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The Performance of Students in the Practical Evaluation of Muscle Recognition in Natural and Artificial Anatomical Parts

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

Learning human anatomy can be challenging for Physical Education and Medicine students. Large volume of information, technical terminology, difficulty in visualizing 3D structures, lack of practice and emotional pressure are some challenges faced by students. However, the study of muscle anatomy is as important for physicians as it is for physical educators, albeit for different main reasons. In this study, the objective was to verify if there are differences in the performance of medical and physical education students in practical tests of recognition of muscular structures in natural and artificial anatomical parts. From approximately 126 muscles of the upper and lower limbs and their girdles, 20 structures were drawn (10 in natural pieces and 10 in artificial pieces). The notes and class notebook records of 86 physical education students and 103 medical students from two public universities were compared, considering that there were no differences between the evaluation methods and the professors in charge. It was found that, despite substantial differences in the socioeconomic profile of each course, physical education students were significantly better at recognizing muscle structures. However, this result was dependent on the

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better performance of physical education students in the evaluation of artificial parts. The students' performance was lower, much more variable and similar between the groups in the evaluation of the natural pieces. Such results suggest the need for greater contact and manipulation, especially of medicine, in cadaver pieces.

Keywords: Muscular anatomy; performance; learning; medicine; physical education.

1. INTRODUCTION

The subject of Human Anatomy is fundamental in the Physical Education and Medicine curricula, as it allows understanding the structure and functioning of the human body, in addition to providing valuable information for professional practice in both areas [1,2]. For doctors, understanding the structure of the human body is essential to diagnose diseases, traumas and abnormalities that can affect the correct functioning of the human body, in order to prescribe appropriate treatments [3]. For Physical Education teachers, knowledge of anatomy allows them to create, select and prescribe physical exercises that are safe, efficient, effective and didactically plausible for their students, avoiding injuries and maximizing results [4].

A deficiency in the domain of Human Anatomy can make integration with other disciplines difficult and sometimes unfeasible. Without the proper anatomical foundation, understanding becomes difficult, as is the case with Biomechanics, Biophysics, Kinesiology, Physiology and Biochemistry of some medical sciences such as: cardiology, dermatology, endocrinology, orthopedics, nephrology, ophthalmology, gynecology, etc. In addition, from disciplines of human movement such as ergonomics, anthropometry, physical exercise, physiotherapy, occupational therapy, sports, etc. [5].

Biomechanics, for example, focuses on understanding how the body moves and how its bones, muscles, tendons and ligaments work together to produce movement [4]. Thus, during a specific movement, it is necessary to know the location, size, shape, direction of the fibers and types of fibers, as well as the joint categories, which support or make up the muscles, bones, ligaments and tendons, in addition to their relationships with other adjacent organs and tissues. In addition, understanding the structure of bones and joints is essential to understand how they support the internal and external forces that act on each body segment during movement [6].

Obviously, the workload dedicated to the discipline in these undergraduate courses differs substantially. However, the emphasis on the musculoskeletal system seems to fall on physical education and physiotherapy courses [7,8]. Despite the importance of these systems for orthopedics and surgery of anybody segment, medical courses do not seem to emphasize the musculoskeletal system [7,9].

Turney [8] argues that, currently, little emphasis has been given to the integumentary and muscular systems in medical schools. However, these systems are extremely important for any medical specialty, especially for performing surgeries. Both one and the other are responsible for the protection and lining of the other organs, in addition to the primary functions of the muscular system: movement and support.

The reading of Araújo Júnior et al. [10] and Smith and Mathias [11] and Moore and Dalley [9] clarifies the importance of an extensive workload in muscular anatomy, mainly. Successful surgical access (for example) and with the least possible sequel is dependent on a deep knowledge of the integumentary and muscular systems, as it defines the positions, angles and depths of surgical incisions in order to guarantee adequate access to organs and internal structures which are the targets of the procedure. A mistaken incision in an adjacent nerve, tendon or muscle, which can sometimes lead to irreparable sequel. In addition, the healing processes, prevention of infections and post-surgical complications are better supported when the incisions are precise due to an excellent muscular and integumentary knowledge.

For physical education, the most relevant anatomical knowledge, without discarding the importance of others, are those of the skeletal and muscular system. The correlation is direct and almost perfect, as Physical Education deals with human movement and these systems are responsible for this movement, in addition to supporting the body in postures that defy the forces of gravity [12].

Oliveira [13] reports some reasons why the anatomy of the skeletal and muscular system is important for Physical Education: 1 — Understand how body movements are performed, which muscles are used and how joints move. This is important for the development of effective and safe exercises; 2 — Identify which exercises and movements can be harmful to joints and muscles. To prevent injuries and ensure the safety of students during physical activities; 3 — Select exercises that effectively work the specific muscles you want to strengthen or stretch. This is important for achieving fitness goals and promoting good health; 4 — Develop personalized training programs for students with different fitness levels. This is important to ensure students achieve their goals and avoid injury; 5 — Educate about the importance of physical activity for bone and muscle health, thus preventing diseases and disorders such as osteoporosis, morbid obesity, heart failure, postural problems, mild and moderate depression, among others.

It turns out that the study of muscle anatomy is as important for physicians as it is for physical educators, although for different main reasons. According to Montes and Souza [14], many questions arise when reflecting on the main difficulties associated with teaching and learning human anatomy. Three points to highlight: (a) the course's curriculum is usually very extensive; (b) in most cases the teaching materials (cadavers and/or synthetic fragments) are not enough for the number of students; (c) insufficient training of students hinders the learning of concepts.

Many areas of health, such as medicine and physical education, need to learn about anatomy. The accurate recognition of muscle structures in anatomical specimens is one of the most important skills for anatomists, which can be acquired by studying natural and artificial anatomical specimens. There are many studies that look at how these anatomical models can be used to teach anatomy [15,16], but it is still not clear if there are considerable differences between students from different areas of training, like medicine and physical education, in how they recognize muscle structures in natural anatomical models. Therefore, the objective of this study is to determine whether there are significant differences between medical and physical education students in practical tests of recognition of muscular structures in natural and artificial anatomical parts. The results of this study are expected to contribute to the development of more effective methodologies for teaching anatomy and provide important information about the use of anatomical models for learning anatomy.

2. MATERIALS AND METHODS

It is a comparative descriptive study, multi cases, with a quantitative approach and with the use of secondary data. Convenience sampling consisted of four medical classes and four physical education classes from public universities in Paraná and Tocantins. The criterion for choosing the classes was because the same teacher who uses a standardized evaluation method taught them. Each class consisted of approximately 25 students and all were submitted to the same test system on the muscular system (Fig. 1).

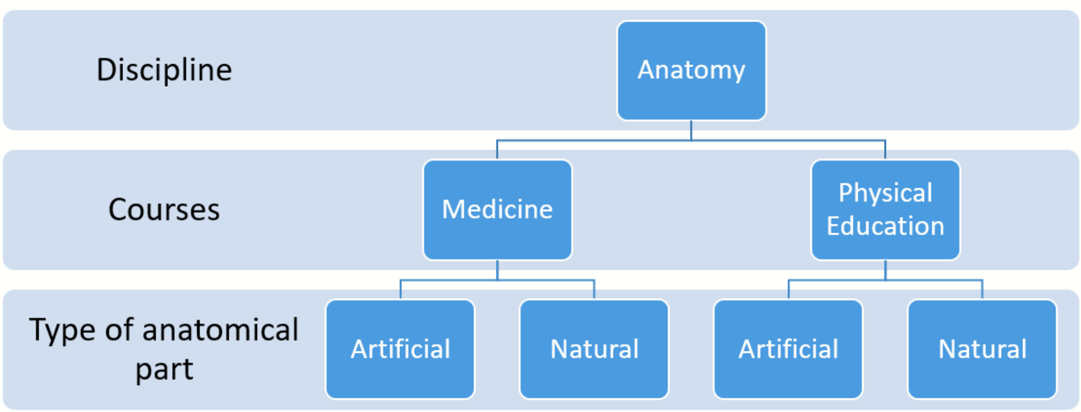

Fig. 1. Organizational chart of test distribution

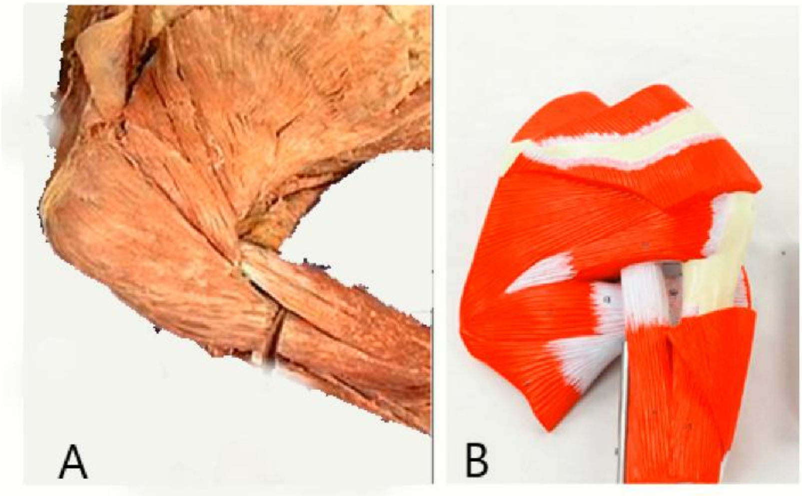

Fig. 2. Example of anatomical parts used in the tests: cadaver (A), doll (B)

The natural pieces consisted of an upper limb connected to its shoulder girdle and a lower limb connected to its pelvic girdle, both from a cadaver properly preserved in formaldehyde composition (Fig. 2A). The artificial parts represented the same body structures, but made of PVC and duly marked and painted to mirror the muscles, bones, nerves and blood vessels (Fig. 2B).

The practical tests consisted of two stages: in the first evaluation, the students had to identify the 10 muscles drawn and marked on the artificial piece, whose coloring and contrast are relatively marked, which facilitates the distinction. In the second assessment, students had to identify the 10 muscles drawn and marked on the natural piece, whose exposure to formaldehyde altered the shape, path and color of the structures.

Students entered a column, one by one, and wrote down the name of the muscles drawn in the pieces in sequence without being able to talk to teachers, monitors and colleagues. After going through all the tables where the pieces rested, each student handed in their duly identified note card to the teacher of the discipline. In this specific process, students should identify 20 muscles in the pieces, in the two phases, out of approximately 126 that make up the pelvic and scapular girdles connected to their limbs.

As this is a retrospective research, the collection of secondary data took place in the professor's files and class notebooks. For ethical reasons, neither the students nor the institutions were identified and their individual data were kept confidential and anonymous, to preserve the privacy of the participants. The data were treated together for strictly statistical purposes, although this type of research does not require evaluation by a research ethics committee [17,18].

Data analysis followed the following sequence: collection, tabulation and statistical analysis. The descriptive analysis techniques used to characterize the non-probabilistic samples under study were applied to the collected data [19]. Data were stored, organized and treated primarily in Microsoft Excel® software. Normality analyzes and correlation and comparison tests were performed using the Paleontological statistics software package for education and data analysis version 2.09 (PAST®). To compare the mean grades obtained by Medicine and Physical Education students in the practical test of recognition of muscle structures, the Mann-Whitney and Kruskal-Wallis test was used with Dunn's post-hoc analysis, since the data distribution was similar, revealed non-parametric. The minimum level of statistical significance used was $p \leq 5\%$ [20].

3. RESULTS

In this study, the 187 students analyzed were divided into four groups: two from medicine and two from physical education. In this sense, 55.1% of them belonged to medicine groups (equivalent to 103 students). Both groups had a similar age range, since 78% of the students were between 18 and 25 years old. However, medical students were 2.5 years older, on average, as can be seen in Table 1.

Table 1. Sociodemographic characteristics of physical education and medicine students at a public university in Paraná and another in Tocantins, Brazil

Variable	Category	Physical Ed. (N = 84)	Medicine (N = 103)	p-value
Age (years)	Female	20 ± 2.1	22± 4.4	.05*
	Male	21 ± 3.7	24 ± 5.4	
Gender (%)	Female	53.8	41.4	.04*
	Male	46.2	58.6	
Training High School (%)	Public school	88.7	16.6	.03*
	Private school	10.0	75.5	
	Both	1.3	7.9	
Pre entrance exam/ ENEM (%)	Yes	12.1	86.3	.01*
	No	87.9	13.7	
Work, in addition to studying (%)	Yes	56	4.9	.01*
	No	44	95.1	
Income for living and studying (%)	< 5 SM[1]	76	10.6	.01*
	> 5 SM	34	89.4	

**Statistically, significant (p = .05) according to the chi-square test. [1]Values refer to the average minimum wage (salário mínimo – SM) necessary for a dignified life in Brazil [21]*

Nevertheless, we found that future physicians were older on average than future physical educators (p= .05), and that women were younger than men in both courses (Table 1) Regarding the gender of the participants, women represented 47.6% of the total. It was, however, found that women are the majority among physical education students and the minority among medical students (p= .04).

There was a significant difference in basic education between the physical education and medicine groups. The majority of future physical educators studied exclusively in public schools (88.7%), while the majority of future physicians mostly come from private schools (75.5%). Of the total number of respondents, almost half attended some preparatory course (49.2%), but 87.5% were medical students. Most physical education students (89.9%) did not have access or felt the need to take a preparatory course to select the desired course.

Other socioeconomic differences that draw attention between the groups include the fact that more than half (56%) of physical education students work concurrently with the course, while only 4.5% of medical students are subject to this condition. Also, more than 89% of medical students have more than five minimum wages to help them and study, while only 34% of physical education students have this basic condition, according to DIEESE [21].

As can be seen in Fig. 3, the significant sociodemographic differences between physical education and medicine students could affect performance in practical anatomy tests. In fact, this was the case. When compared visually by the median graphs, physical education students have a slight advantage over medical students when it comes to recognizing muscle structures in the lower and upper limbs.

Fig. 3 shows that medical students have a higher dispersion in their scores, with three students scoring very high. As can be seen in Table 2, a statistically significant difference is confirmed when the averages of the students are compared. A possible explanation for this was the great variability in medical classes. The 'U' test (Mann-Whitney) resulted in 6569, which in the distribution table for this statistic indicates significance.

When separating the groups by gender, the results remain statistically significant for the class. The adjusted Kruskal-Wallis test strongly suggested that Hc was 21.6 (Fig. 4). It indicates that among the various groups (four), some present significant differences. Dunn's post hoc test was applied to determine which of these groups differed statistically (Table 3).

As shown in Table 2, there is no statistical difference in the grades of physical education and medicine students according to gender within their groups. However, such a difference is present between the courses, with the averages of physical education being higher than those of medicine.

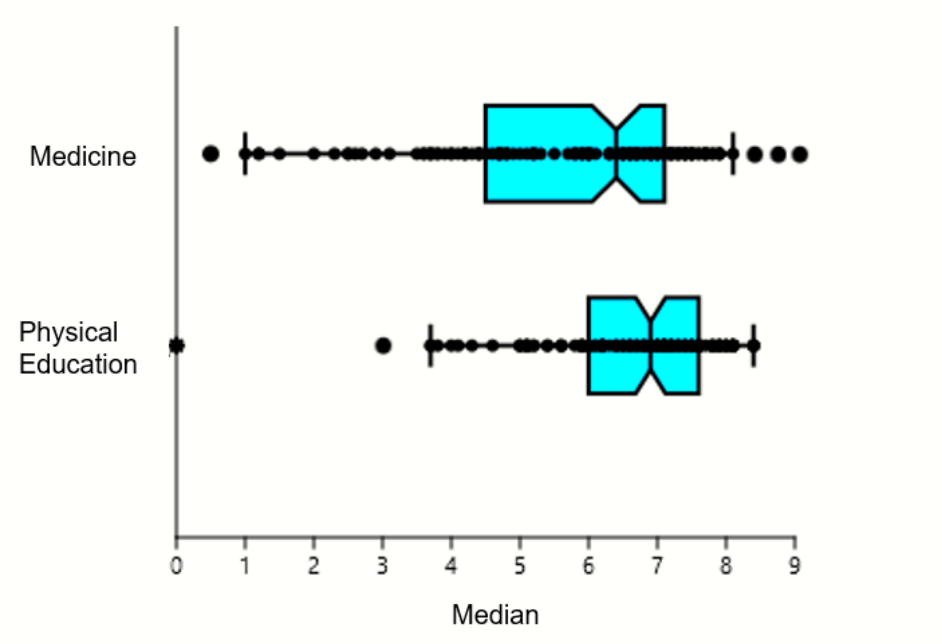

Fig. 3. Shows the medians and interquartile deviations for medical (B) and physical education (A) students grades

Table 2. Descriptive statistical measures of groups of physical education and medicine students at two public universities in Paraná and Tocantins, Brazil

Measures	Physical education	Medicine
Average	6.64592593	5.742963
Standard error	0.10804644	0.149091
Median	6.9	6.35
Mode	7.6	6.9
Standard deviation	1.26002722	1.73869
Sample variance	1.58766859	3.023043
Curtose	5.1361224	0.257135
Asymmetry	-1.6426501	-0.96433
Minimum	0	1
Maximum	8.4	9.8
Score	84	103
Confidence level (95%)	0.21368261	0.294857

Because other categorical variables showed considerable discrepancies, it was possible to analyze only the correlations between grades (performance) and income and concomitant work or not. It is noteworthy that these characteristics strongly reflect socioeconomic differences between the groups, with the medical group being better favored in this regard. The results were similar for the work variable. A significant correlation was observed in the medicine (R = 0.14) or physical education (R = 0.25) groups, nor even among all participants (R = 0.13).

Table 3. Post-hoc averages of groups of students according to course and gender

	Medicine male	Physical education female	Medicine female
Physical education male	.03147*	.1817	.008776*
Medicine male		.0004264*	.718
Physical education female			.00454*

**Statistically significant according to Dunn's test.*

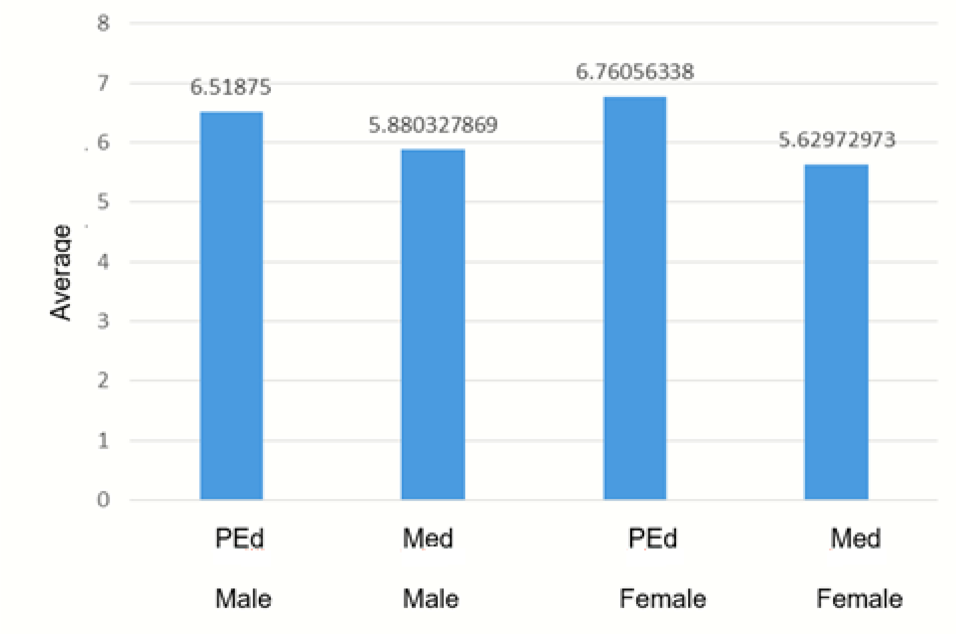

Fig. 4. Averages of medical (Med) and physical education (PEd) students according to female and male gender

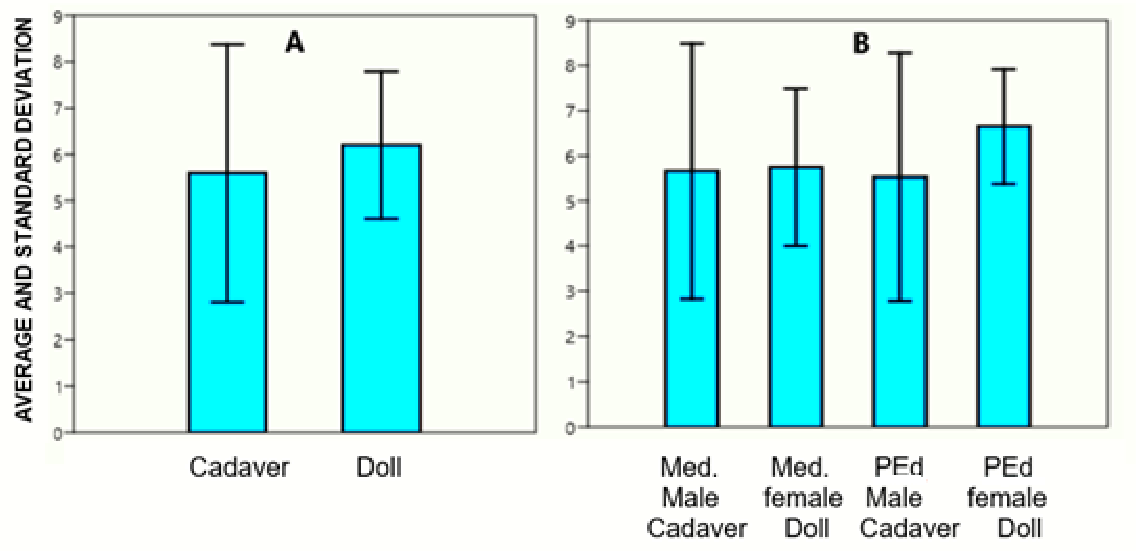

Fig. 5. Means and standard deviation of the performance of medical (Med) and physical education (PEd) students according to the type of anatomical piece, considering only courses (A) and courses by gender (B)

Moreover, another important issue raised in this study was related to the type of anatomical specimen used to recognize the drawn structures. It is evident that there are substantial differences between studying anatomy on cadavers and anatomical dolls. This study specifically examined the hypothesis that it would be easier to identify muscle structures in PVC parts. However, as can be seen in Fig. 5, although there are statistically significant differences in the means of correct answers, the disparities between recognizing structures in cadavers and dolls were not as great as imagined, especially in medicine, which generally has more monitoring time in the laboratory.

Table 4. Post-hoc averages of the groups of students according to the type of anatomical part (N = natural or cadaver; A = artificial or doll), course, and gender

	Medicine Male - A	Physical education Female - N	Physical education Female - A
Medicine female - A	.7667	.7145	.001459*
Medicine male - N		.9254	.0001765*
Physical education male - N			.0003526*

**Statistically significant according to Dunn's test.*

It has been observed that all groups had greater variability in the identification of structures in cadavers (Fig. 5A). In contrast, only female physical education (Fig. 5B) students performed statistically better than all other groups in recognizing anatomical structures in artificial parts (dolls).

All groups had greater variability when it came to the identification of structures in cadavers. However, only female physical education students performed significantly better (Table 4) than all other groups in recognizing anatomical structures in artificial parts (dolls).

4. DISCUSSION

For a number of reasons, it can be challenging for Physical Education and Medicine students to learn human anatomy. Since this is a vast and complex area of study, involving knowledge of numerous body structures and systems, it can be overwhelming for many students, especially at the beginning of the course [22].

Anatomy has a complex and specific technical terminology, which can be difficult to memorize and understand. Numerous students may have difficulty understanding the nomenclature and its relationship to body structures [22,23]. Also, studying anatomy often involves understanding body structures in three dimensions, which can be hard for some students who have trouble seeing objects in 3D [24,25].

A good understanding of human anatomy requires a lot of practice and repetition. Learning can be hindered by a lack of opportunities to practice through practical classes or labs. Consequently, medical students have more time and opportunities to handle natural parts than academics from other courses in the health area [22,26]. As a result, students in the medical program are expected to perform better in anatomy than in physical education, which was not confirmed in the present study, as can be seen in Figs. 2 and 3. Fig. 3 and 5 show that the dispersion of physical education students grades is substantially higher, possibly reflecting the differences in the scores for accessing these courses.

Human anatomy can be an emotionally challenging topic for students in some cases. Especially true in relation to cadaver dissections and other practical activities involving human death [25-28]. It's possible that this is connected to the better performance of physical education students in artificial anatomical models, as shown in Fig. 5B and Table 4.

Although the results of this study showed similar performance among Physical Education and Medicine students, despite the socioeconomic and status advantages of the latter (Table 1), the averages presented were low for a discipline of such relevance (Table 2) for all other matters [21].

Because of the greater variability in the recognition of anatomical structures in natural parts, there is a need for more time, beyond the mandatory workload, in contact with cadavers in monitoring sessions and, especially for future physicians, dissection [26,28]. The study of natural parts provides the opportunity to visualize and manipulate real tissues, in their natural positions and their individual anatomical variations. For future doctors, it allows initiation into surgical practices and techniques during dissection activities, allowing students to develop practical skills [5,15,16,29-31].

Since anatomy is often cited as a basis for acquiring clinical knowledge, many researchers have investigated its impact on medical practice. Analyses of interviews and questionnaires applied to former medical students reveal that the study of cadavers is the most effective way to understand anatomy [11,32]. This suggests that the lower variability in students' performance in recognizing structures in artificial parts may be paradoxical. Because, while it reveals the difficulty of dealing with real structures, with all their variations and deformities, it also reveals that teaching anatomy only with dolls, as is common in private schools of nursing and physiotherapy, is not at all effective.

There are major bottlenecks in teaching anatomy with natural specimens, such as maintenance costs and acquisition difficulties, since it is necessary to obtain human cadavers legally donated for educational purposes. Cordeiro and Menezes [33] state that, considering the significant increase in the number of courses in the health area, there is a need for legislative normative improvements to meet the growing demand for cadavers for the purposes of study and scientific research. Furthermore, the authors rule out the replacement of corpses by emerging technologies (software and simulators), as these should complement the study of anatomy.

The lack of regulatory centers to manage the process of capturing and distributing corpses and the reduction in the number of unclaimed corpses are some of the reasons why relevant materials are lacking. Moreover, despite the existence of legislation on the matter, the legislative process has been very slow, given the needs [27,32,33].

Second, to overcome these difficulties, students must engage actively in the learning process. It is important that they take every opportunity to practice and revise, as well as seek additional help, such as tutoring. Additionally, visual aids such as diagrams and anatomical models can help make learning easier and more interesting [11,15,22].

5. CONCLUSION

The objective of this humble study was to determine if there were significant differences between medical and physical education students when it came to practical tests of recognition of muscular structures in natural and artificial anatomical parts. It is therefore concluded that statistically significant differences were found in the performance of the students, and, although small, they favored the female physical education students.

Students from both courses had better average performance in the artificial pieces; however the variability of results in the natural ones was much higher. When stratifying them by gender, it was found that the small but significant superiority of physical education students over medical students was due to the better performance of future physical educators in recognizing muscle structures in artificial models.

Despite all the socioeconomic advantages of medical students over physical education students, the performance on the tested topics was quite similar, and the statistical tests did not indicate the influence of these socioeconomic factors on the results of these specific classes. This raises questions about the replication of studies like this one, which are advancing towards a more comprehensive approach.

Since not all anatomical models are the same and the variability of natural parts is substantial, further research should be carried out comparing learning in artificial and natural parts. Different brands of anatomical models and individual organ models may be explored in future research. Furthermore, with larger samples of students and with different experimental designs, as a case control, including other computer-based teaching technologies, and finally, to evaluate student performance in simulated clinical situations to determine the effectiveness of artificial anatomical models.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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