etc.): 1/2 point each	76	6.6
19. Which malignancy may be present in bone yet typically is not detected with a bone scan?	Myeloma (full credit for hematological malignancies — leukemia, lymphoma): 1 point	51	6.4
20. What is the function of the normal anterior cruciate ligament at the knee?	To prevent anterior displacement of the tibia on the femur: 1 point	53	6.2
21. What is the difference between osteoporosis and osteomalacia?	Osteoporosis — decreased bone density; osteomalacia — decreased bone mineralization (any true statement about epidemiology, pathophysiology — e.g., estrogen vs. vitamin D — also accepted): 1 point	40	5.7
22. In elderly patients, displaced fractures of the femoral neck are typically treated with joint replacement, whereas fractures near the trochanter are treated with plates and screws. Why?	Blood supply to femoral head (avascular necrosis, non-union also accepted): 1 point	40	5.2
23. What muscle(s) is/are involved in lateral epicondylitis (tennis elbow)?	Wrist extensors (full credit for any wrist extensor — extensor carpi radialis brevis, extensor carpi radialis longus, extensor digitorum communis): 1 point	18	5.1
24. Rupture of the biceps at the elbow results in weakness of both elbow flexion and ___?	Supination: 1 point	49	5.1
25. What muscle(s) control(s) external rotation of the humerus with the arm at the side?	Infraspinatus or teres minor accepted (full credit for rotator cuff): 1 point	28	4.6

*The items are listed in order of the importance scores.

†On a scale of 1 to 10 points.

ing patients who have common orthopaedic problems.

Medical school is usually the primary source of formal education with regard to the musculoskeletal system. For 147 (56 per cent) of 264 primary-care physicians who were surveyed, medical school was the only source of formal instruction on the musculoskeletal system¹⁷. We conjectured that medical school training in musculoskeletal medicine may nonetheless be inadequate. To test this hypothesis, we constructed and validated an examination that we believed evaluated basic competency in musculoskeletal medicine. The examination then was administered to eighty-five recent medical school graduates.

Materials and Methods

Design of the Basic-Competency Examination in Musculoskeletal Medicine

A sample of topics in musculoskeletal medicine with which all physicians should be familiar was selected by means of a review of both the orthopaedic and the primary-care literature^{8,13}. These topics, which

are encountered frequently in primary-care practice, include fractures and dislocations, low-back pain and sciatica, and arthritis. Other subjects that were represented on the examination included emergencies that require immediate referral to an orthopaedic surgeon¹⁴ and basic anatomical knowledge that is necessary for physical diagnosis. Details on treatment and outcome were intentionally omitted from the examination.

These sample topics then were elaborated into twenty-five short-answer questions (Table I). An open-response format was selected to eliminate the possibility of the examinee scoring points on the basis of random guessing. The examination was reviewed for content and clarity by an internist and an orthopaedic surgeon who were not involved with the study. A formal answer key and scoring system were developed before administration of the examination. No time limit was enforced for completion of the examination.

Validation of the Examination

To validate our examination¹⁰, we attempted to

send it for review to all 157 chairpersons of orthopaedic residency programs in the United States¹. We sent copies of the questions, the answer key, and the mechanism for grading. A ten-centimeter visual-analog scale was included for each question. The chairpersons were asked to rate the importance of each question, ranging from not important to very important, with use of this scale. The visual-analog scale was converted to a 10-point importance score for each question, ranging from 0 (not important) to 10 (very important). After reviewing the examination, the orthopaedic chairpersons were asked to suggest a passing score (as a percentage) for all medical school graduates to demonstrate basic competency in musculoskeletal medicine on this examination.

As an additional test of validity, the examination was administered to all eight chief residents in orthopaedic surgery at our institution. This step was performed to ascertain the criterion validity; that is, to assess whether a high score would be attained given an appropriate knowledge of orthopaedics.

Administration of the Examination

The examination was administered to all eighty-five medical and surgical residents who were in their first postgraduate year at our institution; the examination was given on the first day of residency. Testing was performed with the cooperation of the residency directors, who allowed us to include the examination as part of the house-staff orientation program. A questionnaire was used to obtain demographic information, including each resident's medical school of origin and their participation in required or elective courses in orthopaedic surgery, neurology, rheumatology, and psychiatry and rehabilitation medicine while in medical school. Verbal informed consent was obtained before administration of the examination.

The examination was scored anonymously according to the answer key, with a 1-point maximum for each of the twenty-five questions; partial credit was given for some questions (Table I). This raw score then was multiplied by four in order to obtain a percentage score.

Weighted Scores

In order to examine the hypothesis that the overall score may inadequately reflect educational preparation because residents may perform better on the most important questions and worse on the least important ones, a weighted score was calculated. Each question was weighted from 0 to 10 according to its importance score as determined by the chairpersons. The score for each question then was multiplied by the weight of the question. The sum of these products (that is, the score on a given question multiplied by the weight of the question) yielded the raw weighted score. The raw score was converted to a percentage by dividing it by the sum of

the weights assigned by the chairpersons (the highest possible score). The weighted score therefore emphasizes the more important questions.

Statistical Analysis

The mean scores on the examination were compared, according to selected characteristics of the residents, with use of a two-tailed Student t test. Comparisons of multiple means were performed with a one-way analysis of variance, and specific groups were compared with use of the Bonferroni multiple-comparisons adjustment. All proportions were compared with use of the chi-square test or the Fisher exact test (when indicated). All statistical analyses were performed with use of Intercooled Stata 5.0 software (Stata, College Station, Texas).

Results

Validity of the Examination

Responses to the survey: Three of the questionnaires that were sent to the 157 chairpersons were returned unopened because they had been sent to an incorrect address, and they were eliminated from the study. One hundred and twenty-four of the remaining 154 chairpersons completed and returned the questionnaire, for a response rate of 81 per cent.

Passing score and importance score: The mean passing score (and standard deviation) that was proposed by the 124 chairpersons to demonstrate basic competency in musculoskeletal medicine was 73.1 ± 6.8 per cent (range, 50 to 95 per cent). The mean importance score for all questions on the examination was 7.0 of 10 points (range, 4.6 to 9.1 points). Twenty-four (96 per cent) of the twenty-five questions were assigned an importance score of at least 5 points and were therefore considered to be at least important (Table I).

Criterion validity: The eight chief residents in orthopaedic surgery attained a mean score of 98.5 ± 1.07 per cent (range, 97 to 100 per cent) on the examination.

Demographic Characteristics of the Residents

All eighty-five residents who were in their first postgraduate year at the Hospital of the University of Pennsylvania took the examination. There were sixty-one residents from the Department of Medicine, seventeen from the Department of Surgery, and seven categorical orthopaedic residents. The residents from the Department of Surgery included categorical residents in general surgery, urology, neurosurgery, and otorhinolaryngology. Thirty-seven medical schools were represented by the resident population that was studied. Thirteen medical schools had been attended by at least two students. These included the College of Physicians and Surgeons of Columbia University; Cornell University Medical College; Jefferson Medical College; Harvard Medical School; and the Schools of Medicine of Johns Hopkins University, New York University, Pennsylvania State University, University of Chicago, Uni-

TABLE II
PERFORMANCE ON THE EXAMINATION BY RESIDENTS WHO HAD TAKEN
OTHER ROTATIONS IN MUSCULOSKELETAL MEDICINE IN MEDICAL SCHOOL

Group	No. of Residents	Mean Score (per cent)	Result of Comparison with Student t Test	No. of Residents Who Failed Examination	Result of Comparison with Chi-Square Test
Residents who took a rotation in rheumatology	8	55.6	p = 0.32	7	p = 0.69
Residents who did not take a rotation in rheumatology	77	60.2		63 (82%)	
Residents who took a rotation in neurology	47	60.7	p = 0.56	39 (83%)	p = 0.87
Residents who did not take a rotation in neurology	38	59.1		31 (82%)	
Residents who took a rotation in physiatry and rehabilitation medicine	5	64.4	p = 0.39	4	p = 0.89
Residents who did not take a rotation in physiatry and rehabilitation medicine	80	59.5		66 (83%)	

versity of Maryland, University of Pennsylvania, University of Pittsburgh, University of Virginia, and Yale University.

Of the eighty-five residents, forty-four (52 per cent) had taken a required clinical course in orthopaedic surgery in medical school for a mean duration of 1.3 weeks, twenty (24 per cent) had taken an elective course in orthopaedic surgery in medical school for a mean duration of 5.6 weeks, and twenty-eight (33 per cent) had taken neither a required nor an elective course in orthopaedic surgery in medical school. (Seven residents had taken both a required and an elective course in orthopaedic surgery.) In addition, eight residents had taken a rotation in rheumatology; forty-seven, in neurology; and five, in physiatry and rehabilitation medicine.

Examination Scores

Overall Scores

The mean score on the examination for all eighty-five residents was 59.6 ± 12 per cent (range, 35 to 86 per cent). Seventy residents (82 per cent) had a score of less than 73.1 per cent; thus, according to the criterion set by the orthopaedic chairpersons, they failed to demonstrate basic competency on the examination. The scores ranged from as high as 99 per cent for one question to as low as 18 per cent for another question (Table I).

Scores According to Discipline

The mean score was 58.4 ± 11.5 per cent (range, 35 to 81 per cent) for the residents in medicine, 58.1 ± 12.8 per cent (range, 37 to 86 per cent) for the surgical residents, and 74.1 ± 7 per cent (range, 64 to 86 per cent) for the orthopaedic residents ($p = 0.004$). The difference in the mean score for the orthopaedic residents compared with those for both the medical and the surgical residents was significant ($p = 0.004$ and $p = 0.010$, re-

spectively). Fifty-three (87 per cent) of the sixty-one residents in medicine, fourteen of the seventeen residents in surgery, and three of the seven residents in orthopaedics failed the examination ($p = 0.015$).

Scores According to Whether a Required, an Elective, or No Course in Orthopaedic Surgery Had Been Taken

The mean score on the examination for the twenty-eight residents who had taken neither a required nor an elective course in orthopaedic surgery in medical school was 55.9 per cent, that for the thirty-seven residents who had taken only a required rotation in medical school was 57.9 per cent, and that for the twenty residents who had taken an elective course in orthopaedic surgery in medical school was 68.4 per cent ($p = 0.001$). The mean score for the residents who had taken an elective course in orthopaedic surgery was significantly higher than that for the residents who had taken no such rotation ($p = 0.001$) and that for the residents who had taken only a required course in orthopaedic surgery ($p = 0.005$). With the numbers available, no significant difference was detected between the mean scores for the residents who had taken a required course in orthopaedic surgery and those who had not ($p = 0.93$).

Because all orthopaedic residents had taken at least one elective rotation in orthopaedic surgery, we analyzed the effect of an elective course in orthopaedic surgery with the seven orthopaedic residents excluded, in order to remove potential confounding effects. This analysis revealed that there was still a significant difference between the mean scores for the thirteen residents who had taken an elective course in orthopaedic surgery and the sixty-five residents who had not (65.3 compared with 56.9 per cent; $p = 0.02$). Twenty-six (93 per cent) of the twenty-eight residents who had not taken any rota-

tion in orthopaedic surgery failed the examination compared with thirty (81 per cent) of the thirty-seven who had taken only a required rotation in orthopaedic surgery and with fourteen (70 per cent) of the twenty who had taken an elective rotation in orthopaedic surgery ($p = 0.12$).

Scores According to Whether Another Musculoskeletal Rotation Had Been Taken

The mean scores for the residents who had taken a rotation in rheumatology, physiatry and rehabilitation medicine, or neurology in medical school were not found to be significantly different, with the numbers available, from the scores for the residents who had not taken these courses (Table II). We also found no significant effect of these rotations on the proportion of residents who failed the examination.

Weighted Score

As mentioned, in order to examine the hypothesis that the residents scored well on the most important questions and poorly on the least important questions, a weighted score was calculated. For example, question 2 was assigned nearly twice the weight of question 25 because its importance score was nearly twice that of question 25 (Table I). The overall weighted score for all residents was 62 ± 12 per cent (range, 38 to 87 per cent). Sixty-nine (81 per cent) of the eighty-five residents failed the examination even when the questions were weighted according to their attributed importance.

Discussion

Given the high prevalence of orthopaedic problems that are encountered in clinical practice, the importance of basic competency in musculoskeletal medicine for all physicians cannot be disputed. Nevertheless, seventy (82 per cent) of eighty-five medical school graduates from thirty-seven different schools failed to demonstrate such competency on a validated examination of fundamental concepts.

The examination questions were validated with use of several criteria. One hundred and twenty-four chairpersons of orthopaedic surgery residency programs in the United States reviewed the questions and rated the importance of each question for all medical school graduates. Twenty-four of twenty-five questions were rated as important to highly important, and the mean recommended passing grade was 73.1 per cent. These data established the content validity of the examination. In addition, the eight orthopaedic chief residents achieved a mean score of 98.5 per cent, thereby establishing the criterion validity.

The current study clearly documents the inadequacy of medical school education with regard to musculoskeletal medicine. The duration of the residents' preparation in this area was inadequate. For the study population as a whole, the mean duration of instruction in orthopae-

dics was only 2.1 weeks. In addition, twenty-eight residents (33 per cent) had graduated from medical school with no rotation, required or elective, in orthopaedic surgery; these residents had the lowest mean score (55.9 per cent) on the examination and the highest rate of failure (93 per cent).

Devotion of more time in medical school to rotations in orthopaedic surgery was associated with a better performance on the examination. Residents who had taken an elective course in orthopaedic surgery in medical school (mean duration, 5.6 weeks) had a significantly higher mean score ($p = 0.001$) on the examination. However, those who had taken a required course in orthopaedic surgery in medical school were not found to have a significantly higher mean score than those who had not, perhaps because the standard required course was too brief for the essential information to be conveyed.

Because additional instructional time alone was insufficient to guarantee a passing score on the competency examination (the mean score for the residents who had taken an elective course in orthopaedic surgery was still lower than the chairpersons' recommended passing score), we believe that there is a problem with regard to course content as well. Perhaps the elective courses were too narrowly focused. In our experience, many elective rotations stress inpatient experiences in highly specialized areas of orthopaedic surgery rather than common outpatient problems.

Limitations of the Study

The present study had several limitations. One possible weakness was our choice to have orthopaedic chairpersons validate the examination. It could be argued that primary-care physicians rather than academic orthopaedic surgeons would have been the best group to have validated the examination. It is plausible that the chairpersons' determination of what is important may not reflect the true imperatives of primary-care practice. Nevertheless, orthopaedic chairpersons have a broad conception of musculoskeletal medicine, and having them validate the examination was certainly reasonable if not preferable.

Another potential defect was the examination itself, including the distribution of the topics, the open-response format, the wording of the questions, and the accepted answers. Although the examination may be imperfect, these limitations do not nullify our conclusions. The chairpersons who validated the examination were given complete information, including our answer key and scoring system; presumably, the chairpersons accounted for flaws in the examination when determining the passing score and rating the questions. It is reasonable to believe that the appropriate passing score for a perfect competency examination would be nearly 100 per cent. If the material that is tested is truly necessary for competency, the competent examinee should be ex-

pected to answer each question correctly. However, the passing score was set below 100 per cent to adjust for flaws in the examination. In other words, the passing score that was set by the chairpersons already accounted for problems with the examination. In addition, the use of a weighted score helps to rebut questions about the examination; even when the least important questions are discounted, sixty-nine residents (81 per cent) failed the examination.

A final limitation may be that our study population may not have been representative of typical medical school graduates. This bias actually may strengthen our conclusions, as the residents whom we tested had graduated from some of the country's best medical schools and had been accepted into highly selective training programs on the basis of academic excellence. However, it could be argued that this population included a disproportionate share of future specialists and researchers and that the schools that trained them were deficient in primary-care training. Thus, it may not be reasonable to generalize the findings of our study to students nationally. Nonetheless, it is disturbing that so many good students from good schools did so poorly on a basic-competency examination.

Although every medical school academic department can claim a need for more curricular time, the

current study demonstrates that musculoskeletal medicine does require such additional attention. Our findings suggest the need for two educational reforms: an increase in instructional time and a revision of the content of the curriculum. One week of required orthopaedic training is probably insufficient, and many students did not even receive this minimum amount in medical school. Furthermore, the standard orthopaedic rotation should exclude the particulars of operative techniques. An ideal required rotation in musculoskeletal medicine would be at least two weeks in duration and would emphasize common outpatient orthopaedic problems, orthopaedic emergencies, and physical examination for musculoskeletal problems.

Orthopaedic surgeons are the custodians of musculoskeletal knowledge. However, they render only a small proportion of musculoskeletal care, and that amount will probably decrease under managed care. Thus, all students must be instructed in musculoskeletal medicine. Our findings suggest that current medical school training in musculoskeletal medicine is inadequate. Medical schools must reform their curricula by adding more contact hours with broader content, or residency programs must compensate by providing additional training in musculoskeletal medicine. These steps are necessary for optimum patient care.

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