Journal of Orthopaedics, Trauma and Rehabilitation 19 (2015) 34–38

Contents lists available at ScienceDirect

Journal of Orthopaedics, Trauma and Rehabilitation

Journal homepages: www.e-jotr.com & www.ejotr.org

Original Article

Inadequacy of Musculoskeletal Knowledge Among Undergraduate Medical Students
本科醫學生肌肉骨骼知識不足

Bhatnagar Abhinav [a, *], Vadhel Mayur [a], Sethuraman Vanamali [b]

[a] Department of Orthopaedics, Fortis Hospital, Mumbai, India
[b] Department of Orthopaedics, Bangalore Medical College and Research Institute, Bangalore, India

ARTICLE INFO

Article history:
Received 10 January 2014
Received in revised form
25 February 2014
Accepted 26 March 2014

Keywords:
critical difference
Marascuilo procedure
musculoskeletal disorder

ABSTRACT

Background/Purpose: Musculoskeletal disorders (MSDs) are a significant public health problem. It has been observed that after leaving medical school, students are incapable of making a general assessment of the musculoskeletal system.
Methods: Accordingly, a pilot study was planned using the Freedman and Bernstein questionnaire and carried out in medical schools in India. Three hundred and twelve students at different levels were enrolled and administered the questionnaire. The correctness score for each student was obtained in each group and compared with the recommended qualifying score.
Results: For the sixth term and the ninth term, 44.61% and 50.71% students met the criterion, respectively, while interns showed the highest proportion of 71.42%. For the majority of the questions, the awareness level of ninth semester students and interns was better than that of sixth term students.
Conclusion: Compared to studies in other countries, the situation in India is not different. Medical institutions should place stress on orthopaedic education to provide better physicians.

中 文 摘 要

背景/目的: 肌肉骨骼疾病是重要的公共健康問題。有觀察認為醫學生離開醫學院後，無法對肌肉骨骼系統作總體評估。
方法: 研究在印度的醫學院，用弗里德曼和伯恩斯坦問卷(Freedman and Bernstein questionnaire)進行。三百十二名不同學年的醫學生參加了問卷調查。各組獲得的分數經調整後，會與建議的標準分數進行比較。
結果: 對於第六學期(第三年)和第九學期(最後學年)的醫學生，44.61%和50.71%的學生分別達到了標準分數，而實習醫生達到的比例最高，為71.42%。對於大多數的問題，第九學期的醫生和實習醫生的認識水平都比第六學期的醫學生為高。
結論: 相較於其他國家的研究，印度的情況沒有什麼不同。醫療機構應強調骨科教育，以提供更好的醫生。

Introduction

Musculoskeletal conditions have an enormous and growing impact worldwide. They are the most common cause of chronic pain and physical inabilities. Musculoskeletal disorders (MSD) contribute 37% of the disease burden which is attributable to occupational risk factors globally, resulting in substantial disability.[1] Despite mechanisation and automation, there is an ever increasing incidence of MSD, which has an adverse impact on the individual and the society. The Federal Bureau of Labor Statistics (BLS) has defined MSD as injuries and disorders to the muscles, nerves, tendons, ligaments, joints, cartilages, and spinal discs. MSDs are a significant public health problem today, due to their high impact on disability, personal sufferings, absence from work, and the direct and indirect costs to the health care system.

The Bone and Joint Decade (2000–2010) was launched to increase the awareness, and to encourage research and international cooperation in the prevention and treatment of MSD.[2] Orthopaedic surgeons took leadership in this movement; however, to achieve a high quality of musculoskeletal care, all physicians need to understand the basic principles of diagnosing and treating these

* Corresponding author. *E-mail:* b_abhinav@hotmail.com.

http://dx.doi.org/10.1016/j.jotr.2014.03.003

disorders. Medical school education should provide physicians with this critical foundation.[3] A solid knowledge base in orthopaedic medicine should be acquired in medical school and refined during postgraduate training.[4] Surveys show that undergraduate medical students spend very few hours on the musculoskeletal system, both in basic science and in clinical training.[5] Usually, a medical student is considered as incompetent if he/she is unable to adequately assess heart or lung problems; however, it is common that after leaving medical school, most students are incapable of making a general assessment of the musculoskeletal system. This is possibly because training in orthopaedics and rheumatology is rarely mandatory in systems with rotating internships or in family practice training programs.

The frequency of musculoskeletal complaints that arise in clinical practice dictates that all medical students should be well versed in musculoskeletal medicine. However, it has been observed that the medical schools do not provide adequate musculoskeletal education in their curricula. Some students failed to show cognitive mastery in musculoskeletal medicine, as measured by Freedman and Bernstein's validated musculoskeletal examination. Freedman and Bernstein developed a questionnaire with 25 short questions to examine the basic musculoskeletal knowledge in medical undergraduate students. These questions are based on the topics that are repeatedly observed in primary care practice, such as fractures and dislocations, arthritis, low back pain and sciatica, and basic anatomical knowledge that is necessary for physical diagnosis. The questioner was examined for necessary competency in musculoskeletal medicine and validated for significance and to suggest a passing score. This validation was carried out by all 124 chairpersons of orthopaedic residency programs in the United States. The mean passing score proposed by the chairpersons was 73.1 ± 6.8%.[6]

Day and Yeh[7] observed a lack of clinical confidence in examining the musculoskeletal system. In a study by Yeh et al,[8] they reported that only students interested in orthopaedics residencies met the passing criterion for Freedman and Bernstein's examination and exhibited above average clinical confidence. Although most musculoskeletal illness is managed by primary care providers, and not by surgeons, evidence suggests that primary care physicians have inadequate training in musculoskeletal medicine. We believe that the situation in Indian medical education is similar, and accordingly planned a survey based study.

The purpose here was to assess the musculoskeletal knowledge levels in students who are in the final stages of a bachelor's degree of medicine. Thus, 3rd year and final year students, as well as students completing their internship training, were included in the study. The aim was to determine whether there are differences in the knowledge levels of 3rd year, final year, and intern groups and if so, which aspects of knowledge differ and in which student groups. Secondly, it was of interest to determine the proportion of students who met the passing criterion for Freedman and Bernstein's test in these groups.

Methods

A validated musculoskeletal examination questionnaire developed by Freedman and Bernstein (1998) consisting of 25 questions was administered to students in the 3rd year (6th semester) ($n = 130$), final year (9th semester) ($n = 140$), and those completing internship training ($n = 42$). The study was conducted at a medical school in Bangalore, India. All of the 312 students participated voluntarily. It was ensured that no such examination was previously attended by any student. The examination was conducted simultaneously for all three groups, under the supervision of trained invigilators. There was no time limit for the examination, but students had to complete the questionnaire under vigilance of investigators and were not allowed to use any books, the internet, or study material for reference. No communication was allowed between students during the examination. Each question was allotted one mark and the recommended passing score of 73.1%, as suggested by Freedman and Bernstein, was adhered to.[6] The responses to questions obtained for each student were collated and analysed in view of the objectives.

Statistical analysis

The correct responses for each student were aggregated to determine if he/she has met the stated passing criterion. Moreover, the total correct responses for each question were also obtained in each student group. This data was used to assess the overall knowledge level of students on various aspects of MSD across the groups. The statistical significance of difference in the proportion of correct responses to a question between the two groups was evaluated using the Marascuilo procedure.[9] The observed absolute difference for a question between a pair was compared with critical difference obtained by the Marascuilo procedure. If the observed difference exceeded the critical difference, statistical significance was affirmed. The analysis was repeated for all 25 questions and all of the three pairwise comparisons. Also, the statistical significance of difference of qualifying proportions across groups was determined. The significance was tested at the 5% level and analysis was performed using the *R* 2.15 programming package (Kurt Hornik, Auckland, New Zealand).

Results

The responses given by each student to questions were evaluated for correctness by the same investigator. The score in terms of percent was obtained for each student based on correct replies. Also, the number of correct replies to each question was obtained according to groups. Table 1 shows the distribution of correct responses to each question in percentage for the three groups. Overall, it was observed that the knowledge level about fracture treatment [question (Q.) 5] and lumber nerve root testing (Q. 11) was the lowest, with only 16.99% and 16.35% of students, respectively, knowing the right solutions. By contrast, knowledge about examination of newborns (Q. 1), nerve compression in carpal tunnel syndrome (Q. 10), and structures at risk due to displacement of the fibular neck (Q. 15) was much higher, with >75% students correctly answering these questions. To determine the statistical significance of difference in the proportion of correct responses for each question, a pairwise analysis of groups was performed separately for each question using the Marascuilo procedure. The results obtained are shown in Table 2, which displays the observed absolute difference between the paired groups, followed by the corresponding critical difference and the statistical significance. For Q. 1, the difference in the proportion of correct responses across groups was statistically insignificant, as indicated by pairwise comparisons. The findings for Q. 21 and Q. 25 were similar. For Q. 4, Q. 6, and Q. 18, the difference of proportion was insignificant between the sixth term and the ninth term, while it was significant between the sixth and the intern groups. The difference between the ninth term and intern groups was insignificant. For Q.13, Q. 16 and, Q. 19, only the difference of proportion between sixth term and ninth term was significant, while the other two comparisons showed an insignificant difference. For Q. 12, the percentage of correct responses in the ninth term was significantly higher than that of the sixth term and interns. For the remaining 15 questions, the awareness level of students in the ninth term and interns was much better than sixth term students, as revealed through statistical significance. The difference of proportion was insignificant in ninth

Table 1
Percent correct score for each question according to three student groups

Q.	Questions	Percent correct response			
		6th term	9th term	Interns	Overall
1.	What common problem must all newborns be examined for?	70.77	81.79	66.67	75.16
2.	What is a compartment syndrome?	28.46	90.36	94.05	65.06
3.	Acute septic arthritis of the knee may be differentiated from inflammatory arthritis by which laboratory test?	35.00	77.14	80.95	59.94
4.	A patient dislocates his knee in a car accident. What structure(s) is/are at risk for injury and therefore must be evaluated?	23.08	35.36	46.43	31.73
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?	7.31	22.14	29.76	16.99
6.	Patient comes to the office complaining of low back pain that wakes him up from sleep. What two diagnoses are you concerned about?	14.62	23.57	44.05	22.60
7.	How is compartment syndrome treated?	43.85	90.36	96.43	71.79
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?	21.54	81.07	83.33	56.57
9.	A 25-year-old man is involved in a motor vehicle accident. His left limb is in a position of flexion at the knee and the hip, with internal rotation and adduction of the hip. What is the most likely diagnosis?	45.38	78.21	83.33	65.22
10.	What nerve is compressed in carpal tunnel syndrome?	83.08	99.29	100.0	92.63
11.	A patient had a disc herniation pressing on the 5th lumbar nerve root. How is motor function of the 5th lumbar nerve root tested?	5.00	22.86	29.76	16.35
12.	How is motor function of the median nerve tested in the hand?	26.92	75.36	29.76	49.04
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 two possible diagnoses?	33.08	52.5	50.00	44.07
14.	A patient presents with new-onset low back pain. Under what conditions are plain radiographs indicated? Please name 5 (example: history of trauma).	13.85	33.57	46.43	27.08
15.	A patient has a displaced fracture near the fibular neck. What structure is at risk for injury?	65.19	84.64	89.29	77.16
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?	25.77	42.50	41.67	35.42
17.	What are the five most common metastases to bone? Sources of cancer?	46.35	88.04	82.14	70.11
18.	Name two differences between rheumatoid arthritis and osteoarthritis	24.23	31.43	48.81	30.77
19.	Which malignancy may be present and typically is not detected with a bone scan?	12.31	33.57	19.05	22.76
20.	What is the function of the normal cruciate ligament at the knee? anterior	27.31	48.93	65.48	42.15
21.	What is the difference between osteoporosis and osteomalacia?	45.77	46.79	54.76	47.44
22.	In elderly patients, displaced fractures of the neck are typically treated with joint replacement, whereas fractures near the trochanter are treated with plates and screws. Why?	29.23	70.00	78.57	54.17
23.	What muscle(s) is/are involved in lateral epicondylitis (tennis elbow)?	33.08	89.64	78.57	64.58
24.	Rupture of the biceps at the elbow results in weakness of both elbow flexion and _____?	41.54	62.14	66.67	54.17
25.	What muscle(s) control(s) external rotation of the humerus with the arm at the side?	38.85	34.29	52.38	38.62

term students and interns, indicating not much change in the knowledge levels of students in these groups.

As per the recommended passing criterion suggested by Freedman and Bernstein (73.1%), the proportion of students passing the examination in each group was determined. In the sixth term, 58 (44.61%) students met the criterion with a mean score of 40.7 ± 8.73, while in the ninth term, 71 (50.71%) could qualify with a mean score of 60.4 ± 9.81. In the interns group, the qualifying

Table 2
Percentage of correct responses to different questions in three student groups

Q.	Observed absolute difference			Critical values			Significance		
	Terms 6–9	Term 6– interns	Term 9– interns	Terms 6–9	Term 6– interns	Term 9– interns	Terms 6–9	Term 6–interns	Term 9– interns
1	0.1102	0.0077	0.1512	0.1264	0.203	0.1951	No	No	No
2	0.619	0.7029	0.0369	0.1145	0.1317	0.1082	Yes	Yes	No
3	0.4253	0.5038	0.0381	0.134	0.18	0.1718	Yes	Yes	No
4	0.1228	0.2567	0.1107	0.134	0.2089	0.2127	No	Yes	No
5	0.1484	0.2394	0.0762	0.1024	0.1814	0.1928	Yes	Yes	No
6	0.0896	0.3163	0.2048	0.1161	0.2022	0.207	No	Yes	No
7	0.4651	0.574	0.0607	0.1227	0.1275	0.0929	Yes	Yes	No
8	0.5953	0.6596	0.0226	0.1198	0.1661	0.1624	Yes	Yes	No
9	0.3283	0.4212	0.0512	0.1368	0.1767	0.1646	Yes	Yes	No
10	0.1621	0.2192	0.0071	0.0823	0.0804	0.0174	Yes	Yes	No
11	0.1786	0.2625	0.069	0.0987	0.1789	0.1933	Yes	Yes	No
12	0.4843	0.0433	0.456	0.1304	0.1972	0.1943	Yes	No	Yes
13	0.1942	0.1942	0.025	0.1444	0.2141	0.2152	Yes	No	No
14	0.1973	0.349	0.1286	0.1226	0.2024	0.2121	Yes	Yes	No
15	0.1945	0.2856	0.0464	0.1265	0.1552	0.1385	Yes	Yes	No
16	0.1673	0.1798	0.0083	0.1388	0.2085	0.2124	Yes	No	No
17	0.424	0.3928	0.072	0.1254	0.1814	0.1604	Yes	Yes	No
18	0.072	0.2702	0.1738	0.1329	0.21	0.2118	No	Yes	No
19	0.2126	0.0769	0.1452	0.1204	0.1642	0.1775	Yes	No	No
20	0.2162	0.4144	0.1655	0.1408	0.2034	0.2072	Yes	Yes	No
21	0.0102	0.1173	0.0798	0.1486	0.2162	0.2144	No	No	No
22	0.4077	0.5327	0.0857	0.1361	0.1831	0.1816	Yes	Yes	No
23	0.5657	0.4942	0.1107	0.1191	0.1849	0.1673	Yes	Yes	No
24	0.206	0.2846	0.0452	0.1458	0.2071	0.2043	Yes	Yes	No
25	0.0456	0.1615	0.181	0.1434	0.2157	0.2126	No	No	No

proportion was highest, with 30 (71.42%) students meeting the criterion with a mean score of 72.02 ± 10.1. This difference of qualifying proportions across groups was found to be statistically significant ($p = 0.01$).

Discussion

Knowledge about Musculoskeletal disorders is fundamental in clinical practice. However, studies from different countries reveal that during medical schooling, students devote less time to this topic, and as a result they have lesser competencies in handling such cases in their practice.[10] In Canada, 27.4% of primary care practice involves MSD, and only 2.26% of the curriculum in Canadian medical schools is devoted to musculoskeletal education.[3] In the United States, medical schools do not have a formal musculoskeletal course during undergraduation.[11] In India, orthopaedic teaching forms 3.7% of the total undergraduate medical curriculum.[12] In South African medical schools, a small percentage of the undergraduate curriculum is allocated to teaching orthopaedic medicine.[13] Despite the growing burden of Musculoskeletal disorders and the need for appropriate care in this area, young medical professionals lack competency in musculoskeletal knowledge according to the Freedman and Bernstein test. A study by Yeh et al[8] revealed that only those students interested in orthopaedics showed cognitive mastery and adequate clinical confidence in musculoskeletal medicine.

We believe the scenario in Indian medical education to be similar and accordingly conducted a study at the undergraduate and intern level. The Freedman and Bernstein test involves typical orthopaedic problems like fractures and dislocations, low back pain, and osteoarthritis. It also covers basic anatomical knowledge necessary for physical diagnosis. The overall qualifying percentage was 50.96%, which was much higher than a study conducted in Barbados, West Indies with only 18% passing the test.[14] A pass rate of 39% was reported when the same examination was administered to interns in Australia.[15] The overall mean score obtained in the study (57.7 ± 9.02%) was quite close to that reported by Menon and Patro[12] in their study (59.06 ± 12%). In our study, the mean score for interns was highest (72.02 ± 10.1%) compared to the other two undergraduate groups. This score was marginally higher than the mean score of 69.4 ± 12% obtained for interns in Australia.[15]

We further analysed the competencies of students according to type of question: clinical (Q. 1, 4–6, 8, 9, 11–13, 15, 16, 24, and 25) and theoretical (Q. 2, 3, 7, 10, 14, and 17–23). It was observed that the overall percent correctness for theoretical questions was 54.05% compared to 44.85% for clinical questions. This finding was comparable to 51.95% and 44.32%, respectively, obtained by Menon and Patro.[12] Also, Dachs et al[13] obtained the percent correctness for clinical and theoretical questions as 51.4% and 39.4%, respectively. The question relating to clinical examination of newborns (Q. 1) was answered correctly by the majority of students from each group (overall 75.16%), thus showing an insignificant difference of percent correctness across the groups. Another question from the clinical category showing an insignificant difference of percent correctness across the groups was about muscle controlling external rotation of the humerus (Q. 25). Although the difference was insignificant, the percent correctness in each group was lower (overall 38.62%) indicating a lack of awareness of students as regards this clinical aspect. For other clinical questions, such as Q. 5, 8, 9, 11, 15, and 24, the ninth term students and interns had better awareness compared to the sixth term students. Treatment solutions for facial fractures (Q. 5) were least known to students in the sixth term (7.31%) compared to the other two groups. In addition, these students had poor knowledge about testing the motor function of the fifth lumber nerve (Q. 11: 5%) compared to other groups. In a study by Dachs et al,[13] the percent correct response to this question was lowest, i.e., 9%.

On the theoretical front, for Q. 2, 3, 7, 10, 14, 17, 20, 22, and 23, the ninth term students and interns had better knowledge levels as compared to the sixth term students. Compartment syndrome (Q. 2) was much better known to students of the ninth term and interns (90.36% and 94.05%, respectively), as compared to those of the sixth term (28.46%). Students of the sixth term were less aware of low back pain (Q.14: 13.85%) compared to the other two groups. Further, they were less knowledgeable about the malignancy detection (Q. 19: 12.31%). Almost equal proportions of students from the three groups knew about the differences between osteoporosis and osteomalacia (Q. 21), as well as differences between rheumatoid arthritis and osteoarthritis (Q. 18). In general, the theoretical based questions were scored well when compared to clinically oriented questions. This shows the need for more clinical exposure in orthopaedics for medical students in their curriculum.

Responses to the same set of questions were analysed from a region-specific perspective, following the classification provided by Day and Yeh.[7] The percent of correctness and statistical significance of correctness across groups for upper/lower extremity, back, and others was studied. The overall percent correctness of questions related to upper extremity was 53.22%. This was higher than 48.92% which was obtained by Menon and Patro[12] and 39.18% by Dachs et al.[13] The ninth term students and interns performed better than the sixth term students on questions related to upper extremities. For lower extremity, the overall percent correctness in our study was 49.98%, which was close to 42.85% by Menon and Patro[12] and 45.34% by Dachs et al.[13] In this category also, the performance of the senior group was better than that of the junior group. The performance of students was worst on questions related to “back”. The overall correctness was 22.01%, which was lower than that obtained by Menon and Patro[12] (36.25%) and Dachs et al[13] (31.43%). The lack of knowledge about these questions among the sixth term students mainly lowered the overall percent correctness. In the “others” category, our findings almost matched with the above two studies. Overall, it seems that back and lower extremities related knowledge of musculoskeletal medicine was limited in medical students. This correlates with the inadequate clinical exposure to undergraduate students, where the majority of patients come with lower extremity and back complaints in OPD (Outpatient Department) units.

In general it was noticed that the fraction of students with adequate musculoskeletal knowledge in the ninth term and the interns was significantly higher than that in the sixth term students. Awareness about such disorders and treatment modalities were known to more of the ninth term and intern students compared to the sixth term students. The confidence level of senior students in a physical examination was also higher than that of junior level (6^{th} term) students, although it was not measured objectively. Despite a higher percentage of senior students passing the test relative to juniors, it is yet insufficient considering the growing burden of MSD in the Indian population. The role of institutions is paramount in developing a curriculum which gives adequate importance to musculoskeletal disorders and also helps develop interest of students in this field.

There are some limitations of this study. Firstly, it was conducted only in one medical institution from a metro city, Bangalore. There are many institutions in India, which operate in semi-urban and rural sectors. Thus, the exposure to medical students is varied and hence the findings of this study may not be generalised under an Indian scenario. A more comprehensive survey involving institutes across the country would be required for more significant results. Secondly, the questionnaire used in the study has not been

validated in India. Questions related to infections and congenital anomalies needs representation in the test.[12]

In India, the incidence of musculoskeletal disorders has increased with the changing lifestyles of people in the past decade. In view of this, it is essential that young medical graduates have adequate knowledge and practical experience in dealing with this disorder. It is also the responsibility of medical institutions to place more emphasis on orthopaedic education in the curriculum and to generate confidence in students that would help them serve the society as good physicians.

Conflicts of interest

All contributing authors declare no conflicts of interest.

Acknowledgements

The authors would like to thank Dr. Dhananjay V. Raje, Head MDS Bio-Analytics Pvt. Ltd., Nagpur, India for statistical analysis of the data.

References

1. Woolf AD, Akesson K. Understanding the burden of musculoskeletal conditions. The burden is huge and not reflected in national health priorities. *BMJ* 2001;**322**:1079–80.
2. Lidgren L. The bone and joint decade 2000–2010. *Bull World Health Organ* 2003;**81**:629.
3. Pinney SJ, Regan WD. Educating medical students about musculoskeletal problems. Are community needs reflected in the curricula of Canadian medical schools? *J Bone Joint Surg Am* 2001;**83**:1317–20.
4. Johnson WMS, Bertha A. Prevalence of upper extremity musculoskeletal disorders among workers in an industrial town in Tamilnadu. *J Clin Diagn Res* 2011;**5**:187–90.
5. Kumar S, Tuli SM. Orthopedic education: Indian perspective. *Indian J Orthop* 2008;**42**:245–6.
6. Freedman KB, Bernstein J. The adequacy of medical school education in musculoskeletal medicine. *J Bone Joint Surg Am* 1998;**80**:1421–7.
7. Day CS, Yeh AC. Evidence of educational inadequacies in region-specific musculoskeletal medicine. *Clin Orthop Relat Res* 2008;**466**:2542–7.
8. Yeh AC, Franko O, Day CS. Impact of clinical electives and residency interest on medical students' education in musculoskeletal medicine. *J Bone Joint Surg Am* 2008;**90**:307–15.
9. Marascuilo LA. Large sample multiple comparisons. *Physiol Bull* 1966;**65**:280–90.
10. Clawson DK, Jackson DW, Ostergaard D. It's past time to reform the musculoskeletal curriculum. *Acad Med* 2001;**76**:709–10.
11. DiCaprio MR, Covey A, Bernstein J. Curriculum requirements for musculoskeletal medicine in American medical schools. *J Bone Jt Surg Am* 2003;**85**:565–7.
12. Menon J, Patro DK. Undergraduate orthopedic education: is it adequate? *Indian J Orthop* 2009;**43**:82–6.
13. Dachs R, Vrettos B, MacIntyre K, et al. Assessment of undergraduate orthopaedic training at medical schools in South Africa. *SA Orthop J* 2010;**9**:33–7.
14. Jones JK. An evaluation of medical school education in musculoskeletal medicine at the university of West Indies, Barbados. *West Indian Med J* 2001;**50**:66–8.
15. Broadhurst N. Measuring cognitive and clinical competency in orthopedics. *J Bone Jt Surg Am* 2002;**84**:604–8.