Academic benefits of using cadaveric material in health sciences education: Report of an experience

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SUMMARY

The use of cadaveric material to study anatomy has been curbed by the requirements for its maintenance and use and by the anatomical contents in medical curricula, negatively affecting students. This study aimed to demonstrate the reported benefits of using cadaveric material in teaching anatomy. The benefits were categorized into 3 groups: audiovisual resources, teaching, and institutional cooperation and research. 1) Audiovisual resources: 2234 photographs, 256 videos, 16 websites, 28 anatomical replicas using 3D printing, the Laminario Anatómico, and a gymkhana online simulator. Students were surveyed about their perception and use of these resources. Their responses indicate they are considered useful tools for teaching and learning. 2) Teaching: all the practical activities with cadaveric material are comprehensively undertaken in different formats every year. 15 undergraduate programs have prosection activities, 9 graduate degree programs and 4 post-graduate qualification programs have prosection and dissection activities, and 22 graduate degree programs have cadaveric surgical training. 3) Institutional cooperation and research: 2 doctoral theses, 1 master's thesis, and 37 publications. The use of cadaveric material is a contribution that strengthens all aspects of academia in the development of both instructors and institutions.

Key words: Cadaveric material – Academic benefits – Teaching – Anatomy

INTRODUCTION

It is accepted that the use of cadaveric material for teaching anatomy is the only opportunity to empirically confirm the location of the organs and body systems (Inzunza, 2008; Sañudo et al., 2021), despite the fact that three-dimensional (3D) visualization technologies and anatomical replicas are gaining ground due to their ever-increasing realism (Hackett and Proctor, 2016; Yammine and Violato, 2016; Kausar et al., 2020). It is known that multidimensional learning activities that relate cadaveric anatomy to living anatomy ensure the participation and enthusiasm of the learner (Pather, 2015; Abdel et al., 2017; Sadeesh et al., 2021). Although this methodology is old, it confronts the student with visual keys that are

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highly relevant to learning these subjects (Guillot et al., 2007; Dissabandara et al., 2015). However, the use of cadaveric material for teaching in this discipline has been reduced in the curricula, essentially due to time limitations, instructors' training, and the resources needed to teach with corpses, which has decreased the overall level of applied anatomical knowledge in the youngest generations (Leung et al., 2006; Standring, 2009; Estai and Bunt, 2016). This puts the transmission of fundamental knowledge, values, and competences at risk (Rehkämper, 2016; Chipamaunga and Prozesky, 2019). This is worrying: the data show that students in those medical schools that discontinued anatomical work with cadaveric material have been seriously hindered in their clinical abilities and skills (Rizzolo and Stewart, 2006; Stephens et al., 2021). Coincidently, malpractice suits have steadily increased over time (Li et al., 2018).

There are 24 recognized medical schools in Chile with a minimum program duration of 6 years and a maximum of 7. The minimum number of semesters with anatomy courses is 2, with a maximum of 4. Tiznado-Matzner et al. (2019) collected data on 12 anatomy laboratories in Chilean universities, of which just three claimed to have human cadaveric specimens to fully engage with in practical activities. This exposes the difficulties that institutions have in accessing cadaveric material, which implies investments in infrastructure and training of instructors and technicians in using cadaveric preparations for morphological study (Gnanakumar et al., 2018; Singal, 2022). It is understood that the lack of this material poses a disadvantage in accessing knowledge founded on anatomical reality (Farfán et al., 2021). In addition, it must be recognized that there has been a progressive reduction in experts in morphological sciences.

This study aimed to expand on the reported academic benefits of using cadaveric material for audiovisual resources, teaching, and institutional cooperation and research.

MATERIALS AND METHODS

A descriptive study was conducted during the year 2022. All the resources and activities developed from using cadaveric material were organized to analyze the anatomical subjects, separating them into three categories: 1. Audiovisual resources: all the audiovisual resources made from cadaveric material were compiled; 2. Teaching: all undergraduate and postgraduate training programs were organized, and the type of teaching they received was described; 3. Institutional cooperation and research: the publications and institutional affiliations created from cadaveric material were compiled.

Additionally, to know the opinion and ascertain the extent to which the audiovisual resources gen-

Table 1. Audiovisual resources produced from cadaveric material**.**

Category	Photos	Videos	Websites	Laminario Anatómico	Gymkhana Simulator	3D Printing
Head	235	52	1	18	1	1
Central Nervous System	50	12	1	14	1	0
Neck	50	23	1	12	1	2
Thorax	272	52	1	13	1	7
Abdomen	153	37	1	16	1	9
Pelvis	61	22	1	11	1	5
Back	50	7	1	23	1	0
Upper Limb	80	27	1	8	1	2
Lower Limb	90	24	1	8	1	2
Descriptive Anatomy	1043	0	7	55	7	0
Sectional Anatomy	150	0	0	79	0	0
Total	**2234**	**256**	**16**	**257**	**16**	**28**

erated are used, in addition to student preferences and their opportunities to access this material (Table 1), at the end of the second semester of 2021, an online survey in Likert format was sent (Google Forms; Google LLC, Mountain View, California, USA) to all the undergraduate Medical, Dentistry, and Physiotherapy students in the Department of Anatomy at the Pontificia Universidad Católica de Chile who used all these resources. The survey included 16 selection questions about the use of audiovisual resources. 284 first- and second-year students responded, 55% men and 45% women, whose average age was 18 years, and represented 73% of the population, obtaining a homogeneous response rate among the different courses.

The authors confirm that every effort was made to comply with all local and international ethical guidelines and laws concerning the use of human cadaveric donors in anatomical research. After authorization from the appropriate ethics review board, 30 bodies were obtained through the donation program in the Pontificia Universidad Católica de Chile (PUC) Faculty of Medicine. This donation program fully complies with the World Medical Association's Declaration of Helsinki and national legal and ethical requirements, was approved by the CEC (Comité Ético Científico) MED-UC of the Pontificia Universidad Católica de Chile (No: 190115002).

Data and statistical analysis

The data collected were organized in Microsoft® Excel tables for MacOS (v.16.43, Microsoft® Corporation) and then exported to GraphPad Prism 9.0 for MacOS (v9.1.0. GraphPad Software, La Jolla, California USA) to generate descriptive statistics.

RESULTS

Audiovisual resources

Photographs: A registry of 2234 photos of dissections carried out on cadaveric preparations (Fig. 1A); 3D printing replicas: 28 replicas of cross sections digitized and printed using 3D technology (Fig. 1B); Websites: 16 websites with original

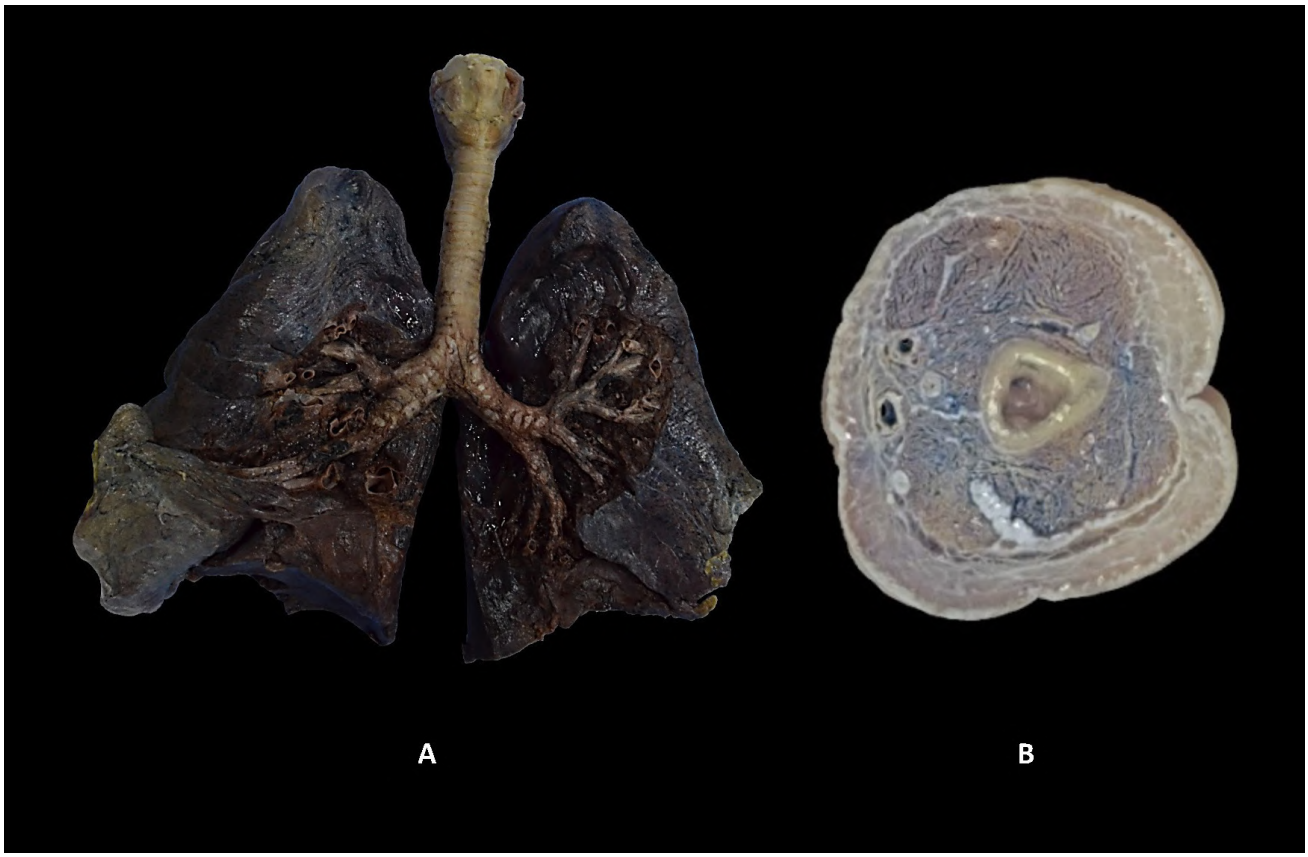

Fig. 1.- A. Photograph of lower airway dissection. **B.** Anatomical replica printed with 3D technology of an arm.

texts on anatomical contents supported by photos; Laminario Anatómico, an interactive photographic web atlas for the recognition of anatomical structures in cadaveric images and videos, with sections on descriptive anatomy, topographic anatomy, sectional anatomy. These sections include all systems and regions of the human body and can be retrieved from anywhere and on any device with internet access. (Fig. 2A); Videos: A registry of 256 videos with explanations on anatomical content using cadaveric preparations, an average of 4 minutes each (Fig. 2B); Gymkhana online simulator, a software that can simulate practical assessments conducted in the anatomy building, which has 16 different content simulations; in it, students can perform evaluations of descriptive anatomy, topographic anatomy, embryology, and histology. In addition, students can configure the number of questions and the duration of each station, being able to practice freely without the pressure of an evaluation (Fig. 3, Table 1). All these resources were generated from cadaveric material and are free and open access.

Undergraduate student survey

The survey results indicated that 98.5% of the undergraduates use a computer, 70.3% a tablet, and 60.5% a smartphone as a study tool. Concerning Internet access, 87.1% have mobile Internet on their study device; however, 87.6% use Wi-Fi when studying.

In relation to the audiovisual resources generated by the authors' department, 79.9% said they use the Laminario Anatómico for daily study, and 97.9% use it to prepare for theoretical and practical evaluations (gymkhanas).

Concerning the use of anatomy videos recorded in the anatomy building, 68.7% of the students surveyed indicated that they use them for daily study, 68.3% at least once a week, 83.7% review them to prepare for theoretical examinations and gymkhanas, and 94% consider this tool to be a contribution to their learning. Regarding the gymkhana online simulator, 74.7% of students confirmed they use it for examination preparation.

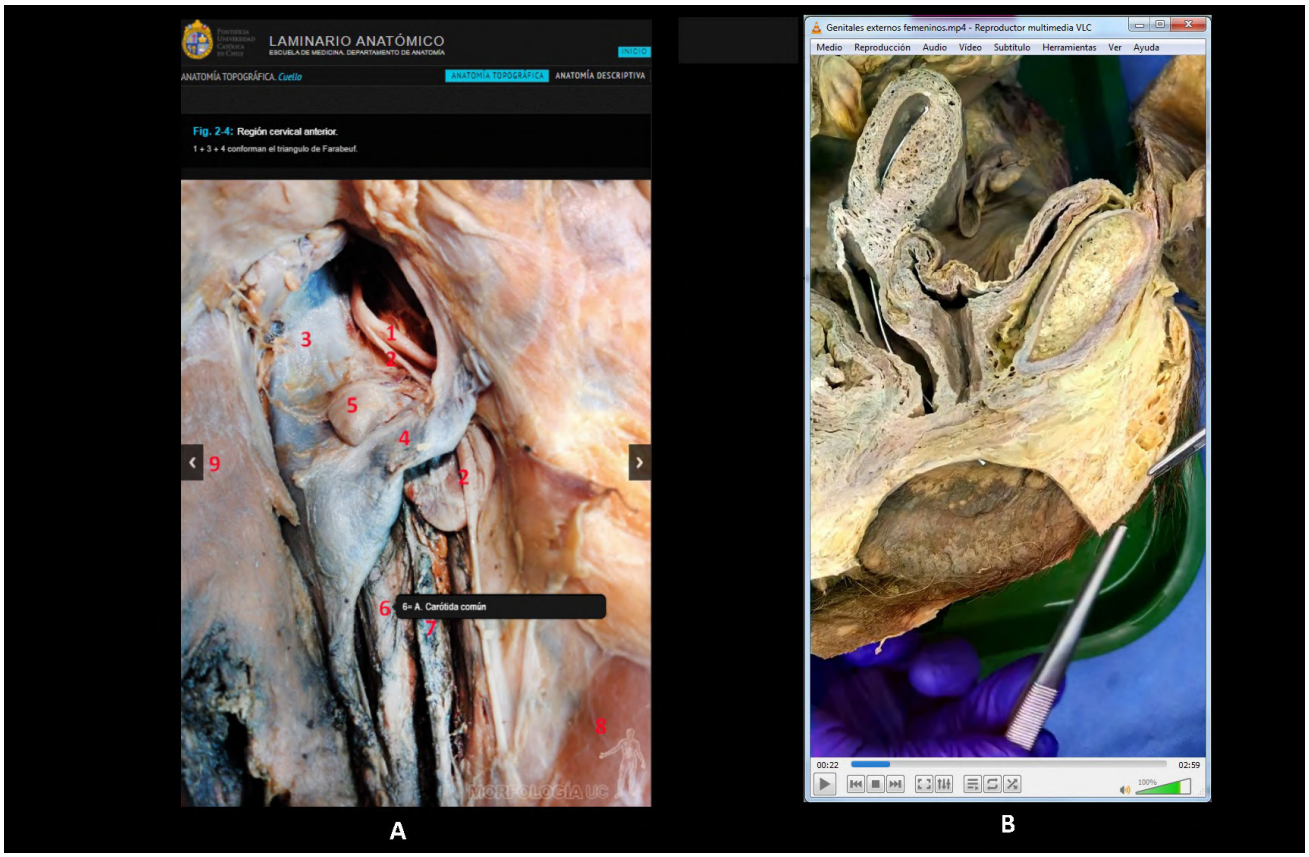

Fig. 2.- A. Image from the "Laminario Anatómico". The black box indicates the name of the structure labeled when clicking on the number 6. **B.** Screenshot of an explanatory video on anatomical content recorded in the anatomy building.

Table 2. Teaching using cadaveric material in undergraduate and graduate degree studies.

N°	Undergraduate programs	Course code	Graduate degree programs	Course code
1	Medicine I	MED-111A	Orthopedics	No code
2	Medicine II	MED-212A	General surgery I	No code
3	Medicine III	MED-213A	General surgery II	No code
4	Dentistry I	MED-101o	Otorhinolaryngology	No code
5	Dentistry II	MED-102o	Oncological surgery	No code
6	Dentistry III	MED-201o	Maxillofacial surgery	No code
7	Kinesiology I	MEK-101A	Orthodontics	No code
8	Kinesiology II	KIN-102A	Oral Radiology	No code
9	Speech Therapy I	MEF-101A	Master in Medical Physics	MAF3000
10	Speech Therapy II	FON-102A		
11	Teaching Physical Education I	MEP-101A		
12	Teaching Physical Education II	MEP-201A		
13	Occupation Therapy	MET-201A		
14	Nursing	MEB-103F		
15	Nutrition	MEN-101A		

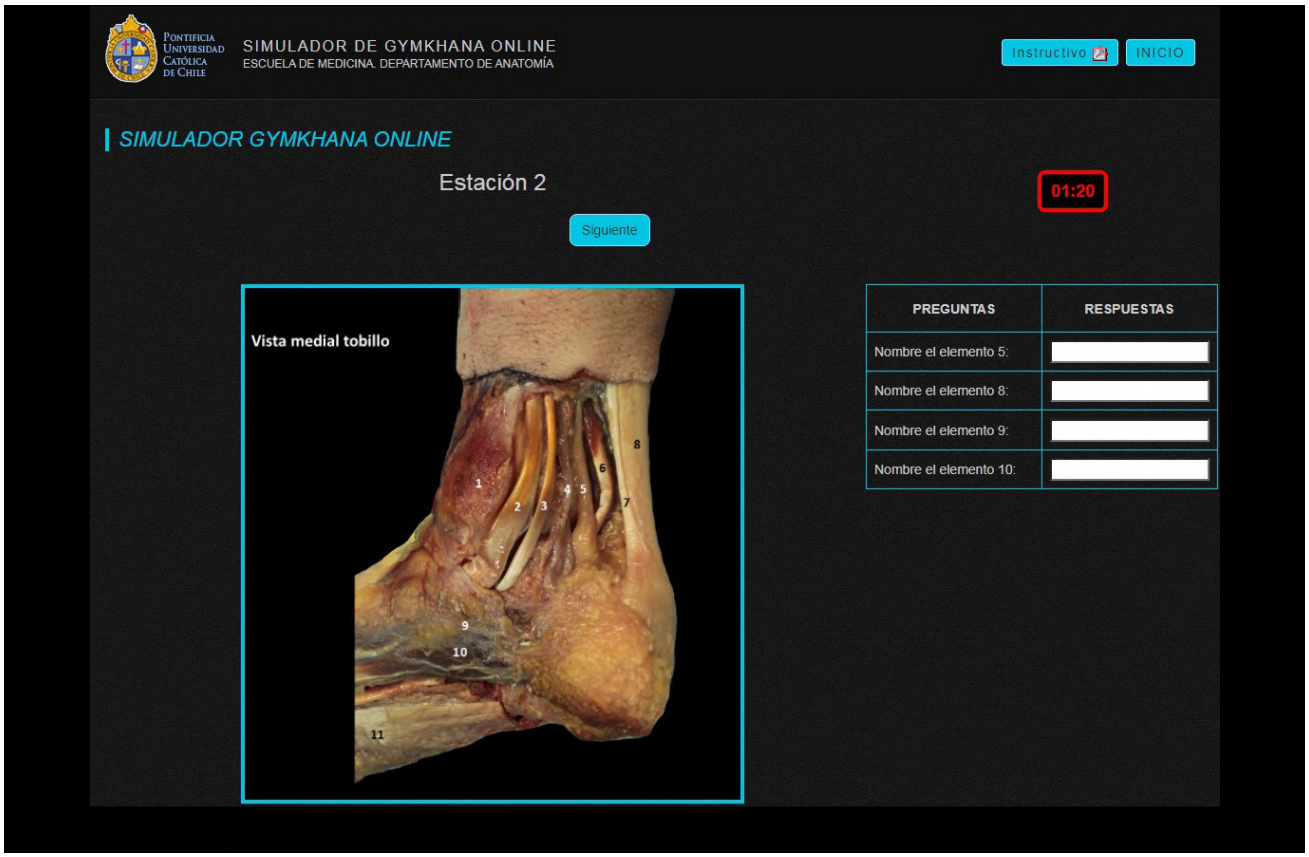

Fig. 3.- Photograph of the "Gymkhana Online Simulator". The light blue box shows the image about which questions are asked, the calypso blue box the questions and blank spaces to answer, and the red box is the time remaining to change to the following image.

Teaching anatomy

There are 15 undergraduate programs structured on 5, 10, and 15 credits (5 credits = 64 hours of instruction). In these courses, prosection activities are carried out in the anatomy building (Table 2). Graduate degree teaching for 8 medical specialty programs and 1 master's program structure is based on 5 credits; these activities include prosection and dissection. Post-graduate

Table 3. Teaching using cadaveric material in graduate qualification programs.

N°	Graduate qualification programs	Course code	Surgical training	Course code	Type of surgical approach
1	Diploma in Human Anatomy	DAH	Hip prosthesis	No code	Manual
2	Diploma in Head and Neck Anatomy	DACYC	Knee prosthesis	No code	ROSA robot
3	Diploma in Neuroanatomy	MEDNAH	Ankle prosthesis	No code	Manual
4	Diploma in Histology and Embryology	MEDDHEA	Hallux valgus correction	No code	Manual
5			Shoulder prosthesis	No code	Manual
6			Elbow prosthesis	No code	Manual
7			Hand tendon repair	No code	Manual
8			Cochlear implant	No code	Manual
9			Blepharoplasty	No code	Manual
10			Scoliosis correction	No code	Manual
11			Spinal osteosynthesis	No code	Manual
12			Skin flaps	No code	Manual
13			Nasal septum correction	No code	Manual
14			Prostatectomy	No code	HUGO robot
15			Nephrectomy	No code	HUGO robot
16			Bariatric surgery	No code	HUGO robot
17			Penile prosthesis	No code	Manual
18			Organ procurement	No code	Manual
19			Canthotomy	No code	Manual
20			Entropion	No code	Manual
21			Ectropion	No code	Manual
22			Abdominal hernias	No code	Laparoscopy

qualification teaching for 4 diploma programs is structured into 20 credits; these activities include prosection and dissection. 22 structured surgical training programs carry out cadaveric surgical simulation training (Table 3). All programs are offered in one academic year, and the courses have been repeated every year since 2021.

Institutional cooperation and research

The Department of Anatomy has made cadaveric material available for 2 doctoral theses and 1 master's thesis (Table 4). In relation to scientific article output, 37 papers have been published on cadaveric dissections in 18 years (Table 4).

Table 4. Institutional cooperation and Research.

Institutional cooperation	Dissections
Doctoral Thesis 1	30
Doctoral Thesis 2	8
Master's thesis 1	6
Anatomy Publications	**N°**
Cadaveric dissections	37

DISCUSSION

The audiovisual resources produced from cadaveric material have been very well received by the students, who have skills *per se* in using technologies (Farfán et al., 2016). This is demonstrated in the survey responses, which indicate a positive answer on using such tools, which also affects student performance, i.e., the "Laminario Anatómico". Since the implementation of this resource, the results of the gymkhanas have yielded an increase in performance, e.g., in gymkhana 4 of the MEK-101A course in 2014, the average score was 39 out of 56 total points. By contrast, in 2015, the average was 37 out of 56. However, the average score on gymkhana 4 in 2016 (when the Laminario Anatómico was implemented) was 41 out of

56; the following year, it was 42 out of 56. On the other hand, the direct benefit of producing these resources is an economic saving, given that all the resources mentioned here were created based on projects that made their funding possible, which is "a zero cost" for the department and simultaneously an achievement for the instructor, which has benefit to their academic career. For example, a virtual dissection table is over US$ 80,000, a cost that is not reasonable for any institution and far beyond the cost of developing all the audiovisual resources generated in the authors' department from cadaveric material. Further, for the students, cadaveric material work remains the preferred means of learning anatomy (Johnson et al., 2013; Viswasom and Jobby, 2017; Mustafa et al., 2021).

Given the authors' successful experience as a teaching team, they consider the integration between technology and the resources generated using cadaveric material fundamental (Casado et al., 2012; Paech et al., 2018; Bork et al., 2021; Nakai et al., 2022), and it has become one of the pillars that supports their teaching-departmental development. These resources stand in support of the demands that the current education system must consistently satisfy the rise in new teaching methods equipped with greater flexibility and the ability to generate student-centered learning, which can be also seen in other experiences regarding the development of applications that combine the use of cadaveric material and technology (McMenamin et al., 2014; Moro et al., 2014; Dua et al., 2021). Additionally, within the scope of institutional cooperation, the Internet resources produced from cadaveric material are free to access, so students and instructors from other universities can also use them; however, the impact on other universities has not been measured. This is not a minor point, since these tools were widely used during the Covid-19 pandemic due to the impossibility of attending anatomy buildings, which has been commented on in recent publications (Bauler et al., 2021; Babacan and Dogru Yuvarlakbas, 2022).

In relation to teaching, the authors' anatomy department offers differentiated courses on morphological sciences for the various programs in the faculty of medicine and the different graduate degree programs. The undergraduate programs mentioned in Table 2 include more than 1200 students per year, taught by instructors corresponding to the equivalent of 11 full working days, who perform prosection activities in the laboratories. On the other hand, the graduate degree programs mentioned in Tables 2 and 3 include approximately 200 students annually, who, through prosection, dissection, and surgical training activities can verify the theoretical contents from the source, developing, in addition, basic surgical skills and a suitable three-dimensional conceptualization of the human body. This is highly relevant, since there is consensus among researchers that training with corpses is important for surgeons to understand the anatomical approaches, which increases their knowledge, surgical confidence, and skills, underscoring that dissection contributes significantly to the work of prosection (Hazan et al., 2018; Kobayashi and Nudeshima, 2018; Torres et al., 2018; Sañudo et al., 2021). These findings provide evidence of the role of dissection in learning and the application of practical anatomical knowledge (Thompson and Marshall, 2020; Huynh et al., 2021), surfacing as the first preference of those who study anatomy, and it enables greater knowledge acquisition (Zibis et al., 2021). The benefits of cadaveric anatomy training reflect the real evolution of medicine and its learning (Jansen et al., 2014), and it suggests that dissection be re-established as the primary method of anatomy education to guarantee safe medical practice (Ghosh, 2017; Onigbinde et al., 2021). The evidence and international experiences justify incorporating cadaveric anatomy training in the curricula of medical specialties (Memon, 2018; Dee et al., 2021).

An interesting point to consider is that laboratory work with small groups is effective in the education of human anatomy, especially when the use of samples is varied, combining preparations, plastinated bodies, corpses, body parts, and methods (Chan and Ganguly, 2008; Fu et al., 2022), a material that over the years the authors have managed to produce and are periodically renewed. The practical activities and the structured practical assessments (gymkhanas), carried out on cadaveric preparations, essentially demand

lived experiences in the activities in the anatomy building, being placed above the greater or lesser skill or experience the student has in terms of their school of origin and the initial cultural capital they possess (Inzunza et al., 2017).

With respect to research and institutional collaboration, history shows that by the end of the 19th century, due to the scant supply of morphological training in Chile, it was customary to send young doctors to Europe for graduate training (Cárdenas, 2020). Currently, there are graduate degree offerings in Chile, both master's and doctoral programs in morphological sciences, diploma programs, and continuing education courses. However, the paucity of cadaveric material needed to achieve a representative sample of the population is making researchers in the 21st century repeat the behaviors of the 19th century, having to leave to seek cadaveric material for their research in other institutions, an area in which the authors have been able to collaborate by receiving researchers from external graduate degree programs in their department.

Participation in medical gross anatomy increases students' visual-spatial ability (Lufler et al., 2012; Vorstenbosch et al., 2013); therefore, it is reasonable to think that moving forward, anatomy learning should still be cadaveric-based coupled with complementary technological innovations (Chang Chan et al., 2019; Uruthiralingam and Rea, 2020; Cheung et al., 2021; Iwanaga et al., 2021; Abu Bakar et al., 2022).

Finally, it is only fair to point out that none of these teaching contributions and results would be possible without the invaluable generosity of those who joined the Body Donation for Science and Teaching Program. These people disinterestedly donated their bodies to continue serving life after their death. It is hoped that, with the generation of these academic benefits, the authors will be honoring their donors' wishes.

This study has significant limitations. It is in the context of the national reality of Chile, which is a limitation because there are countries where there is no lack of cadaveric material for the teaching of human anatomy. Therefore, it is possible that some researchers do not identify with the problem.

CONCLUSIONS

The use of cadaveric material is a contribution that strengthens all aspects of academia, teacher training, student learning, and the positioning of institutions: 1) for the management of teaching material, it facilitates the development and production of new resources, avoiding unreasonable costs; furthermore, the generation of these resources is an opportunity to create basic clinical projects that can access competitive funds; 2) for teaching, it represents the best chance to verify the studied theoretical contents empirically, as well as develop surgical skills and abilities; 3) for morphological research and institutional collaboration, it is the generation of new instances of teamwork within the university and with other universities, producing robust research projects that culminate in the publication of results in indexed journals with an impact factor.

University authorities must know and understand these benefits when deciding to use cadaveric material in their institutions. With these results, we hope to encourage them to develop body donation programs for science.

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ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The body was obtained through the Faculty of Medicine donation program at the Pontificia Universidad Católica de Chile (PUC), which complies fully with the World Medical Association's Declaration of Helsinki and national legal and ethical requirements. Consequently, the program was approved by the MED-UC Scientific Ethics Committee of the Pontificia Universidad Católica de Chile (No: 190115002).

REFERENCES

ABU BAKAR YI, HASSAN A, YUSOFF MSB, KASIM F, ABDUL MANAN SULONG H, HADIE SNH (2022) A scoping review of effective teaching strategies in surface anatomy. *Anat Sci Educ,* 15(1): 166-177.

ABDEL EM, KHALIL MK (2017) Measuring medical students' motivation to learning anatomy by cadaveric dissection. *Anat Sci Educ,* 10(4): 363-371.

BABACAN S, DOGRU YUVARLAKBAS S (2022) Digitalization in education during the COVID- 19 pandemic: emergency distance anatomy education. *Surg Radiol Anat,* 44(1): 55-60.

BAULER LD, LESCIOTTO KM, LACKEY-CORNELISON W (2021) Factors impacting the rapid transition of anatomy curricula to an online environment in response to Covid-19. *Anat Sci Educ,* 15(2): 221-232.

BORK F, LEHNER A, ECK U, NAVAB N, WASCHKE J, KUGELMANN D (2021) The effectiveness of collaborative augmented reality in gross anatomy teaching: A quantitative and qualitative pilot study. *Anat Sci Educ,* 14(5): 590-604.

CÁRDENAS VJ (2020) Historia de la anatomía en Chile. Parte II. El alma mater. *Int J Morphol.* 38(4): 1074-1089.

CASADO MI, CASTAÑO G, ARRÁEZ-AYBAR LA (2012) Audiovisual material as educational innovation strategy to reduce anxiety response in students of human anatomy. *Adv Health Sci Educ Theory Pract.* 17(3): 431-440.

CHAN LK, GANGULY PK (2008) Evaluation of small-group teaching in human gross anatomy in a Caribbean medical school. *Anat Sci Educ,* 1(1): 19-22.

CHANG CHAN AY, CATE OT, CUSTERS E, LEEUWEN M, BLEYS R (2019) Approaches of anatomy teaching for seriously resource-deprived countries: A literature review. *Educ Health (Abingdon),* 32(2): 62-74.

CHEUNG CC, BRIDGES S M, TIPOE GL (2021) Why is anatomy difficult to learn? The implications for undergraduate medical curricula. *Anat Sci Educ,* 14(6): 752-763.

CHIPAMAUNGA S, PROZESKY D (2019) How students experience integration and perceive development of the ability to integrate learning. *Adv Health Sci Educ Theory Pract,* 24(1): 65-84.

DEE EC, ALTY IG, AGOLIA JP, TORRES-QUINONES C, VAN HOUTEN T, STEARNS DA, LILLEHEI CW, SHAMBERGER RC (2021) A surgical view of anatomy: perspectives from students and instructors. *Anat Sci Educ,* 14(1): 110-116.

DISSABANDARA LO, NIRTHANAN SN, KHOO TK, TEDMAN R (2015) Role of cadaveric dissections in modern medical curricula: a study on student perceptions. *Anat Cell Biol,* 48(3): 205-212.

DUA A, COPPOLA KM, MULHERON GW, TROUPE D, LEBEAU R (2021) Development of anovel peer-sharing application to supplement learning from cadaveric dissection. *Anat Sci Educ,* 14(4): 491-504.

ESTAI M, BUNT S (2016) Best teaching practices in anatomy education: A critical review. *Ann Anat,* 208: 151-157.

FARFÁN E, CÁRDENAS J, ESPINOSA-NAVARRO O, LIZANA PA, PACHECO J, SALINAS P, RIVEROS A, VILLARROEL M (2021) Profile of morphology teachers in Chilean universities. *Int J Morphol,* 39(6): 1615-1624.

FARFÁN E, SCHNEEBERGER D, BESA J, SALGADO G, INZUNZA O (2016) Web al servicio de la anatomía: Relato de una experiencia docente. *Int J Morphol,* 34(1): 136-142.

FU X, WU X, LIU D, ZHANG C, XIE H, WANG Y, XIAO L (2022) Practice and exploration of the "student-centered" multielement fusion teaching mode in human anatomy. *Surg Radiol Anat,* 44(1): 15-23.

GNANAKUMAR S, KOSTUSIAK M, BUDOHOSKI KP, BARONE D, PIZZUTI V, KIROLLOS R, SANTARIUS T, TRIVEDI R (2018) Effectiveness of cadaveric simulation in neurosurgical training: A review of the literature. *World Neurosurg,* 118: 88-96.

GHOSH SK (2017) Cadaveric dissection as an educational tool for anatomical sciences in the 21st century. *Anat Sci Educ,* 10(3): 286-299.

GUILLOT A, CHAMPELY S, BATIER C, THIRIET P, COLLET C (2007) Relationship between spatial abilities, mental rotation and functional anatomy learning. *Adv Health Sci Educ Theory Pract,* 12(4): 491-507.

HACKETT M, PROCTOR M (2016) Three-dimensional display technologies for anatomical education: A literature review. *J Sci Educ Technol,* 25: 641-654.

HAZAN E, TORBECK R, CONNOLLY D, WANG JV, GRIFFIN T, KELLER M, TRUFANT J (2018) Cadaveric simulation for improving surgical training in dermatology. *Dermatol Online J,* 24(6): 13030/qt5cq2n3vp.

HUYNH N, BURGESS A, WING L, MELLIS C (2021) Anatomy by whole body dissection as an elective: Student outcomes. *J Surg Educ,* 78(2): 492-501.

INZUNZA O (2008) Competencias generales en medicina, rol de la anatomía. *Int J Morphol,* 26(2): 243-246.

INZUNZA O, SCHNEEBERGER D, SALGADO G, CANTIN M (2017) Actividades prácticas en anatomía: Factor nivelador de los contrastes de origen entre los alumnos de medicina. *Int J Morphol,* 35(2): 494-499.

IWANAGA J, LOUKAS M, DUMONT AS, TUBBS RS (2021) A review of anatomy education during and after the COVID-19 pandemic: Revisiting traditional and modern methods to achieve future innovation. *Clin Anat,* 34(1): 108-114.

JANSEN S, COWIE M, LINEHAN J, HAMDORF JM (2014) Fresh frozen cadaver workshops for advanced vascular surgical training. *ANZ J Surg,* 84(11): 877-880.

JOHNSON IP, PALMER E, BURTON J, BROCKHOUSE M (2013) Online learning resources in anatomy: What do students think? *Clin Anat,* 26(5): 556-563.

LEUNG KK, LU KS, HUANG TS, HSIEH BS (2006) Anatomy instruction in medical schools: connecting the past and the future. *Adv Health Sci Educ Theory Pract,* 11(2): 209-215.

LUFLER RS, ZUMWALT AC, ROMNEY CA, HOAGLAND TM (2012) Effect of visual-spatial ability on medical students' performance in a gross anatomy course. *Anat Sci Educ,* 5(1): 3-9.

KAUSAR T, CHANDIO S, QUDDUS I, QURESHI GS, BALOCH ZH, PARIO A (2020) Effectiveness of teaching with visualisation table in comparison to traditional lecture in anatomy department, Jinnah Sindh Medical University. *J Coll Physicians Surg Pak,* 30(10): 1074-1077.

LI Y, GAO D, LIANG W, QIU L, LIU X, ZHANG L, DENG Z (2018) A comparison of malpractice lawsuits mediated and judged in court in China. *J Forensic Leg Med,* 54: 109-113.

MCMENAMIN PG, QUAYLE MR, MCHENRY CR, ADAMS JW (2014) The production of anatomical teaching resources using three-dimensional (3D) printing technology. *Anat Sci Educ,* 7(6): 479-486.

MEMON I (2018) Cadaver dissection is obsolete in medical training! A misinterpreted notion. *Med Princ Pract,* 27(3): 201-210.

MORO C, ŠTROMBERGA Z, RAIKOS A, STIRLING A (2017) The effectiveness of virtual and augmented reality in health sciences and medical anatomy. *Anat Sci Educ,* 10(6): 549-559.

MUSTAFA AG, TAHA NR, ZAQOUT S, AHMED MS (2021) Teaching Musculoskeletal Module using dissection videos: feedback from medical students. *BMC Med Educ,* 21(1): 604.

KOBAYASHI E, NUDESHIMA J (2018) Current state of surgical training using cadavers in Japan compared with Western countries. *Surg Today,* 48(9): 891-893.

NAKAI K, TERADA S, TAKAHARA A, HAGE D, TUBBS RS, IWANAGA J (2022) Anatomy education for medical students in a virtual reality workspace: A pilot study. *Clin Anat,* 35(1): 40-44.

ONIGBINDE OA, CHIA T, OYENIRAN OI, AJAGBE AO (2021) The place of cadaveric dissection in post-COVID-19 anatomy education. *Morphologie,* 105(351): 259-266.

PAECH D, KLOPRIES K, DOLL S, NAWROTZKI R, SCHLEMMER HP, GIESEL FL, KUNER T (2018) Contrast-enhanced cadaver-specific computed tomography in gross anatomy teaching. *Eur Radiol,* 28(7): 2838-2844.

PATHER N (2015) Teaching anatomy: prosections and disections. In: Chan L, Pawlina W (eds). *Teaching Anatomy*. Springer Cham, Heidelberg New York Dordrecht London, pp 213-221.

REHKÄMPER G (2016) Human dissection in medical education: More than just anatomy. *GMS J Med Educ,* 33(5): Doc68.

RIZZOLO LJ, STEWART WB (2006) Should we continue teaching anatomy by dissection when ...? *Anat Rec B New Anat,* 289(6): 215-218.

SADEESH T, PRABAVATHY G, GANAPATHY A (2021) Evaluation of undergraduate medical students' preference to human anatomy practical assessment methodology: a comparison between online and traditional methods. *Surg Radiol Anat,* 43(4): 531-535.

SAÑUDO J, TALARICO E, DUPARC F, VÁZQUEZ T, VALDERRAMA F, MOMPEO B, MIRAPEIX R, ELIZONDO-OMAÑA R, LARKIN T, MCHANWELL S, MARANILLO E, MORIGGL B, KONSCHAKE M (2021a) Practical pregraduate teaching in Human Anatomy: A review. *Eur J Anat,* 25(S1): 81-90.

SAÑUDO J, VÁZQUEZ T, TALARICO E, DUPARC F, PAULSEN F, MACCHI V, FEIGL G, ELIZONDO-OMAÑA R, DE CARO R, ARAGONÉS P, MCHANWELL S, MORIGGL B, KONSCHAKE M (2021b) Practical postgraduate teaching in Human Anatomy: A review. *Eur J Anat,* 25(S1): 91-99.

SINGAL A (2022) Transforming anatomy education: then and now. *Anat Sci Int,* 97(2): 230-231.

STANDRING S (2009) New focus on anatomy for surgical trainees. *ANZ J Surg,* 79(3): 114-117.

STEPHENS GC, REES CE, LAZARUS MD (2021) Exploring the impact of education on preclinical medical students' tolerance of uncertainty: a qualitative longitudinal study. *Adv Health Sci Educ Theory Pract,* 26(1): 53-77.

THOMPSON AR, MARSHALL AM (2020) Participation in dissection affects student performance on gross anatomy practical and written examinations: Results of a four-year comparative study. *Anat Sci Educ,* 13(1): 30-36.

TIZNADO-MATZNER G, BUCAREY-ARRIAGADA S, ARAVENA PC (2019) Recorrido por la realidad de los laboratorios de anatomía humana de 12 Universidades Chilenas. *Int J Morphol,* 37(1): 17-21.

TORRES K, DENISOW-PIETRZYK M, PIETRZYK Ł, MACIEJEWSKI R, TORRES A (2018) Does simulation-based training facilitate the integration of human anatomy with surgery? A report of a novel surgical anatomy course. *Folia Morphol (Warsz),* 77(2): 279-285.

URUTHIRALINGAM U, REA PM (2020) Augmented and virtual reality in anatomical education - a systematic review. *Adv Exp Med Biol,* 1235: 89-101.

YAMMINE K, VIOLATO C (2016) The effectiveness of physical models in teaching anatomy: a meta-analysis of comparative studies. *Adv Health Sci Educ Theory Pract,* 21(4): 883-895.

VISWASOM AA, JOBBY A (2017) Effectiveness of video demonstration over conventional methods in teaching osteology in anatomy. *J Clin Diagn Res,* 11(2): JC09-JC11.

VORSTENBOSCH MA, KLAASSEN TP, DONDERS AR, KOOLOOS JG, BOLHUIS SM, LAAN RF (2013) Learning anatomy enhances spatial ability. *Anat Sci Educ,* 6(4): 257-262.

ZIBIS A, MITROUSIAS V, VARITIMIDIS S, RAOULIS V, FYLLOS A, ARVANITIS D (2021) Musculoskeletal anatomy: evaluation and comparison of common teaching and learning modalities. *Sci Rep,* 11(1): 1517.