An Assessment of Undergraduate Musculoskeletal Training at Medical Schools in South Africa

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This research is based on independent work performed by myself and neither the whole work nor any part of it has been, is being, or is to be submitted for another degree to any other university. This work was not published prior to registration for the MMed degree.

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Acknowledgements

Statistical analysis by Dr H Carrara, Analytical Epidemiologist/Biostatistician, School of Public Health and Family Medicine, UCT.

Abstract

A basic familiarity with common musculoskeletal disorders is of vital importance for medical school graduates. The purpose of this study was to assess a group of newly qualified South African medical school graduates commencing internship at Groote Schuur and Tygerberg hospitals for competency in musculoskeletal injury and disease.

A basic competency examination in musculoskeletal medicine was used as the assessment tool. The examination consisted of 25 short-answer questions and was marked using a validated answer key and scoring system. Topics included fractures and dislocations, back pain, arthritis, basic anatomical knowledge and emergencies that require urgent referral to an orthopaedic surgeon.

The study group comprised 79 interns who were in their first postgraduate year at Groote Schuur or Tygerberg hospitals in 2010. The examination was administered during the orientation programme on their first day of work. The same examination was administered to all registrars in orthopaedic surgery at the University of Cape Town. The results were analysed using Stata 11 to estimate percentages and their binomial exact 95 percent confidence intervals.

The recommended mean passing score for the examination was 73.1 ± 6.8 percent. The mean score for the 17 orthopaedic registrars was 96.0 percent,

and for the 79 interns in their first postgraduate year was 45.3 percent (95%CI 42.3-48.4). Seventy-two (91 percent) of the 79 interns failed to demonstrate basic competency in the examination.

The same basic competency examination was applied at the end of 2011 to a second study group of first and second-year interns at Groote Schuur Hospital, to establish whether a two-month orthopaedic rotation during internship significantly improved the pass rate in the competency examination. The examination was administered via e-mail. A response rate of 66 percent was achieved (50 of 76). The mean score for the group was 56.8 percent. Those who had completed an orthopaedic rotation during their internship (18/50) achieved a mean score of 62.8 percent, compared to 54.1 percent amongst those who had not yet completed an orthopaedic rotation (32/50). Eighty-three percent (15/18) of those who had completed an orthopaedic rotation and 94 percent (30/32) of those who had not completed an orthopaedic rotation failed the assessment. The additional exposure to musculoskeletal medicine during an internship rotation did not show statistical benefit.

In summary, 91 percent of medical school graduates in our study failed a valid musculoskeletal competency examination, and no additional benefit was found from completing an internship rotation in musculoskeletal medicine. We therefore believe that medical school preparation in musculoskeletal injury and

disease in South Africa is inadequate and that undergraduate training programmes throughout the country should be reassessed.

Introduction and Literature Review

Musculoskeletal symptoms account for 23–28 percent of primary care, and 20–30 percent of accident and emergency attendances internationally.[12345] They are the second most common reason for consulting a doctor after upper respiratory tract infections and account for the majority of health problems limiting work in developed countries.[6] Approximately 60 percent of people on early retirement or long-term sick leave in Europe claim a musculoskeletal problem as the reason.[7] The economic burden of musculoskeletal illness is massive, accounting for 2.5–7.7 percent of the Gross National Product of many Western nations.[8]

In 2001, injuries killed 5.1 million people and accounted for 12% of the disability-adjusted life years lost worldwide, which was more than that lost due to tuberculosis, diarrhoea and malaria combined and twice as much as that lost due to either HIV/AIDS or cancer.[9]

The leading cause of death in low and middle-income countries amongst people between the ages of five and 45 years is injury, and the leading cause of disease burden among children between the ages of five and 14 years is caused by falls, followed by road-traffic injuries.[10] A Ugandan study found that for each person who dies from trauma, three to eight more are permanently disabled.[11] In South Africa, disability-adjusted life years lost due to injury is ranked third behind HIV/AIDS and infectious/parasitic illnesses, and above cardiovascular disease, respiratory disease, malignancies and

diabetes mellitus.[12] In 2000, musculoskeletal diseases accounted for the loss of more than 45 000 disability-adjusted life years in South Africa.[13] Furthermore, the impact of musculoskeletal conditions is predicted to increase dramatically in both developing and developed countries with the aging of the population, lifestyle changes resulting in a lack of physical fitness and obesity, and the increase in motor vehicle accidents with the urbanisation and motorisation of the developing world.[14] Injury presently accounts for 12 percent of the global burden of disease and is predicted to increase to 20 percent by 2020. By that time, road-traffic injuries, now ranked the ninth leading cause of disability-adjusted life years lost, will be the third leading cause worldwide.[15] Paediatric deaths resulting from traffic accidents are three times higher in low-income countries (30 per 100 000 children) than in high-income countries (10 per 100 000 children).[16]

The provision of musculoskeletal care comes from a broad spectrum of practitioners, including general practitioners, emergency medicine specialists, physicians, rheumatologists and paediatricians. Orthopaedic surgeons provide only 6 percent of musculoskeletal care in the United States.[17] In South Africa there are an estimated 1.5 orthopaedic surgeons per 100 000 of the population.[18] In eight East African countries, there are an estimated 40 orthopaedic surgeons serving a population of over 200 million.[19]

Junior doctors in South Africa are exposed to one of the highest loads of musculoskeletal illness and injury.[2021] This is particularly relevant during the compulsory two years of community service, often served in rural areas far

from specialist support. Much of the death and disability from injury in developing countries has been attributed to inadequate care. Daar et. al. estimated that 20 percent of deaths among young adults in developing countries could be prevented by simple surgical interventions.[22] Nunn et al assessed factors associated with a delay to arthrotomy in paediatric septic arthritis of the hip[23]. In their study from northern Kwazulu-Natal, they found that deprivation, consultation with a traditional healer, maternal education and distance to a health care facility were not associated in a delay to arthrotomy, but initial misdiagnosis was.

A good understanding of musculoskeletal medicine is therefore essential for the future good practice of most, if not all, medical school graduates.

The knowledge base in musculoskeletal medicine needs to be acquired in medical school and then refined during postgraduate training. However, throughout the world, undergraduate curriculae are dedicating less and less time to the teaching of the musculoskeletal system, both in basic science and in clinical training.[24] Pre-clinical curriculae in North America and the United Kingdom devote on average only 2-3 percent of their time to the teaching of musculoskeletal injuries and diseases.[25] In the United Kingdom, only 2 percent of the available teaching time during the clinical years is devoted to trauma and orthopaedic surgery.[26] If accident and emergency medicine and rheumatology are included, musculoskeletal teaching still represents less than 4 percent of the curriculum, with a decrease over the past decade from 6 percent.[27] Freedman and Bernstein assessed new residents at the University

of Pennsylvania School of Medicine and found that the average duration of orthopaedic undergraduate training received at medical schools was 2.1 weeks.[28] One-third of the residents had not taken any orthopaedic surgery course during medical school. It is difficult to justify an undergraduate programme with no formal orthopaedic training when musculoskeletal injury and disease is so prevalent and its care still provided by a broad spectrum of health care practitioners.

Furthermore, when considering postgraduate education, training in orthopaedic surgery and rheumatology is not compulsory in family medicine training programmes, despite the large number of patients treated by doctors in these programmes.[29] In elective programmes in Canada, only 3.5 percent of rotating postgraduate interns had training in orthopaedic surgery.[30] Only 10 percent of the vocational training schemes for GPs in the United Kingdom include orthopaedics[31] and more than half of North Carolina family practitioners reported medical school as their only source of formal instruction in musculoskeletal medicine.[32] Al-Nammari et. al. assessed junior doctors in England at the completion of their foundation programme,[33] a mandatory two-year period of postgraduate training designed to provide doctors with the clinical skills needed to work in the National Health Service.[34] They found that only 15 percent of the interns had gained any exposure to musculoskeletal medicine during these two years. In South Africa, Orthopaedics/Orthopaedic Trauma has been incorporated into the two-year internship programme as a two-month Additional Clinical Domain. To our knowledge the efficacy of this programme has not previously been investigated.

How does this perceived inadequate undergraduate and postgraduate training impact on clinical practice and the delivery of good health-care? Govender stated that the deficiencies in musculoskeletal trauma care in low and middle-income countries are essentially due to failure of the health system to provide the necessary service to prevent death and disability.[7] He stated that strengthening the delivery of services for musculoskeletal injuries would require providing appropriate initial management, which in turn may reduce the cost and complexity of the definitive treatment.

Many international studies express concern that their doctors lack the competency, skills and confidence to manage adequately the musculoskeletal disorders seen in daily practice. A survey of Ontario primary care physicians found the unnecessary use of diagnostic tests, inappropriate prescription of non-steroidal anti-inflammatory drugs and lack of diagnostic suspicion of dangerous musculoskeletal conditions to be common problems.[35] This inability to recognise common musculoskeletal conditions and a lack of understanding of the appropriate use of special investigations results in ineffective usage of valuable health care resources.

Duckett et. al. from Warrington Hospital in the UK found that after a short orthopaedic training fellowship, GPs were managing many conditions more appropriately.[36] There was also an increase in the number of referred cases being listed for surgery, indicating a more appropriate referral pattern to hospital. An Australian study revealed that only 10 percent of 166 medical

inpatients had undergone a musculoskeletal examination, despite the fact that 40 percent had a documented history of musculoskeletal symptoms on admission.[37] In another survey, 80 percent of nearly 400 Australian interns were unable to assess musculoskeletal disability adequately.[38] In the United States, family medicine graduates reported a lower level of confidence in their physical examination, radiographic evaluation, diagnosis and treatment of musculoskeletal patients compared with their confidence levels in dealing with other patients.[39] Those with training periods on an orthopaedic service of eight weeks or longer, however, reported significantly higher levels of confidence in these areas.[40] Primary care physicians in Canada have also been shown to be significantly more confident in performing a cardiovascular examination than a musculoskeletal examination.[41]

Lynch et. al. from the University of Washington found that greater musculoskeletal knowledge and confidence amongst GPs was associated with the number of years in clinical practice, male gender and prior participation in a musculoskeletal course.[42] In their study, GPs also demonstrated greater confidence in treating medical conditions other than musculoskeletal conditions. Jandial et. al. from Newcastle University assessed self-rated confidence in paediatric musculoskeletal clinical assessment in doctors who are likely to see children with musculoskeletal problems.[43] Of the 346 respondents, the majority had no or little confidence in the musculoskeletal assessment, while most respondents were confident in most aspects or very confident for cardiovascular, respiratory, and abdominal systems. Paediatric musculoskeletal assessment ranked lowest of all

systems. In addition, only half of the respondents recalled any teaching of paediatric musculoskeletal medicine at undergraduate level. Myers et al. compared the assessment of the musculoskeletal system to other systems in paediatric inpatients.[44] They found the cardiovascular, respiratory and gastrointestinal systems were assessed in the vast majority (>90 percent) of patients, irrespective of the underlying diagnosis. However, other systems were less well recorded; the trend being the same in each hospital and in descending order, the neurological system (38 percent), skin (32 percent), eyes (10 percent) and musculoskeletal system (4 percent). Only 2.7 percent of patients had been asked about musculoskeletal symptoms, and only 1.6 percent had any documented joint examination, and no patients had documentation of gait being examined, even in those children presenting with a limp. The self-rated confidence in musculoskeletal assessment was markedly low in comparison with other systems. Of note none of the participating doctors could recall teaching as an undergraduate in paediatric musculoskeletal assessment. It would be considered negligent for a medical graduate to be incompetent at adequately assessing the cardiovascular or respiratory system, yet these studies show it is common for students to leave medical school without being able to make an adequate assessment of the musculoskeletal system.

In an attempt to quantify the perceived lack of musculoskeletal competence amongst medical graduates, Freedman and Bernstein from the University of Pennsylvania designed a basic competency examination in musculoskeletal medicine[45] (table 1). The purpose was to assess whether recently graduated

medical doctors had an adequate knowledge of basic musculoskeletal topics. The examination was validated by 124 chairs of Orthopaedic residency programmes in the United States. The chairs weighted the questions according to importance and recommended a pass mark of 73.1 percent. They assessed 85 residents at the start of their first post-graduate year. Seventy (82 percent) of the residents failed the basic competency examination in musculoskeletal medicine. The chairs found the residents who had taken an elective course in orthopaedic surgery in medical school scored significantly higher (68 percent) on the examination than did those who had taken only a required course or had no rotation in orthopaedic surgery (56 percent). If one accepts the orthopaedic chairs' recommended pass mark of 73.1 percent, then additional instructional time alone was insufficient to achieve an adequate knowledge of musculoskeletal medicine. The authors suggested that the course content may be inappropriate, with too much emphasis on inpatient experiences in highly specialised areas of orthopaedic surgery rather than common outpatient problems. Al-Nammari et. al. from Barts in London used the same competency examination on 112 interns at the end of their two-year foundation programme.[46] 102 of 112 (91.1 percent) failed the same musculoskeletal assessment. Only 15 percent of the interns had gained some exposure to orthopaedics during their foundation programme. The mean score for this group (62 percent) was significantly higher than those who had had no orthopaedic exposure (51 percent).

We wanted to investigate the magnitude of this problem in a South Africa context. Freedman and Bernstein's assessment tool was applied to a group

of recently graduated doctors to assess them for competence in musculoskeletal medicine. The assessment was reapplied two years later to evaluate whether the recently instituted two-year internship, with its complusory two month Orthopaedic/Orthopaedic trauma rotation had a significant effect on musculoskeletal competency.

Methods

We enrolled interns who were in their first post-graduate year in 2010 at Groote Schuur and Tygerberg Hospitals and asked them to complete the Freedman and Bernstein Musculoskeletal examination (Table 1). The test was administered on the first day of each hospital's intern orientation programme. Health Sciences Faculty Research Ethics Committee approval was obtained and testing was performed with the co-operation of the intern curators. Verbal informed consent was obtained and the examination was anonymous. The participants were asked to record only the medical school from which they obtained their medical degree. No time limit was applied. All interns who were approached agreed to participate. In total, 79 interns completed the examination, 53 from Groote Schuur Hospital and 26 from Tygerberg Hospital.

The Freedman and Bernstein musculoskeletal examination was developed to test how well medical school graduates understood basic musculoskeletal problems. It was produced and later validated by those chairing residency programs in both orthopaedic and internal medicine. The pass mark was set at 73.1 percent by the 124 chairs of orthopaedic residency programmes, and 70 percent by the 240 chairs of internal medicine residency programmes. The examination consists of 25 short-answer questions with an open response format. The questions were also weighted according to importance from 0 to 10 by the orthopaedic chairs. Topics included fractures and dislocations, back pain, arthritis, basic anatomical knowledge and emergencies that require

immediate referral to an orthopaedic surgeon. Details on treatment and outcome were omitted from the examination.

The examination was scored anonymously according to the validated scoring system and answer key. In our study, the overall unweighted score was calculated as described in the original paper and the recommended pass mark set at 73.1 percent as recommended by the 124 chairpersons of orthopaedic residency programmes in the United States. Each question was worth a maximum of 1 point. To obtain a score from 0 to 100, raw scores were multiplied by four.

Weighted scores were also calculated to examine the hypothesis that the overall score may inadequately reflect the participant's level of competence in orthopaedic medicine because interns may perform better on the most important questions and worse on the least important questions. For example, question 2: 'What is a compartment syndrome?' was weighted twice as important as question 25: 'What muscle(s) control(s) external rotation of the humerus with the arm at the side?'

As an additional test of validity, the examination was administered to all registrars in orthopaedic surgery at the University of Cape Town. This step was performed to ascertain whether a 'perfect' score would be attained given an appropriate knowledge of orthopaedics.

Data were analysed using Stata 11 to estimate percentages and their binomial exact 95 percent confidence intervals.

To ascertain whether a two month orthopaedic rotation during internship significantly improved performance in the musculoskeletal assessment, the examination was applied to a second study group consisting of all first and second year interns at Groote Schuur Hospital during 2011. A list of 76 interns was obtained from the intern curator, and the examination was administered via e-mail. The examination was sent out at three-weekly intervals during a four month period between September and December 2011. Those who had not responded within the first three months were contacted telephonically. A lucky-draw cash prize of R1 600 was offered for participation in the assessment. A final response rate of sixty-six percent was achieved (50 of 76).

We corresponded with the Heads of Orthopaedic Departments of all South African medical schools and collected data relating to the nature of their undergraduate orthopaedic programmes. Information collected included total time allocated to musculoskeletal medicine, the breakdown into pre-clinical and clinical exposure, the proportion of time allocated to whole class lectures and small group teaching and exposure to after-hours on-call duties.

Results

Overall unweighted score

The mean score for the 17 orthopaedic registrars was 96.0 per cent (table II), and that for the seventy-nine interns in their first postgraduate year was 45.3 percent (95 %CI 42.3-48.4), with a range of 8.0 to 77.0 percent (table III). Only seven interns (9 percent) had as score of more than 73.1 ± 6.8 percent and thus demonstrated basic competency on the examination. The scores for the individual questions ranged from as high as 92.3 percent to as low as 9.0 percent (Table IV).

Weighted score

To examine the hypothesis that the interns may have scored well on the most important questions and poorly on the least important questions, a weighted score was calculated (Table V). The overall weighted score for all interns was 47.0 percent (95 %CI 43.9-50.1). Seventy-one (90 percent) of the 79 interns failed the examination when the questions were weighted according to their attributed importance (Table VI).

Individual component scores

Anatomy based questions (Q8, 10, 11, 12, 15, 20, 22, 23, 24, 25) were answered poorly, with an average score of 37.9 percent (95%CI 33.6-42.3) (Table VII), compared to the overall average score of 45.3 percent. 'Red flag' questions (Q2, 4, 5, 6, 7) were better answered, with an average score of 55.3

percent (95%CI 50.7-59.8) (Table VIII), compared to the overall average score of 45.3 percent.

Cohen method

A pass mark was calculated using the Cohen method (70 percent of the 95th percentile).[47] This was done to set a pass mark as a function of the performance of the top candidates so as to adjust for the difficulty of the examination. Fifty-six of the 79 interns (70.9 percent) failed the assessment according to the pass mark (53.9) set by the Cohen method.

In the follow-up study the mean score for the 50 first and second year interns was 56.8 percent. Those who had completed an orthopaedic rotation during their internship (18/50) achieved a mean score of 62.8 percent, compared to 54.1 percent amongst those who had not yet completed an orthopaedic rotation (32/50). Eighty-three percent (15/18) of those who had completed an orthopaedic rotation and 94 percent (30/32) of those who had not completed an orthopaedic rotation failed the assessment.

Data collected from the various undergraduate orthopaedic training programmes showed the average time allocated to teaching in musculoskeletal medicine is six weeks. Allocated time in the clinical years is frequently shared with other disciplines. Only half of the programmes had on-call exposure for the students.

Whilst our study population was too small to allow any statistically significant sub-analysis, we were able to demonstrate two trends, with the interns who scored higher in the assessment coming from programmes with more time allocated to orthopaedic training and from programmes that included on-call duties for the students.

There are several limitations to this study. Freedman and Bernstein's musculoskeletal examination is the only validated assessment tool currently available. The authors of the questionnaire accept its weaknesses and acknowledge that its validity may be limited by 'the distribution of the topics, the open response format, the wording of the questions, and the accepted answers'.

We used the pass mark of ≥73.1% established by 124 orthopaedic program directors instead of that of ≥70% established by 240 internal medicine programme directors. Selecting the lower pass mark may have changed some of our findings. Whilst the pass mark was validated by 124 programme directors, it is open to criticism. However, using the Cohen method, which uses the top performing students as a point of reference to set a pass mark that reflects the difficulty of the assessment, more than 70 percent of the interns still failed. Our study may have been limited by sample bias, with participants coming exclusively from two large tertiary hospitals in Cape Town. Our intern group did, however, include graduates from all eight South African medical schools.

In the follow-up study the 66 percent response rate may have introduced selection bias. Administering the questionnaire by e-mail introduced two possible limitations. To guarantee anonymity the participants were asked to place their answers in a box at the intern curator's office. However due to logistical factors, most chose to reply via e-mail, thus effectively compromising their anonymity. Participants were asked to answer without the use of textbooks or other resources, but this could not be guaranteed. This may be the reason the group who responded by e-mail achieved a 9 percent (those that had not completed an orthopaedic rotation) higher mark than those in the original study, who competed the assessment in a lecture hall during their orientation programme. However, it was not the aim of the study to make any comparison between these two groups, and the analysis between participants who had, or had not, completed an orthopaedic rotation during internship was limited only to the participants who responded by e-mail.

The second-year interns who responded may have benefited from writing the same test two years earlier. However, on analysing the results, there was no significant difference in the results of this group (57.9 percent) compared to the overall group average of 56.8 percent.

Discussion

Our study suggests that the majority of newly qualified South African doctors do not have a basic level of competence in musculoskeletal medicine. At the start of their internship, with their final undergraduate medical exams only recently completed, only 9 percent of the interns passed the Freedman and Bernstein basic musculoskeletal assessment. This is alarming, not only because of the high prevalence of musculoskeletal conditions in both trauma and general medicine, but also because a large number of interns, Community Service Officers and Medical Officers in South Africa work in rural areas without specialist support. Almost two decades later, we are still not producing graduates fit for service in post-apartheid South Africa, as set out in the National Health Plan of 1994.[48]

It is a major challenge to identify and quantify the specific factors which contribute toward the poor performance of our medical graduates. Factors such as curricular content, time allocation, teaching methods and teacher skills, amongst others, are all likely to contribute.

The majority of South African medical schools have recently restructured their undergraduate programmes, which have been accredited by the Undergraduate Education and Training Committee of the Health Professions Council of South Africa. Our findings suggest that these programmes may not be effective in providing adequate undergraduate musculoskeletal training, or are possibly not being applied as intended.

We corresponded with our fellow medical schools and collected data relating to the nature of their undergraduate orthopaedic programmes. The national average is six weeks of time allocated to training, which amounts to a little over 2 percent of the total curriculum. The majority of medical schools combine this time with training in other specialties such as anaesthetics, thereby effectively reducing the exposure to musculoskeletal medicine even further. Half of our medical schools also do not have on-call duties for their medical students. This is a disproportionately small amount of time given the current musculoskeletal load experienced in our hospitals.

Orthopaedic surgery is taught in year 5 of the MBChB program at the University of Cape Town. It has a Higher Education Qualifications Framework (HEQF) credit value of 7 out of a total of 197 (3.6%) for year five (table IX). This is a disproportionately low figure given the clinical load of musculoskeletal injury and disease. In comparison, Anaesthesia has a HEQF credit value of 19, Psychiatry, which is taught in year 4 and 6, a credit value of 42, and Public Health/Health Promotion a combined credit value of 34.

Many of the programmes still included a large number of large group didactic lectures. This was also found by Blitz et. al. from the University of Pretoria.[49] Their Family Medicine block based largely on didactic lectures was consistently evaluated by students from 2001 to 2006 as one of the worst two blocks in the curriculum.

Another concerning finding was that most programmes only had contact with students in the final two or three years of training. This contradicts the concept of early clinical contact, a key strategy of the South African Council on Higher Education for student academic development.[50] In many ways the courses show more resemblance to an old curricular model than new. Reversion to old curricular habits is a major limitation to the modernisation of medical education.[51] Seggie recommended the establishment of medical education units within faculties, staffed by education specialists.[52] These units would oversee the teaching programme, facilitate staff development, promote research, and prevent reversion to old-school teaching.

It is a recognised educational principle that information is better retained when taught in context.[53] The intern group performed particularly poorly in the anatomy-based questions, with an average score of 37.9 percent. Proficiency in gross anatomy is an absolute prerequisite for competence in musculoskeletal medicine, with direct correlation to performance in all aspects of a final musculoskeletal examination,[54] as well as being a predictor for performance in the United States Medical Licensing Examination.[55] The poor performance in the anatomy questions suggests that current teaching is ineffective. Teaching basic science together with directly related clinical medicine provides a context and helps to rationalise and clarify clinical practices. It has also been shown to significantly improve performance[56] and encourages students to think scientifically when they practice medicine.[57]

Our findings were comparable with similar studies from other centres. In their original study from Philadelphia in 1997, Freedman and Bernstein found an 82 percent failure rate among their residents.[58] Al-Nammari et al. (London, 2008) found a 91.1 percent failure rate amongst their interns.[59] These studies signal similar concern regarding the adequacy of musculoskeletal training amongst medical practitioners worldwide.

Haywood et. al. from the University of Arizona assessed musculoskeletal training in primary care residency programmes to determine whether formal orthopaedic instruction increased musculoskeletal knowledge.[60] They administered Freedman and Bernstein's examination to 38 primary care residents and found that those who had completed an orthopaedic rotation achieved a significantly better score (61.5 percent compared to 47.3 percent). Similar results were found by Queally et. al. from Cappagh National Orthopaedic Hospital in Ireland, who administered the examination to 303 volunteers consisting of medical students, orthopaedic registrars and general practitioners.[61] While 71 percent of general practitioners failed the examination, the pass rate improved by 30 percent for general practitioners who had completed a postgraduate rotation in musculoskeletal medicine. Williams et. al., from the University Hospitals of Leicester, showed a 6 percent improvement in performance by undergraduate students when the orthopaedic surgery component of their training was increased by just one week.[62] They also showed the quality of education received in a given subspecialty may influence the eventual choice of an undergraduate student's

career.[63] Consequently, it is important to provide high-quality musculoskeletal education if only to attract the best candidates to orthopaedic surgery.

The association between increased time in a discipline and improved competency is apparent. However, given the vast and ever-expanding scope of modern medicine, and the curricular demands imposed by other disciplines/sub-specialties on curriculum time, simply demanding an increased allotment of time may not be a realistic solution to the problem.

Alternative ways to increase total contact time include on call duties shadowing an orthopaedic registrar, which showed some benefit in our study. This would allow exposure to the diagnosis and management of orthopaedic emergencies, topics which were poorly answered in our assessment.

Most orthopaedic departments have well-established primary care outreach programmes. Including students in these programmes may be an effective method of exposing them to the common musculoskeletal conditions they will encounter after graduating. The Parallel Rural Clinical Curriculum (PRCC), initiated in 1997 at Flinders University School of Medicine in South Australia, rotates medical students through rural general practices, regional and district hospitals for an entire year (their pre-final year).[64] The students reported numerous benefits, including exposure to a broad range of patient presentations, continuity of care, mentorship, increased responsibility in the care of patients, and, most significantly, better performance in the exit examination. Whilst available resources may differ greatly in a South African

context, Couper argues that improving the quality of rural health-care through academic involvement is part of the mandate of medical schools in South Africa.[65] The rural GPs involved in the Flinders model reported improved quality of care and evidence-based practice after the advent of the PRCC. The orthopaedic service in the Cape Town metropol provides regular outreach clinics to areas such as Vredenburg and Vredendale, and the University of Cape Town Health Sciences Faculty has an established clinical teaching site at Vredenburg. Coupling these resources would provide a fairly simple way of ensuring students develop clinical skills in musculoskeletal medicine which are directly relevant to practice in South Africa.

Student participation in structured elective blocks have also been shown to be of benefit and may be another effective strategy to increase exposure to musculoskeletal medicine.[66] Day et. al. found medical students at Harvard Medical School felt a low level of confidence in performing a musculoskeletal physical examination and failed to demonstrate competency in Freedman and Bernstein's musculoskeletal assessment (>80 percent failed). Increasing exposure to the subject by taking clinical electives resulted in significantly greater clinical confidence and improved performance on the exam.

Self directed learning is now a significant part of most undergraduate training programmes. The overall effectiveness of a course depends substantially on the students' activities outside the classroom.[67] This needs to be encouraged and facilitated by providing appropriate and current online resources. These resources need to be carefully managed, to ensure they support the curricular

content, cover all aspects required, and are current. They should include specific sections which the students can read before class to prepare appropriately and be able to address any questions at the time of the class. A department approved standardised examination technique should also be available online.

Several studies have documented the use of portfolios to be an effective method of self-directed learning.[68] Ezeala et. al. found the portfolio method facilitated better feedback and was a valid means of assessment of competence at undergraduate level.[69]

More focused teaching of the basic sciences may also make additional time available for the teaching of the clinical skills so lacking in musculoskeletal medicine. Addressing the content of the curriculum however involves more than just reassessing the teaching of basic sciences. Several studies have shown that undergraduate training is frequently not directly relevant to the knowledge and skills commonly required for management of musculoskeletal conditions in a general outpatient setting. Woolf found that elective programmes available to medical students and interns usually emphasise surgically managed musculoskeletal problems, which resulted in a bias towards more severe or specialised cases that are not relevant to the future practice of most doctors.[70] In elective 4–6-week orthopaedic training programmes in United States medical schools, 88 percent of the time involved hospital-based teaching of musculoskeletal problems requiring surgery, leaving very little time for outpatient teaching.[71] Rural rotations, such as the

PRCC at Flinders University, have been shown to address this bias toward tertiary medicine.[72] In our study, the lack of significant improvement in the musculoskeletal assessment after a two month internship program may be due to the nature of the exposure experienced by the interns, which is frequently limited to managing a ward of tertiary patients, with little exposure to common orthopaedic pathology.

In a follow-up study by Freedman and Bernstein, they asked 240 programme directors of residency programmes in internal medicine to rate the importance of various topics in orthopaedic medicine.[73] They suggested the current curriculum in the United States probably over-emphasised surgical practice, as the training in musculoskeletal injuries and diseases is commonly taught by hospital-affiliated physicians and surgeons, with the result that this teaching case load is typically skewed towards serious surgical problems. They recommended that the ideal course in musculoskeletal medicine should focus on common outpatient problems, orthopaedic emergencies, and the musculoskeletal physical examination.

We found that amongst South African medical schools, approximately 60 percent of group teaching of musculoskeletal medicine consisted of whole-class lectures. However, students who are actively involved in the learning process are more efficient learners.[74] Increasing the proportion of small group teaching will facilitate engagement of the students in critical thinking and problem-solving and allow interaction with the instructor and with their peers, both giving and receiving immediate feedback. Costa et. al. from Warwick

University compared the use of didactic lectures with that of interactive discussion sessions in undergraduate teaching of orthopaedics and trauma.[75] In their randomised study, the students in the interactive discussion group rated the presentation of their teaching more highly and performed better on their end-of-placement written test.

This is most critical when it comes to teaching of the clinical examination. Thompson found that large-group teaching of physical examination skills does not allow students the opportunity to attempt the skills discussed or for them to receive feedback from the teachers.[7677]

Interestingly these findings are far from new. Abraham Flexner, regarded as the first medical educationalist, advised over a century ago that medical training should be 'marked by small classes, personal attention and hands-on teaching'. He believed lectures allowed medical schools to 'handle cheaply by wholesale a large body of students that would otherwise be unmanageable and thus give the lecturer time for research'.[78]

Flexner's latter comment brings up another important point. Specialists working in the state have numerous commitments outside of their clinical work, including research, fellowship programmes, post-graduate education and often private practice commitments. These trends may well mean registrars are becoming increasingly more responsible for undergraduate training. They in turn are often new to student supervision and lack the appropriate training. Archer from Stellenbosch University found a short

course in undergraduate clinical supervision improved interaction with students and provided supervisors with previously unused teaching strategies.[79] The participants 'emphasised that the faculty has an obligation to provide opportunities for clinical supervisors to improve their skills to supervise students and to better understand adult learning'.

Seggie's recommendation of education units run by education specialists would allow for these opportunities.[80] The regular turnover of registrars would require a formally established unit to provide continued training. If units were established in each department, they would have the time available to facilitate research and also assist in post-graduate education.

The Centre for Higher Education Development at UCT has modules in teaching, learning and assessment for postgraduate teachers. These programmes may well assist registrars and other teachers of undergraduate students in gaining appropriate skills, but are currently under-utilized.

The Bone and Joint Decade Undergraduate Curriculum Development Group published their core recommendations for a musculoskeletal undergraduate curriculum in 2004.[81] The recommendations set global standards for the minimum level of competence in managing patients with musculoskeletal problems, regardless of further specialisation. They are intended to form the basis of a curriculum for a musculoskeletal course and were designed to be adapted for any medical school in any country. They recommended that the major emphasis of an undergraduate musculoskeletal course should be on

clinical skills. This should be supported by knowledge of the relevant basic science. The course should also reflect the importance of the various musculoskeletal conditions prevalent in that specific country.

The initial focus of their recommendations was on the basic skills necessary to assess and diagnose a person with a musculoskeletal problem, which is the ability to take an appropriate history and perform a musculoskeletal examination. They recommended that a single method of assessing the musculoskeletal system should be taught irrespective of which specialty is teaching it. As it is a basic skill, they recommend that the examination should be taught early in the curriculum along with the methods to assess other organ systems.

Their second recommendation was the competency to assess urgent problems of the musculoskeletal system. Emergencies may not be common, but it is essential to recognise them and to manage or refer as appropriate. In our study, whilst the 'red flag' group of questions were better answered than the average (average score of 55.3 percent compared to the overall average score of 45.3 percent) this was not reassuring, as only half the candidates knew to look for a vascular injury in a patient with a dislocated knee, and only 13 percent knew the basic management of an open fracture. In addition, only 6 percent of the study group considered both tumour and infection in someone with lower back pain that woke them from sleep. Fundamental ingredients of an effective curriculum must include teaching both common and urgent/life threatening conditions. Our results show that South African

graduates have a poor understanding of these important orthopaedic emergencies and may benefit from increased exposure through involvement in on-call duties.

Bilderback et al. from Louisiana State University designed a self-contained six-week course in musculoskeletal medicine and then used Freedman and Bernstein's examination to measure the level of competence achieved by a class of first-year medical students who took their course.[82] The average student score on the basic competency examination was 77.8 percent, compared with 59.6 percent for a historical comparison group.

A closer look at the main principles of their new curriculum illustrates possible solutions to deficiencies in current musculoskeletal education. Most significantly they believed that medical education would be improved if clinical instruction began during the pre-clinical years.

The main features of their course were: (1) an emphasis on both cognitive and process-based knowledge; (2) more contact hours and broader content than in previous musculoskeletal courses; (3) the use of small groups to focus on problem-solving and the physical examination; (4) basic-science teaching which was directly related to clinical practice.

Faculty from the departments of orthopaedic surgery, anatomy and rheumatology designed the course. The aim was to provide an adequate foundation of primary-care knowledge of the musculoskeletal system. The

clinical lectures were directly preceded by relevant anatomy lectures and dissections to provide a context for the clinical information.

They acknowledged that the effectiveness of the course depended partly on self-learning outside the classroom. This was facilitated by placing current lecture material on a course website, which the students were encouraged to study before class. An orthopaedic surgeon with fellowship training in the topic gave the lectures. Attendance at lectures was not mandatory, but students who missed no more than two lectures were given a bonus in the final examination.

The lectures on basic science were designed to rationalise clinical practices. The lectures on muscle, bone, and soft tissue were given by basic scientists and covered the material at the scientific depth presented in the prescribed orthopaedic textbook. The course directors identified the material that they judged essential and then recruited basic-science experts in those areas to teach it. This contrasts with the old style where the basic scientist decides the content of the pre-clinical curriculum.

Small-group activities allowed the students to engage in critical thinking and problem solving. These groups of no more than five students allowed greater interaction with instructors and peers, and allowed for immediate feedback.

A general musculoskeletal physical examination was taught in two two-hour-long small-group sessions by orthopaedic residents. Interestingly, they felt the differing techniques and principles of examination between orthopaedic

surgeons and rheumatologists were both important, and both were thus included in the course, despite the time constraints.

The sessions ran parallel with the students' anatomic studies of the related body areas so that the rationale for the steps in the physical examination could be related to the musculoskeletal anatomy. The content of the anatomy sessions were similar to that of the old curriculum, but was taught over a period of six weeks, compared to two years previously. They found (albeit subjectively) that students were better able to grasp clinical material when the relevant anatomy was taught concurrently.

Weekly quizzes were given in the anatomy laboratories. The students were required to demonstrate an appropriate level of knowledge before being permitted to proceed to the next session. Mid-course and final anatomy examinations were given, consisting of timed stations where the students identified structures in tagged cadavers.

Significantly, Bilderback et. al. found the anatomy score was a surrogate for general academic performance, and may assist course directors in identifying weaker students during the course on the basis of their performance in the anatomy laboratory, allowing for earlier intervention.

At the end of the block, each student demonstrated the ability to adequately perform a general musculoskeletal physical examination in twenty minutes, and the encounter was videotaped to allow an assessment of whether each

step in the examination had been performed properly. In addition, checklists were prepared to aid in probing the students' knowledge of individual steps in the physical examination. In a short period, they showed a demonstrable improvement in clinical competency in their student group (20% improvement in the Freedman and Bernstein competency examination) through increased contact time, more relevant basic science teaching, early teaching of and greater emphasis on the musculoskeletal physical examination, and small group teaching.

Conclusion

Undergraduate training in musculoskeletal medicine is inadequate in South Africa, and studies suggest that worldwide the standard is dropping. The delivery of musculoskeletal care is not the exclusive domain of the orthopaedic surgeon or rheumatologist, and is in fact provided largely by other practitioners. Competency in musculoskeletal medicine must therefore be a requirement before graduating, regardless of further specialisation.

A restructuring of the undergraduate curriculum is required to achieve these goals.

A review of the literature supports several recommendations:

1) Emphasis should be placed on the musculoskeletal examination, which should be taught during the pre-clinical years.

The literature conclusively shows that doctors are more competent in the examination of other organ systems. The examination of these organ systems are taught, on average, two years before the musculoskeletal examination, allowing for more time to obtain and consolidate these skills.

2) More curricular time should be allocated to teaching musculoskeletal medicine.

The amount of time devoted to musculoskeletal medicine in the typical undergraduate curriculum is disproportionately low compared with the frequency of musculoskeletal complaints that occur in a general practice. More contact time has been shown to improve competency levels in musculoskeletal medicine. A minimum of six weeks dedicated to musculoskeletal training is needed. Consideration should be given to making passing of the orthopaedic rotation a requirement before graduating.

3) A larger proportion of curricular time should be spent on teaching the musculoskeletal examination. The major emphasis of an undergraduate musculoskeletal course should be on the clinical skills necessary to assess and diagnose a person with a musculoskeletal problem. The teaching of basic sciences should support this emphasis.

4) The examination should be taught during small group sessions.

This measure allows students to attempt the skills discussed and to receive individual and immediate feedback from the instructors.

5) Self-teaching should be encouraged and facilitated using department resources, online teaching programmes and possibly a portfolio.

6) Basic science should be taught at the same time as clinical medicine, and be directly relevant to clinical practice.

7) Other strategies to increase contact hours should be investigated.

These strategies include on call duties shadowing the orthopaedic registrar, including students in established primary care outreach programmes, facilitating after-hours self-teaching, and encouraging participation in structured orthopaedic elective blocks.

8) Course material should reflect the incidence of musculoskeletal pathology.

Course material should not be skewed towards tertiary surgical problems, but should focus on common outpatient problems and orthopaedic emergencies. Centres managing primary and secondary level orthopaedic problems should be utilized and students should participate in the established primary care outreach programmes.

These steps are necessary to create a relevant and effective curriculum which will train competent doctors. Undergraduate students themselves recognise the current deficits in training.[83] Harvard medical students rated musculoskeletal education to be of major importance but rated the amount of curriculum time spent on musculoskeletal medicine as poor. With increased exposure to the subject by taking clinical electives, they demonstrated greater clinical confidence and improved performance. The students' feedback suggested that musculoskeletal education could be better integrated into the

pre-clinical curriculum, more time should be spent in the field, and more focus should be placed on common clinical conditions.

Table I: Freedman and Bernstein questionnaire

Question	Answer	Interns' score
1. What common problem must all newborns be examined for?	Congenital dislocation of the hip (CDH, dislocation, subluxation also accepted): 1 point	80.7%
2. What is a compartment syndrome?	Increased pressure in a closed fascial space: 1 point	71.8%
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	21.8%
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	51.3%
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 debridement; risk of infection: 1/2 point each	32.7%
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?	Tumour and infection: 1/2 point each	28.2%
7. How is compartment syndrome treated?	Fasciotomy (surgery also accepted): 1 point	92.3%
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	50.0%
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?	Hip dislocation: 1 point	59.0%
10. What nerve is compressed in carpal tunnel syndrome?	Median nerve: 1 point	87.2%
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?	Dorsiflexion of the great toe (toe extensors also accepted): 1 point	9.0%
12. How is motor function of the median nerve tested in the hand?	Any median function (metacarpophalangeal finger flexion; thumb opposition, flexion, or	44.2%

	abduction): 1 point	
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	41.7%
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); paediatric population: 1/4 point each, full credit for 4 correct responses	57.1%
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	35.9%
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	37.2%
17. What are the five most common sources of cancer metastases to bone?	Breast, prostate, lung, kidney, thyroid: 1/4 point each, full credit for 4 correct responses	63.3%
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	46.8%
19. Which malignancy may be present in bone yet typically is not detected with a bone scan?	Myeloma (full credit for haematological malignancies - leukemia, lymphoma): 1 point	38.5%
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	24.4%
21. What is the difference between osteoporosis and osteomalacia?	Osteoporosis: decreased bone density; osteomalacia; decreased bone mineralisation (any true statement about epidemiology, pathophysiology, e.g. estrogen vs vitamin D, also accepted): 1 point	27.8%
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	67.9%
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	17.9%
24. Rupture of the biceps at the elbow results in weakness of both elbow flexion and _____?	Supination: 1 point	28.2%
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	14.1%

Table II: individual scores for registrars (scored out of 25)

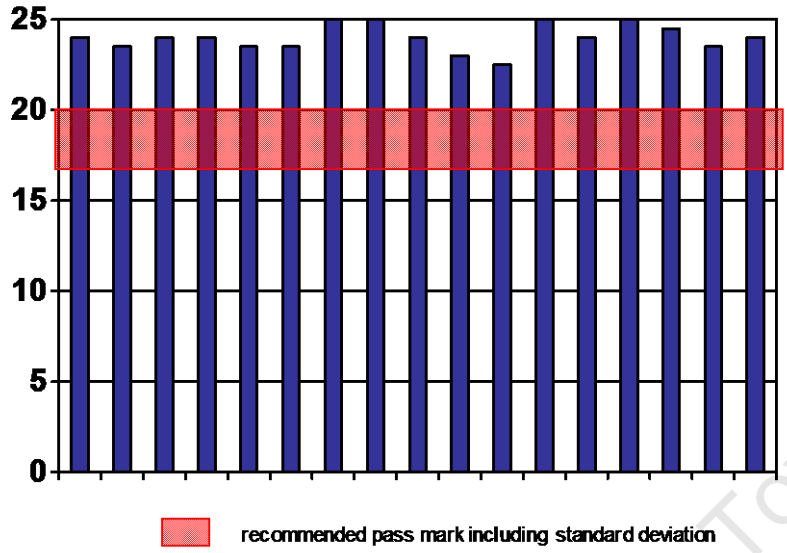

Table III: individual scores for interns (scored out of 25)

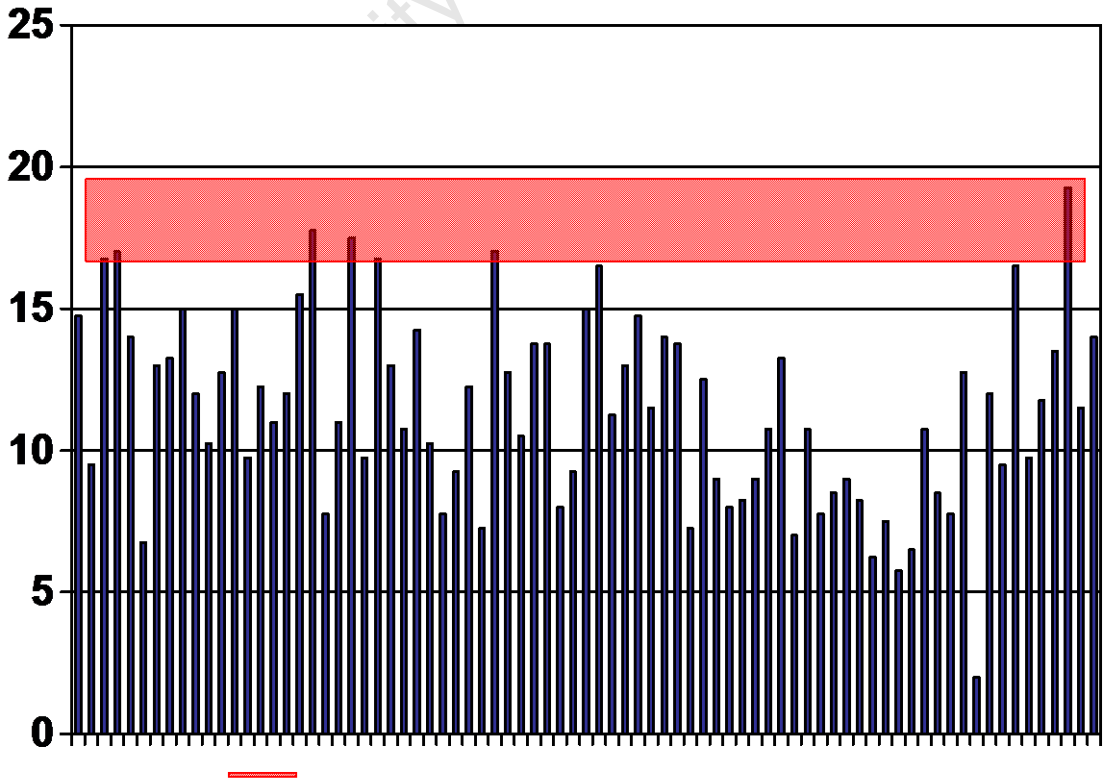

Table IV: Average mark per question

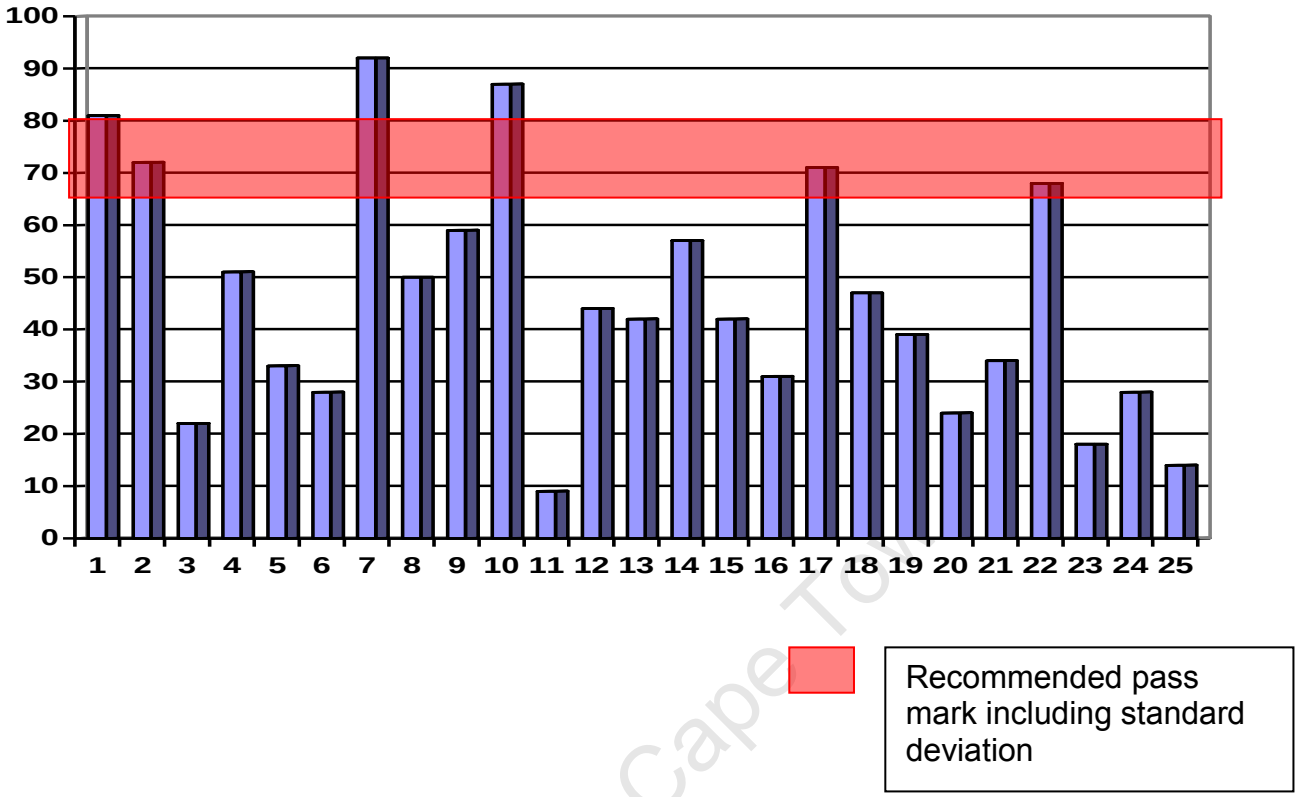

Table V weighted score out of 10 for individual questions

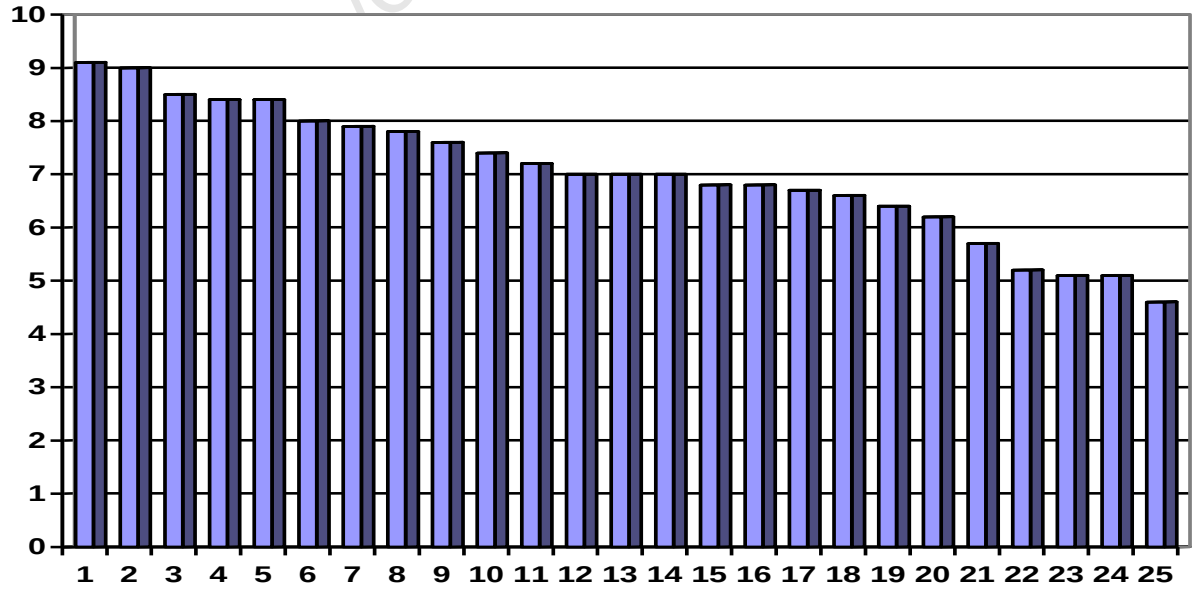

table VI: weighted scores for interns (scored out of 25)

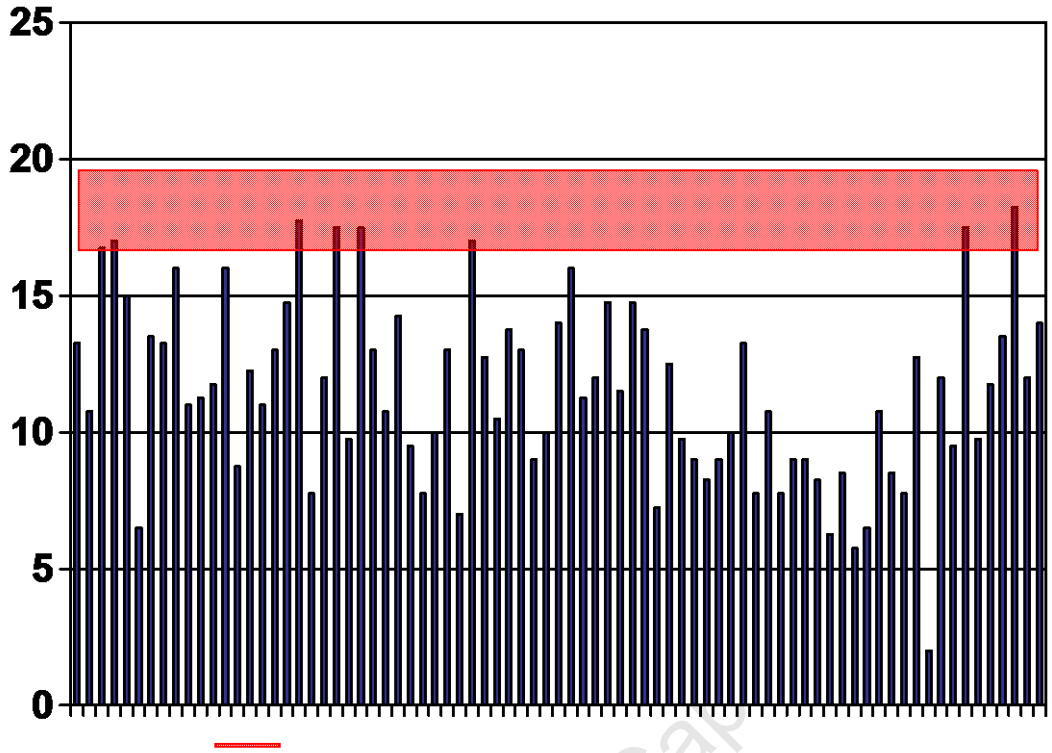

Table VII: scores for anatomy-based questions (Q8, 10, 11, 12, 15, 20, 22, 23, 24, 25)

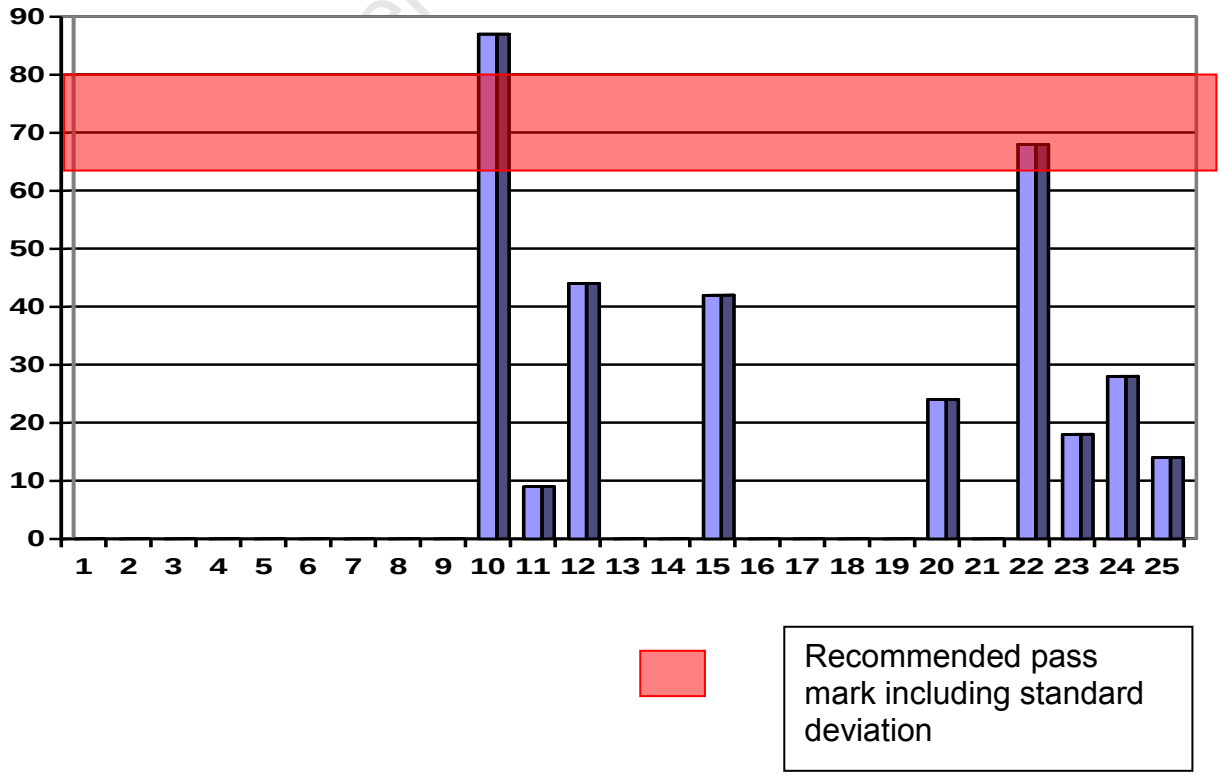

Table VIII: scores for ‘red-flag’ questions (Q2, 4, 5, 6, 7)

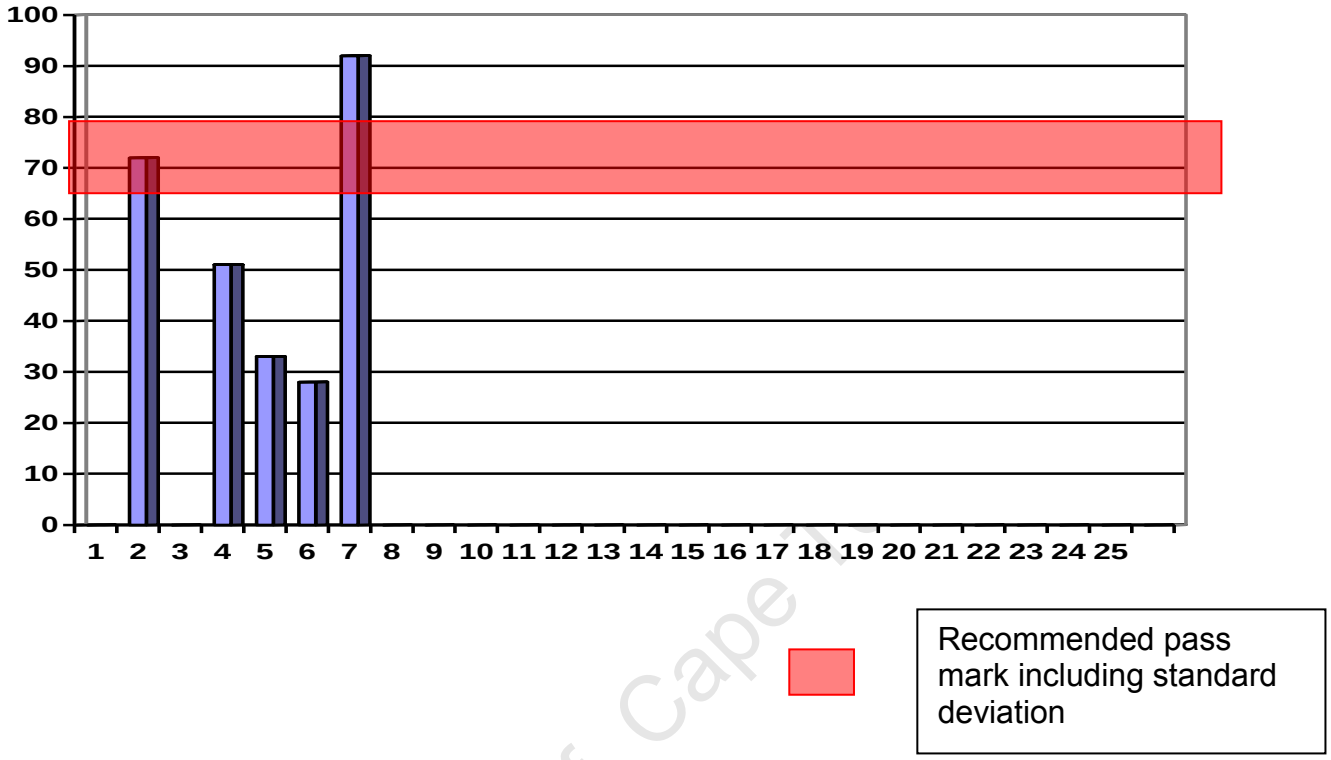

Table IX

Course Code	Description	HEQF Level	HEQF Credits
Year 1			
PPH1001F	Becoming a Professional	5	15
HUB1006F	Introduction to Integrated Health Sciences: Part I	5	30
CEM1011F	Chemistry for Medical Students	5	18
PHY1025F	Physics	5	18
SLL1044H	Beginners Afrikaans for Medical Students	5	1.2
PPH1002S	Becoming a Health Professional	5	15
HUB1007S	Introduction to Integrated Health Sciences: Part II	5	35
			132.2
Year 2			
SLL2002H	Becoming a Doctor Part IB	6	24
HUB2017H	Integrated Health Systems Part IA	6	57
LAB2000S	Integrated Health Systems Part IB	6	35
PPH2000W	Becoming a Doctor Part IA	6	43
N/A	SSM	6	16
			175
Year 3			
PPH3000H	Becoming a Doctor Part IIA	7	25
MDN3001H	Introduction to Clinical Practice	7	68
SLL3002H	Becoming a Doctor Part IIB	7	24
LAB3009H	Integrated Health Systems Part II	7	59
			176
Year 4			
SLL3003W	Clinical Language	7	0
PRY4000W	Psychiatry	8	21
AAE4002W	Anaesthesia	8	0
OBS4003W	Obstetrics	8	25
MDN4011W	Medicine (including Dermatology)	8	53
PPH4013W	Public Health	8	17
MDN4015W	Pharmacology & Applied Therapeutics	8	13
PED4016W	Neonatology	8	0
PPH4043W	Health Promotion	8	17
			146
Year 5			
AAE5000H	Anaesthesia	8	19
PPH5000H	Primary Health Care Elective	8	19
PED5001W	Paediatrics (including Paediatric Surgery)	8	44
MDN5002W	Medical & Surgical specialities	8	35
CHM5003W	Surgery (including General Surgery, Plastic Surgery and Urology)	8	35
MDN5003H	Pharmacology & Applied Therapeutics	8	7
CHM5004H	Trauma	8	7
CHM5005H	Orthopaedic Surgery	8	7

OBS5005W	Gynaecology	8	14
LAB5008H	Forensic Medicine	8	10
			197
Year 6			
CHM6000W	Surgery	8	41
MDN6000W	Medicine (including Dermatology)	8	41
OBS6000W	Obstetrics and Gynaecology	8	41
PED6000W	Paediatrics (including Paediatric Surgery)	8	41
PPH6000W	Family Medicine	8	21
PRY6000W	Psychiatry	8	21
MDN6004W	Exit examination on procedural competence	8	0
			206
Total Excl IP			1032.2
IP			
HUB1010S	Fundamentals of Integrated Health Sciences Part 1	5	0
CEM1111S	Chemistry for Medical Students	5	0
CEM1011X	Chemistry for Medical Students	5	105
HUB1011F	Fundamentals of Integrated Health Sciences Part 2	5	18
PHY1025F	Physics	5	18
			141
Total Incl IP			1173.2

References

[1] Kahl, L.E. 1987. 'Musculoskeletal problems in the family practice setting: guidelines for curriculum design' in Journal of Rheumatology 1987, 14:811-14.

[2] Spitzer, W.O., Harth, M., Goldsmith, C.H., et al. 1976. 'The arthritis complaint in primary care: prevalence, related disability and costs' in Journal of Rheumatology 1976, 3:88-99.

[3] De Lorenzo, R.A., Mayer, D. & Geehr, E.C. 1990. 'Analyzing clinical case distributions to improve an emergency medicine clerkship' in Annals of Emergency Medicine 1990, 19:746-51.

[4] Jones, G.A. 1983. 'Musculoskeletal problems at an accident and emergency department and in general practice' in New Zealand Medical Journal July 1983, 96(735):529-31.

[5] Mulhall, K.J. & Masterson, E. 2005. 'Relating undergraduate musculoskeletal medicine curricula to the needs of modern practice' in Irish Journal of Medical Science April-June 2005, 174(2):46-51.

[6] Rasker, J.J. 1995. 'Rheumatology in general practice' in British Journal of Rheumatology 1995, 34:494-7.

[7] National Board of Health and Welfare. 2001. Year Book of Health and Medical Care. Stockholm: Socialstyrelsen.

[8] Reginster, J.Y. 2002. 'The prevalence and burden of arthritis' in Rheumatology (Oxford) 2002, 41:Suppl.1:3-6.

[9] World Health Organization. 2002. World Health Report 2002: Statistical annex 3: Burden of disease in DALYs by cause, sex and mortality stratum in WHO regions, estimates for 2001.

[10] Krug, E. 1999. Injury: a leading cause of the global burden of disease. Geneva: World Health Organization. Document WHO/HSC/PVI/99.11.

[11] Kobusingye, O., Guwatudde, D. & Lett, R. 2001. 'Injury patterns in rural and urban Uganda' in Inj Prev. 2001, 7:46-50.

[12] Beveridge, M. & Howard, A. 2004. 'The burden of orthopaedic disease in developing countries' in Journal of Bone and Joint Surgery 2004, A6:1819-22.

[13] SA MRC, initial burden of disease estimates for South Africa, 2000

[14] Woolf, A.D. & Akesson, K. 2001. 'Understanding the burden of musculoskeletal conditions. The burden is huge and not reflected in national health priorities' in BMJ 2001, 322:1079–80.

[15] Murray, C.J.L. & Lopez, A.D. 1996. The global burden of disease. A comprehensive assessment of mortality and disability from diseases, injuries, and risk factors in 1990 and projected to 2020. Cambridge MA: The Harvard School of Public Health, on behalf of The World Health Organization and The World Bank.

[16] Barss, P., Smith, G., Baker, S. & Mohan D. 1998. Injury prevention: an international perspective. Epidemiology, surveillance, and policy. New York: Oxford University Press.

[17] Karpman, R.R. 2001. 'Musculoskeletal disease in the United States: who provides the care?' in Clin Orthop Relat Res. April 2001, 385:52-6.

[18] Health Professions Council of South Africa, http://www.statssa.gov.za.

[19] Beveridge, M. & Howard, A. 2004. 'The burden of orthopaedic disease in developing countries' in Journal of Bone and Joint Surgery 2004, A6:1819-22.

[20] Krug, E. 1999. Injury: a leading cause of the global burden of disease. Geneva: World Health Organization. Document WHO/HSC/PVI/99.11.

[21] Murray, C.J.L. & Lopez, A.D. 1996. The global burden of disease. A comprehensive assessment of mortality and disability from diseases, injuries, and risk factors in 1990 and projected to 2020. Cambridge MA: The Harvard School of Public Health, on behalf of The World Health Organization and The World Bank

[22] Daar, A.S., Rizvi, S.A. & Naqvi, S.A. 2000. 'Surgery with limited resources' in Morris, P.J. & Wood, W.C. 2000. Oxford textbook of surgery (2nd ed.) New York: Oxford University Press, p. 3386.

[23] Nunn, T.R., Cheung, W.Y., Rollinson, P.D. 2007. 'A prospective study of pyogenic sepsis of the hip in childhood' in J Bone Joint Surg Br. 2007, 89-B (1): 100-106.

[24] Pinney, S.J. & Regan, WD. 2001. 'Educating medical students about musculoskeletal problems. Are community needs reflected in the curricula of Canadian medical schools?' in J Bone Joint Surg Am. 2001, 83:1317-20.

[24] Williams, J.R. 2000. 'The teaching of trauma and orthopaedic surgery to the undergraduate in the United Kingdom' in Journal of Bone and Joint Surgery [Br] 2000, 82:627-8.

[25] Craton, N. & Matheson, G.O. 1993. 'Training and clinical competency in musculoskeletal medicine. Identifying the problem' in Sports Medicine 1993, 15:328-37.

[26] Williams, J.R. 2000. 'The teaching of trauma and orthopaedic surgery to the undergraduate in the United Kingdom' in Journal of Bone and Joint Surgery [Br] 2000, 82:627-8.

[27] Kay, L.J., Deighton, C.M., Walker, D.J. & Hay, E.M. 2000. 'Undergraduate rheumatology teaching in the UK: a survey of current practice and changes since 1990' in Rheumatology 2000, 39:800-3.

[27] Booth. A. & Wise, D.I. 1990. 'General practice training in musculoskeletal disorders' in British Journal of General Practice 1990, 40:390.

[28] Freedman, K.B. & Bernstein, J. 1998. 'The adequacy of medical school education in musculoskeletal medicine' in J Bone Joint Surg Am. 1998, 80:1421-7.

[29] Rasker, J.J. 1995. 'Rheumatology in general practice' in British Journal of Rheumatology 1995, 34:494-7.

[30] Craton, N. & Matheson, G.O. 1993. 'Training and clinical competency in musculoskeletal medicine. Identifying the problem' in Sports Medicine 1993, 15:328-37.

[31] Booth, A. & Wise, D. 1990. "General Practice Training in Musculoskeletal Medicine' in Br J Gen Pract. 1990 December; 40(341): 522.

[32] Sneiderman, C. 1977. 'Orthopedic practice and training of family physicians: a survey of 302 North Carolina practitioners' in J Fam Pract 1977, 4:267-50.

[33] Al-Nammari, S.S., James, B.K. & Ramachandran, M. 2009. 'The inadequacy of musculoskeletal knowledge after foundation training in the United Kingdom' in Bone Joint Surg [Br] 2009, 91-B:1413-18.

[34] The Foundation Programme Curriculum [online]. Available: http://www.foundationprogramme.nhs.uk/pages/home/key-documents.

[35] Glazier, R.H., Dalby, D.M., Badley, E.M., Hawker, G.A., Bell, M.J., Buchbinder, R., et al. 1998. 'Management of common musculoskeletal problems: a survey of Ontario primary care physicians' in Canadian Medical Association Journal 1998, 158:1037-40.

[36] Duckett, S. 2003. 'Orthopaedic GP Fellowship: does it work?' in Ann R Coll Surg Engl. May 2003, 85(3):195-6.

[37] Ahern, M.J., Soden, M., Schultz, D & Clark, M. 1991. 'The musculo-skeletal examination: a neglected clinical skill' in Australian and New Zealand Journal of Medicine 1991, 21:303-6.

[38] Crotty, M., Ahern, M.J., McFarlane, A.C. & Brooks, P.M. 1993. 'Clinical rheumatology training of Australian medical students. A national survey of 1991 graduates' in Medical Journal of Australia 1993,158:119-20.

[39] Matheny, J.M., Brinker, M.R., Elliott, M.N., Blake, R. & Rowane, M.P. 2000. 'Confidence of graduating family practice residents in their management of musculoskeletal conditions' in American Journal of Orthopedics 2000, 29:945-52.

[39] Saywell, R.M. Jr, O'Hara, B.S., Zollinger, T.W.,Wooldridge, J.S., Burba, J.L. & McKeag, D.B. 2002. 'Medical students' experience with musculoskeletal diagnoses in a family medicine clerkship' in Medical Teacher 2002, 24:186-92.

[41] Glazier, R.H., Dalby, D.M., Badley, E.M., Hawker, G.A., Bell, M.J., Buchbinder, R., et al. 1998. 'Management of common musculoskeletal problems: a survey of Ontario primary care physicians' in Canadian Medical Association Journal 1998, 158:1037-40.

[42] Lynch, J.R., Schmale, G.A., Schaad, D.C. & Leopold, S.S. 2006. 'Important demographic variables impact the musculoskeletal knowledge and confidence

of academic primary care physicians' in J Bone Joint Surg Am. July 2006, 88(7):1589-95.

[43] Jandial, S., Rapley, T. & Foster, H. 2009. 'Current teaching of paediatric musculoskeletal medicine within UK medical schools – a need for change' in Rheumatology 2009, 48:587-90.

[44] Myers, A., McDonagh, J.E., Gupta, K., Hull, R., Barker, D., Kay, L.J. & Foster, H.E. 2004. 'More "cries from the joints": assessment of the musculoskeletal system is poorly documented in routine paediatric clerking' in Rheumatology (Oxford) August 2004, 43(8):1045-9.

[45] Freedman, K.B. & Bernstein, J. 1998. 'The adequacy of medical school education in musculoskeletal medicine' in J Bone Joint Surg Am. 1998, 80:1421-7.

[46] Al-Nammari, S.S., James, B.K. & Ramachandran, M. 2009. 'The inadequacy of musculoskeletal knowledge after foundation training in the United Kingdom' in Bone Joint Surg [Br] 2009, 91-B:1413-18.

[47] Cohen-Schotanus, J. 2010. 'A standard setting method with the best performing students as point of reference:practical and affordable' in Med Teach 2010, 32(2):154-160.

[48] RSA, 1997. 'White paper on transformation of the health system' in Government Gazette 1997, 382.

[49] Blitz, J.J. 2010. 'Is temperament a key to the success of teaching innovation?' in African Journal of Health Professions Education August 2010, 2(1).

[50] Council on Higher Education. 2004. Improving Teaching and Learning Resources. Pretoria: Council on Higher Education.

[51] Seggie, J.L. 2010. 'MBChB curriculum modernisation in South Africa – growing doctors for Africa' in African Journal of Health Professions Education August 2010, 2(1).

[53] Bonwell, C.C. & Eison, J.A. 1991. Active learning: creating excitement in the classroom. Report no. 1. Washington DC: ERIC Clearinghouse on Higher Education.

[54] Bilderback, K. 2008. Design and implementation of a system-based course in musculoskeletal medicine for medical students' in J Bone Joint Surg Am. 2008, 90:2292-2300.

[55] Peterson, C.A, & Tucker, R.P. 2005. 'Medical gross anatomy as a predictor of performance on the USMLE Step 1' in Anat Rec B New Anat. 2005, 283:5-8.

[56] Bilderback, K. 2008. Design and implementation of a system-based course in musculoskeletal medicine for medical students' in J Bone Joint Surg Am. 2008, 90:2292-2300

[57] Seggie, J.L. 2010. 'MBChB curriculum modernisation in South Africa – growing doctors for Africa' in African Journal of Health Professions Education August 2010, 2(1).

[58] Freedman, K.B. & Bernstein, J. 1998. 'The adequacy of medical school education in musculoskeletal medicine' in J Bone Joint Surg Am. 1998, 80:1421-7.

[59] Al-Nammari, S.S., James, B.K. & Ramachandran, M. 2009. 'The inadequacy of musculoskeletal knowledge after foundation training in the United Kingdom' in Bone Joint Surg [Br] 2009, 91-B:1413-18.

[60] Haywood, B.L., Porter, S.L. & Grana, W.A. 2006. 'Assessment of musculoskeletal knowledge in primary care residents' in Am J Orthop (Belle Mead NJ) June 2006, 35(6):273-5.

[61] Queally, J.M., Kiely, P.D., Shelly, M.J., et al. 2008. 'Deficiencies in the education of musculoskeletal medicine in Ireland' in Ir J Med Sci June 2008, 177(2):99-105.

[62] Williams, S.C. 2010. 'A new musculoskeletal curriculum: Has it made a difference?' in Journal of Bone and Joint Surgery [Br] 2010, 92-B:7-11.

[63] Kolasinski, S.L., Bass, A.R., Kane-Wanger, G.F., et al. 2007. 'Subspecialty choice: Why did you become a rheumatologist?' in Arthritis Rheum 2007, 57:1546-51.

[64] Couper, I.D. 2006. Evaluation of the Parallel Rural Community Curriculum at Flinders University of South Australia, in the context of the GEMP Year 3. Johannesburg: University of the Witwatersrand.

[65] Couper I.D. 2010. 'Evaluation of the Parallel Rural Community Curriculum at Flinders University, South Australia: Lessons learnt for Africa' in African Journal of Health Professions Education December 2010, 2(2).

[66] Day, C.S. 2007. 'Musculoskeletal medicine: an assessment of the attitudes and knowledge of medical students at Harvard Medical School' in Acad Med May 2007, 82(5):452-7.

[67] Fink, L.D. 2003. Creating significant learning experiences: an integrated approach to designing college courses. San Francisco: Wiley/Jossey-Bass.

[68] Thome, G., Hovenberg, H. & Edgren, G. 2006. 'Portfolio as a method for continuous assessment in an undergraduate health education programme' in Medical Teacher 2006, 28(6):e171-9.

[69] Ezeala, C.C. 2010. 'Using portfolios to assess professional competence and development in medical laboratory sciences' in African Journal of Health Professions Education August 2010, 2(1).

[70] Craton, N. & Matheson, G.O. 1993. 'Training and clinical competency in musculoskeletal medicine. Identifying the problem' in Sports Medicine 1993, 15:328-37.

[71] Di Paola, M., Bennet, G.C. & Shearer, J.R. 1986. 'Orthopaedic teaching in United Kingdom medical schools' in Medical Teacher 1986, 8:155-8.

[72] Couper, I.D. 2006. Evaluation of the Parallel Rural Community Curriculum at Flinders University of South Australia, in the context of the GEMP Year 3. Johannesburg: University of the Witwatersrand.

[73] Freedman, K.B. & Bernstein, J. 2002. 'Educational deficiencies in musculoskeletal medicine' in J Bone Joint Surg Am. 2002, 84:604-608.

[74] Cross, K.P. 1987. 'Teaching for learning' in AAHE Bull 1987, 39:2-6.

[75] Costa, M.L. 'Does teaching style matter? A randomised trial of group discussion versus lectures in orthopaedic undergraduate teaching' in Medical Education 41(2):214-7.

[76] Thompson, A.E. 2008. 'Improving undergraduate musculoskeletal education: a continuing challenge' in J Rheumatol 2008, 35:2298-9.

[77] Peyton, R., Fry, H., Hadfield-Law, L., Harris, D. & Walker, M. 2003. Training the Trainers: Learning and teaching. London: Royal College of Surgeons of England.

[78] Wear, D. 2002. 'Iconoclast: Abraham Flexner and a Life in Learning' in New England Journal of Medicine 2002, 347:2008-9.

[79] Archer, E. 2011. 'Improving undergraduate clinical supervision in a South African context' in African Journal of Health Professions Education December 2011, 3(2).

[80] Seggie, J.L. 2010. 'MBChB curriculum modernisation in South Africa – growing doctors for Africa' in African Journal of Health Professions Education August 2010, 2(1).

[81] Woolf, A.D., Walsh, N.E. & Akesson, K. 2004. 'Global core recommendations for a musculoskeletal undergraduate curriculum' in Ann Rheum Dis 2004, 63:517-524.

[82] Bilderback, K. 2008. Design and implementation of a system-based course in musculoskeletal medicine for medical students' in J Bone Joint Surg Am. 2008, 90:2292-2300.

[83] Day, C.S. 2007. 'Musculoskeletal medicine: an assessment of the attitudes and knowledge of medical students at Harvard Medical School' in Acad Med May 2007, 82(5):452