RESEARCH ARTICLE

Adequacy of Gross Anatomy Knowledge among the Orthopedic Residents: An Interdisciplinary Educational Research

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Abstract

Objectives: We evaluated the adequacy of gross anatomical knowledge of the upper and lower limbs among 20 orthopedic residents and two groups of undergraduate medical students in the Department of Orthopedics.

Methods: Twenty orthopedic residents completed a review course on the gross anatomy of the upper and lower limbs, delivered by the Department of Anatomy. Two quizzes were administered to the orthopedic residents and to two groups of undergraduate medical students. The first quiz, consisting of 42 questions, assessed the knowledge of upper limb gross anatomy among the residents and 22 undergraduate students (Group I). The second quiz, administered one month later, consisted of 25 questions and assessed the knowledge of lower limb gross anatomy among the residents and 42 undergraduate students (Group II).

Results: The mean scores on the 42 upper limb questions were 27 ± 7 (60%, range 13–38) for the orthopedic residents, 17 ± 4 (37%, range 9–33) for the interns, and 18 ± 7 (40%, range 12–24) for the undergraduate students. The mean scores on the 25 lower limb questions were 20 ± 4 (80%, range 10–24) for the residents, 11 ± 5 (44%, range 3–18) for the interns, and 12 ± 4 (48%, range 3–19) for the students.

Conclusion: The present study demonstrated that the gross anatomical knowledge of our orthopedic residents was suboptimal. This deficiency may stem from insufficient exposure to anatomy during undergraduate medical education. Therefore, orthopedic residents should regularly review and update their anatomical knowledge through collaboration and interdisciplinary courses conducted in conjunction with the Department of Anatomy.

Level of evidence: III

Keywords: Anatomy knowledge, Educational research, Medical student education, Orthopedic residency program, Research in education

Introduction

Inadequate anatomical knowledge is a major concern in residency programs worldwide.[1-10] In our country, the orthopedic residency program consists of four years. The majority of patients with upper and lower limb conditions and traumatic injuries are initially evaluated by orthopedic surgeons. Consequently, a sound knowledge of gross anatomy constitutes an indisputable foundation of orthopedic practice. A persistent challenge for residents is maintaining and updating their knowledge of human anatomy—including gross, clinical, surgical, topographic, and cross-sectional anatomy. This knowledge must be specifically tailored to the needs of orthopedic surgeons to ensure accurate clinical examination, safe surgical dissection, and appropriate surgical approaches.[3,4,10]

The purpose of the present study was to evaluate the adequacy of gross anatomical knowledge of the upper and lower limbs among orthopedic residents during their residency training and among undergraduate medical students in orthopedics.

Materials and Methods

This interdisciplinary educational study was approved by the Medical Research and Ethics Committee of the University and Hospital. To enhance knowledge of upper and lower limb anatomy, 20 residents from the Department

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of Orthopedics completed a review course in gross anatomy, which consisted of didactic lectures and the inspection of prosected cadavers, delivered by the Department of Anatomy. These residents had graduated from different universities. The distribution of postgraduate year (PGY) levels among the residents was as follows: eight PGY-1, six PGY-2, and six PGY-3.

Two groups of undergraduate medical students participated in the study: Group I, comprising 15 medical students and seven interns, and Group II, comprising 27 medical students and 15 interns. All participants had previously completed anatomy courses during the first or second year of their medical education. They had been taught through didactic lectures and inspection of prosected cadavers, delivered by the Department of Anatomy. Each medical student and intern also spent one month in the orthopedic ward. Before assessment, the students and interns were instructed to review gross anatomy topics based on the general medical curriculum and recommended references. Subsequently, a quiz consisting of 42 multiple-choice questions on upper limb anatomy was administered to the orthopedic residents and Group I students. One month later, a second quiz comprised of 25 multiple-choice questions on lower limb anatomy was administered to the residents and Group II students. Both quizzes were designed and administered by the Department of Anatomy.

A one-way analysis of variance (ANOVA) was used to compare the mean scores among orthopedic residents, interns, and students. Post hoc tests were performed to assess pairwise differences between the groups. The mean scores of the two quizzes taken by the residents were analyzed using the Student's t-test. A p-value of < 0.05 was considered statistically significant.

Results

The mean scores for correct answers on the 42 upper limb gross anatomy questions were 27 ± 7 (60%, range: 13–38) for the orthopedic residents, 17 ± 4 (37%, range: 9–33) for the interns, and 18 ± 7 (40%, range: 12–24) for the students, respectively [Table 1].

The mean scores for correct answers on the 25 lower limb gross anatomy questions were 20 ± 4 (80%, range: 10–24) for the orthopedic residents, 11 ± 5 (44%, range: 3–18) for the interns, and 12 ± 4 (48%, range: 3–19) for the students, respectively [Table 2].

Although the differences in mean scores for both upper and lower limb anatomy were statistically significant in favor of the residents (post hoc test, $p < 0.01$), some undergraduates nevertheless scored higher than particular residents.

The difference between the undergraduates' mean scores on the upper and lower limb quizzes was not statistically significant (Student's t-test, $p = 0.2$). None of the undergraduate groups achieved a mean score above 50%.

In contrast, the difference between the residents' mean scores on the first quiz (upper limb) and the second quiz administered one month later (lower limb) was statistically significant, favoring the second quiz (Student's t-test, $p < 0.01$).

Discussion

Knowledge of anatomy remains a significant concern not only for our orthopedic residents but also for residency programs worldwide. Toogood et al., in a multicenter prospective study, evaluated the adequacy of anatomical knowledge among applicants to orthopedic residency programs. Their results demonstrated that the percentage of correct responses did not exceed 50%, leading the authors to conclude that applicants were not adequately prepared with the prerequisite anatomical education.[10] Similarly, in a 1999 survey of orthopedic residency programs, Cottam reported that gross anatomy was considered the most essential basic science for mastering orthopedic surgery. He also examined the adequacy of medical students' preparation in gross anatomy upon entry into postgraduate residency training. In a previous survey, 57% of orthopedic residency program supervisors reported that incoming residents required a review of gross anatomy, 29% believed that they were sufficiently prepared, and 14% felt they were markedly deficient.[3] To address this deficit, the Department of Orthopedics, in collaboration with the Department of Neurobiology and Anatomy at the University of Utah School of Medicine, has conducted an interdisciplinary annual Orthopedic Resident Anatomy Review Course during the summer months for all junior and senior residents since 2004.[4] Similarly, the University of British Columbia offers a weekly summer anatomy course that includes cadaveric dissection, while Vanderbilt University provides an eight-week winter course focusing on operative orthopedic dissections. At the University of Michigan, an anatomy laboratory provides comprehensive monthly sessions that include cadaver workshops to reinforce anatomical knowledge and surgical dissection skills. The orthopedic residency program at the University of California, Davis

Table 1. The mean scores out of 42 upper limb gross anatomy questions among the orthopedic residents, interns and students

	Twenty Orthopedic residents	Seven Orthopedic Interns	Fifteen Orthopedic students
Mean scores (range)	27 ±7 (60%) (range:13-38)	17± 4 (37%) (range: 9-33)	18 ±7 (40%) (range: 12-24)

Table 2. The mean scores out of 25 lower limb gross anatomy questions among the orthopedic residents, interns and students.

	Twenty Orthopedic residents	Fifteen Orthopedic Interns	Twenty Seven Orthopedic students
Mean scores (range)	20 ±4 (80%) (range:10-24)	11 ±5 (44%) (range: 3-18)	12 ±4 (48%) (range: 3-19)

incorporates anatomy laboratories into its basic science curriculum, offered each autumn. Similarly, the University of Iowa conducts weekly anatomy and training courses for its orthopedic residents, while the University of Maryland offers a yearlong refresher course in anatomy with weekly dissections.[4] The present study demonstrated that the anatomical knowledge of our orthopedic residents was suboptimal. Although the anatomical regions assessed in the two quizzes differed, the residents' performance improved significantly from 60% on the first (upper limb) quiz to 80% on the second (lower limb) quiz administered one month later. We believe that this improvement reflects the residents' greater seriousness and preparation for the second assessment. These findings underscore the necessity for orthopedic residents to regularly review and update their anatomical knowledge. Structured courses, particularly those involving cadaveric dissection, can substantially enhance residents' anatomical competence beyond what is achieved through current educational practices.[6]

The present study also demonstrated that the knowledge of upper and lower limb gross anatomy among medical students and interns was suboptimal. Medical schools are expected to provide students with sufficient training in basic gross anatomy to meet the needs and standards required for residency programs. However, with the continuous expansion of medical curricula and the limitations of available instructional time, reductions in basic science courses, including anatomy, may occur. Several studies have reported that the time allocated to human gross anatomy within medical school curricula is insufficient, which may adversely affect the anatomical knowledge of future orthopedic residents as well as trainees in other residency programs.[11,12] In 2004, the University of Michigan Medical School reduced its gross anatomy curriculum.[2] To evaluate the impact of this reduction on residents' perceptions of their clinical preparedness, Bohl and Gest surveyed graduates from both the original and the revised curricula. Surgical residents reported that cadaveric dissection was essential for residency readiness and that a more rigorous anatomy curriculum would have better prepared them for clinical training.[2] Similarly, Freedman and Bernstein assessed recent medical school graduates on fundamental topics in musculoskeletal medicine to determine the adequacy of their preparation in this field. Their findings revealed that 70 of 85 graduates (82%) failed a validated musculoskeletal competency examination, leading the authors to conclude that medical school training in musculoskeletal medicine was inadequate.[12] These findings emphasize the need to address deficiencies in anatomical knowledge during residency to train competent surgeons capable of performing accurate clinical examinations and mastering surgical techniques. Future research could expand the scope of the current study to a larger scale at the national level, across multiple universities, and in comparison with international experiences.

Conclusion

Current orthopedic residents are not adequately prepared with the prerequisite anatomical knowledge. This deficit may stem from insufficient exposure to anatomy during undergraduate medical education. To address this gap, orthopedic residents should regularly review and update their anatomical knowledge through collaboration and interdisciplinary courses in partnership with the Department of Anatomy.

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