IJAE
ITALIAN JOURNAL OF ANATOMY AND EMBRYOLOGY

Firenze University Press
www.fupress.com/ijae

OPEN ACCESS

Citation: Jurand Domański, Marta Wanat, Jacek Ciach, Angelika Osuch, Bożena Kurc-Darak, Sławomir Woźniak, Zygmunt Domagała (2022) Off-line or on-line? – near-peer assisted anatomy education in the time of Covid-19 pandemic – a single center randomized controlled study. *Italian Journal of Anatomy and Embryology* 126(2): 17-24. doi: 10.36253/ijae-13877

Data Availability Statement: All relevant data are within the paper and its Supporting Information files.

Competing Interests: The Author(s) declare(s) no conflict of interest.

ORCID
JD: 0000-0003-2416-8062
MW: 0000-0002-6471-3706
JC: 0000-0002-4219-1445
BK-D: 0000-0003-0491-622X
SW: 0000-0002-7450-7993
ZD: 0000-0002-2317-1932

Off-line or on-line? – near-peer assisted anatomy education in the time of Covid-19 pandemic – a single center randomized controlled study

Jurand Domański[1,*], Marta Wanat[2], Jacek Ciach[1], Angelika Osuch[2], Bożena Kurc-Darak[1], Sławomir Woźniak[1], Zygmunt Domagała[1]

[1] *Division of Anatomy, Department of Human Morphology and Embryology, Wroclaw Medical University, Faculty of Medicine, Wroclaw, Poland*
[2] *Clinical and Dissecting Anatomy Students Scientific Club, Wroclaw Medical University, Wroclaw, Poland*
*Corresponding author. E-mail: jurand.dom@gmail.com

Abstract. The COVID-19 pandemic significantly changed the way anatomy classes were carried out, depriving students of practical learning using real anatomical specimens. Once COVID restrictions were lifted and students returned to a normal class setting a randomized study was carried out to elevate effectiveness of practical anatomy didactics. The aim of this study was to evaluate the impact of an anatomy workshop based on demonstrating anatomical structures delivered in a face-to-face format, and to compare it with a standard course based on online learning. The randomization involved 350 students from whom 80 participants were drawn to form both a study and control group. The study consisted of three parts: exam 1, workshop, exam 2. The study group participated in all parts of the project, while the control group participated only in the exam. The workshop was held by near peer teachers (NPT). Statistical analysis showed that participation in the workshop had an effect on the passing score of exam 2 (p=0.039). It was also shown that the difference in scores was significantly higher (p=0.049) in the study group compared to the control group. The study proved that the workshops which were based on demonstrating anatomical structures by NPT significantly affected the scores obtained by trainees. In conclusion, the project confirmed the importance of student interaction with anatomical specimens and that online teaching is not a substitute for teaching in a dissecting room. Additionally, this study confirmed the high usefulness of NPT as a support for the didactic process conducted by experts.

Keywords: anatomical education, medicine students, human specimen, teaching, Covid, PAL, near-peer teaching.

INTRODUCTION

The didactics of anatomy in Poland differs from other countries in the European Union [3, 4, 20] primarily because the academic teachers play

a dominant role in the learning process, but also the method of teaching is based on anatomical demonstrations. In Germany, teaching of anatomy relies on easily accessible cadavers from the national donation programs. Also important is the didactic activity carried out by medical students in upper years [11], providing young students with direct knowledge from soon-to-be specialists. Some colleges in the United Kingdom shifted the majority of their anatomy course to the post-graduate period, limiting the amount of anatomy classes in the pre-graduate studies. Similarly like in Germany, access to cadavers in the UK is quite easily available, often centralized in a single specialized location [17, 27]. As mentioned earlier teaching anatomy in Poland are structured around the dominance of the academic teacher and their methods of conducting classes as well as preparing specimens. The above mentioned along with the limited availability of cadavers results in practical anatomy classes which are more difficult to conduct [29]. A common solution is demonstrating anatomical structures on previously prepared anatomical specimens [2].

In many European countries as well as in numerous universities in the USA and Canada, a significant portion of the anatomy course consists of practical learning, dissections and preparation of whole cadavers. The theoretical part of classes is limited to an introductory seminar at the beginning of the course [28].

It is worth mentioning that senior medical students play a significant role in these countries, directly influencing the learning process. By taking part in anatomy classes, they generate psychological support for junior colleagues and develop essential teaching skills [12, 26].

In scientific nomenclature, this kind of student teaching is defined as peer-assisted learning [32]. Student-teachers may be peer teachers of students (co-peer teachers) or they may be senior year students - near-peer teachers (NPT) [22].

This is a relatively popular form of education in many countries and it is worth noting that in Germany a near-peer-educator receives a small salary and is employed as a student assistant (personal communication with prof. Lars Brauer, FAU University, Erlangen, Germany).

This type of solution greatly relieves the workload of the staff, who can focus on the individual needs of each student during classes or devote more time towards scientific and organizational activities. Furthermore, near- peer teachers are a necessity due to the shortage of trained and experienced anatomy teachers.

Peer assisted learning has not been implemented in Poland as an educational tool due to legal as well as financial limitations. Students are not recognized by the legislator as academic teachers, so their employment in such a position is impossible. Such decisions are the result of high expectations for academic lecturers in Poland [31].

The system in German universities proves that even when the dominant role is carried out by the academic teacher, there is still room for peer assisted education. It should be emphasized that the Covid 19 pandemic in Poland made access to anatomical preparations significantly more difficult. In many Polish medical universities, as well as in parts of Europe, dissection classes have been abandoned and replaced with online teaching. Depending on the financial status of the university, in-person classes were substituted by short films showing the stages of anatomical dissections/demonstrations and commercially available 3D solutions such as 3D atlases or 3D films of idealized dissections [13, 24, 37]. Upon return to the dissecting room, halfway through the previous academic year, a project was carried out, evaluating the effectiveness of teaching anatomy using real anatomical specimens. In addition, due to NPT-based didactics demonstrated in the global literature [9, 22], it was decided that the students' first exposure to human cadavers should be carried out in a student-friendly atmosphere in order to minimize any stress and simultaneously increase the sensitivity of the study and improve its quality.

The aim of this study was to evaluate the effectiveness of anatomy workshops based on demonstrating anatomical structures using real human specimens, conducted face-to-face, and compare this to a standard course conducted online using available 3D atlases and online presentations and visualizations.

MATERIAL AND METHODS

All (350 individuals, including 230 females and 120 males) 1st year students of the Faculty of Medicine from the year 2020/2021 were invited to participate in the study. 80 study participants in the age range 19-21 years were selected based on randomization techniques (40 participants were qualified to the control group and 40 participants were qualified to the study group). Randomisation was conducted using the computer program - "R" package, version 4.1.2 (The R Foundation for Statistical Computing, Vienna, Austria).The system numerically selected participants from a group of volunteers who volunteered for the project based on their album number. This guaranteed anonymity and randomness of qualification.

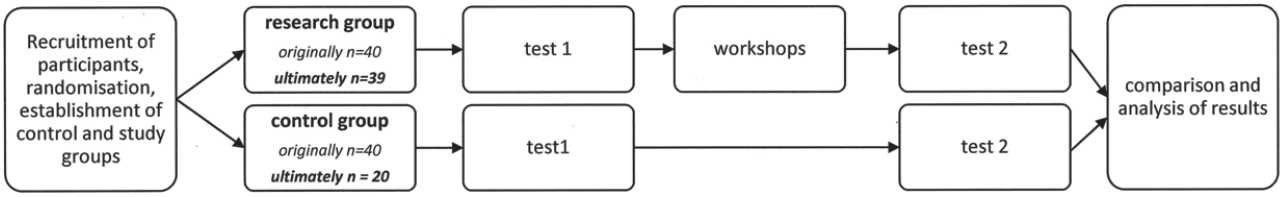

Figure 1. Flow chart of conducting the research project.

During the study, 21 people resigned from both groups (20 people in the control group and 1 person in the study group) for reasons beyond the control of the researchers (lack of consent to continue participation, Covid infection, accidental reasons, fear of the impact of the test result on the final exam, lack of willingness). In order to keep the same conditions of the experiment, no new participants were recruited in their place. Finally, 59 people (25 men, 34 women) participated in the study.

All eligible students were never before exposed to donor specimens/cadaver throughout their anatomical education due to the Covid 19 pandemic restrictions. Each random and qualified participant gave their informed and free willed consent to participate in the study. The limited number of participants in the project was due to restrictions related to the SARS-CoV-2 pandemic. A maximum of 60 subjects could be accommodated in the dissecting rooms at one time.

Recruited participants were coded and then a computer system randomly selected individuals and separated them into a control group as well as a study group (Figure 1). Randomization was conducted by a researcher (ZD) who did not personally know the students or have contact with them at the time of recruitment to the study. The research consisted of three parts: (i) exam 1 (test 1), (ii) workshop, (iii) exam 2 (test 2). The study group participated in all parts of the project and the control group only in the exams (Figure 1). Both groups also participated in a standard course delivered online without access to a dissecting room.

Examination

Each exam consisted of 10 stations with anatomical specimens, 2 arrows (each representing a question) per station (20 arrows in total). The amount of points necessary to pass was set according to the exam regulations published at the beginning of the academic year by the department. On the basis of these regulations standardized sets of questions were prepared from structures similar in area and characterized by a similar level of difficulty. All participants in the study answered the same questions. The test was carried out simultaneously for all groups. The number of stations and the way that the test was organised was such that no exchange of information between students was possible.

The eligibility of pin sets and selected specimens was decided by consensus. A team of experts (ZD,BKD,SW) was responsible for the substantive assessment of the pins/arrows.

The order of the stations was fixed, and each particular anatomical region was associated with a certain position. Each student had 60s per station (30s per question) and station changes were indicated audibly by an electronic timer. Students wrote their answers on answer sheets prepared by the organizers. There was a maximum of 20 answers available and the passing grade of the exam was at least 14 correct answers (70% of the maximum score). The results were checked twice by the same experts. In case of doubts concerning the correctness of an answer, the decision to credit or not to credit the answer was made jointly by two experts. The experts could not see the personal data of the students and did not know whether the test came from a person from the study group or from the control group. Doubts arose when students used similar names or the names of anatomical details located "near" the indicated structure. The rules of assessment were laid down in the exam regulations. Results were published online no later than one week after the examination due to multiple test checks.

Workshops

The workshop included 4 topics. The topics were chosen by the students in an anonymous questionnaire. A total of 8 workstations were created following the suggestions of the respondents. Two students from higher years were assigned to each station (near peer teachers -NPT). NPT student instructors did not attend the first round of exams. The demonstration time at the station was 30 min. followed by a change of student groups. The presentation was limited to the most important, relevant information with emphasis on clues to quickly identify the marked anatomical structure. Continuous supervision of

student tutors was provided by experts (BKD/SW) with over 10 years of experience in anatomy education.

Final evaluation.

In order to evaluate the impact of the workshop and assess its quality, the results of the study group from the first and second test dates were compared and analyzed in relation to the final results of the control group.

Statistical analysis

A significance level of p = 0.05 was assumed for the experimental design. The randomisation and statistical calculations were performed using the statistical package "R", version 4.1.2 (The R Foundation for Statistical Computing, Vienna, Austria) and the PyCharm 2021.2.3 environment (Community Edition, Vienna, Austria), graphing was performed using the ggplot2 library for the R package (R-Studion, Boston, USA) [14]. The software was used to calculate descriptive statistics, non-parametric tests: the Shapiro-Wilk normality test, the McNemar's test, to look for inter-group differences, and a paired Wilcoxon signed rank test with continuity correction and Mann-Whitney test with correction for continuity.

The research project received a positive opinion from the UMW local bioethics committee (No. of approval: 451/2021).

RESULTS

The evaluation of both the control group and the study group showed that 49% of the participants passed the first test and 69% of the participants passed the second test (Table 1). Based on McNemar's test, there is no reason (p=0.37) to reject the hypothesis that retaking the exam, not preceded by a workshop, had no effect on the pass rate in the control group. In the control group, the number of points obtained by students in E2 was significantly higher (p = 0.029) than the number of points obtained in E1 (Wilcoxon signed rank test with continuity correction) (Figure 2).

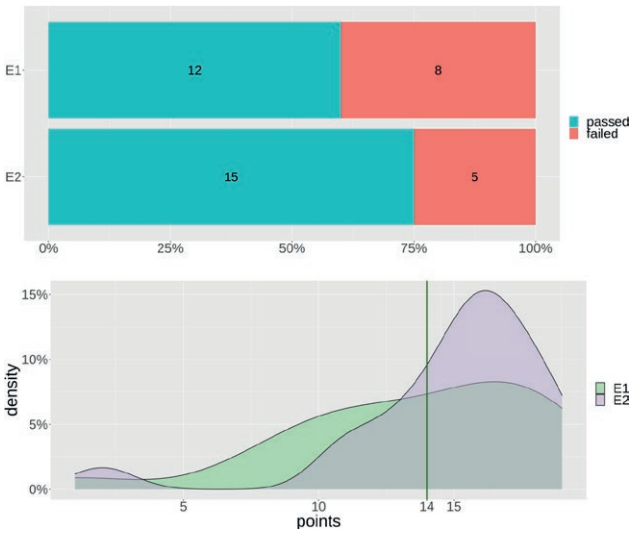

Figure 2. Assessment of the effect of a second attempt on the pass rate and scores in the control group.

Evaluating the impact of workshops on pass rates and scores

It was demonstrated that attending a workshop had an effect on the score pass rate of test 2 (McNemar test; p=0.039) (Figure 3). In the study group, the number of points obtained by students in test E2 is statistically and significantly higher ($p<10^{-4}$) than the number of points gained in test E1 (Wilcoxon signed rank test with continuity correction).

Comparison of the impact of workshops on pass rates and scores between the control and research groups

In the study group the workshops had a significant impact on the pass rate in the group, but at the same time in the control group there is no reason to reject the assumption that the workshops had no impact on the pass rate .

Due to the significantly higher (p=0.042) scores

Table 1. Comparison of all participants' results - pass rate (Z) and number of achieved points, E1-first test, E2-second test, Q- quartile

All participant	N	Z (N)	Z (%)	min	Q1	median	mean	Q3	max
E1	59	29	49%	1.0	9.0	13.0	12.1	16.0	19.0
E2	59	41	69%	2.0	13.0	15.0	14.4	16.5	20.0

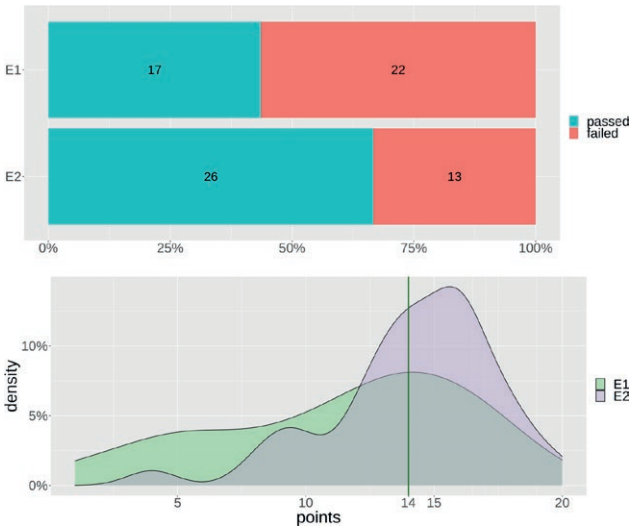

Figure 3. The results of exams in the study group (E1- exam 1 before the workshop, E2- exam 2 after the workshop)

Table 2. Difference in the number of scores in the study group and the control group between examination 1 (E1) and examination 2 (E2); Q- quartile, N-number of participants.

	N	E2 - E1					
		min	Q1	median	mean	Q3	max
Control group	20	- 2.0	0.0	0.0	1.3	2.3	9.0
Study group	39	- 5.0	0.0	2.0	2.9	5.5	11.0

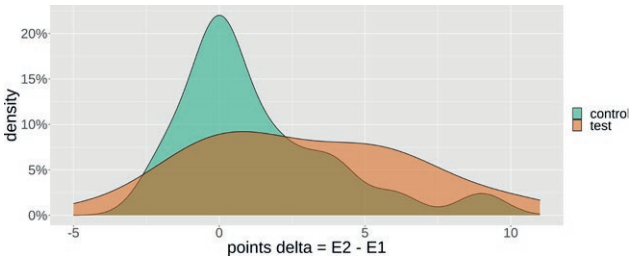

Figure 4. Individual (for each student) differences in the number of credits obtained between E2 and E1 in both groups (E1 - exam 1; E2 - exam 2).

achieved by the students in the control group in test E1 compared to E1 of the study group, and the higher pass rate in E1 and E2 of the control group - in order to compare the effect of the workshops on the number of obtained points - the individual differences in the number of obtained points between E2 and E1 in both groups were calculated (Figure 4). It was shown that the difference in the number of obtained points was significantly higher (p=0.049) in the study group compared to the control group (Table 2) (Mann-Whitney test, Wilcoxon rank sum test with continuity correction).

DISCUSSION

In the present study, the effectiveness of practical training in anatomy was proven. The participants in the control group achieved better results during the second test, which the researchers interpret as the effect of familiarizing the students with this form of examination, training better concentration and developing strategies for completing it.

Furthermore, it has been shown that this result can be improved by a series of demonstrations carried out by the NPT using anatomical preparations made before the start of the study and cadavers obtained through a local conscious donation programme.

The first medical anatomical dissections were initiated in antiquity by Herophilus of Chalcedon (325-255 BC). In contrast, the use of the human body for the systematized study of anatomy was introduced in the late 14th and early 15th centuries by Italian anatomists [19]. The most famous of these (from Brussels) working in Padua- Andrea Vesalius- through the creation of anatomical atlases based on experiments and observations, brought anatomy into medical sciences [10, 30]. The study of anatomy is a challenge that requires the acquisition of a vast amount of knowledge which can only be studied in the appropriate setting. As early as the 16th century, Charles Estienne argued that anatomy can only be learned accurately in specially equipped places [35]. Students themselves used to proclaim that there is no better teacher of anatomy, teacher of empathy and teacher of the human body, than the corpse itself [15]. The topic of concern for the ethos of anatomy and the humanistic basis of medicine, is threatened by the need to digitalize the classroom in the age of the pandemic, as particularly relevant in the twenty-first century [23].

The COVID-19 pandemic made it impossible for students to interact with cadavers and participate in autopsies. While theory can be discussed through distance learning, there is no substitute for dissecting in any way [33]. Among the various methods of teaching anatomy (e.g. dissecting room classes, lectures, e-learning), the most highly rated are those that allow contact with human cadavers, based on demonstrations in small groups of students [6]. The reduced availability of cadavers in some universities has naturally forced the partial replacement of learning at the dissecting table

with teaching using modern technologies. Centers where donor cadavers are still available put an emphasis on the active participation of students in autopsy. Ghosh et al. stated that this is the only possibility that combines theoretical knowledge with medical practice [16].

Current works prove the crucial importance of contact, even limited, with real human bodies in anatomical didactics. Direct exposure to the specimen is a more effective way of learning anatomy than using alternative - digital or traditional - educational techniques. The recent anatomy literature is replaced with articles explaining the advantages of digitization and replacing dissecting classes with classes based on modern information technologies [7, 8, 34].

However, the results obtained here clearly indicate the necessity of great caution in implementing new digital technologies and abandoning the traditional form of anatomy classes. The qualitative advantage of typical dissecting classes over online classes in anatomy teaching has been proven, demonstrating the importance of contact with the specimen in gaining a better understanding of human morphology, as demonstrated in this publication.

It is worth noting that the high usefulness of workshops co-delivered by students from higher years of study - (NPT) has already been demonstrated [5].

The hybrid workshop based on NPT and experienced teachers used in the present study therefore meets the recommendations from scientific papers. [36]. The form of classes conducted in the relationship between a student of first year and a student of the senior years, allows diversity in methods of acquiring knowledge, supports the development and broadens the scientific horizons of students interested in teaching, and also constitutes a certain facilitation for academic teachers. It is worth highlighting that this type of assistance takes place in European countries on a paid basis (Bugaj et al., 2019). The effectiveness of the so-called peer-assisted learning can be evidenced, among other things, by the fact that this solution is an academic everyday feature of many universities across Europe, including Germany [20] .

The high effectiveness of NPT in anatomy teaching demonstrated in current work can be attributed to the fact that, students who have recently studied a subject may have a better understanding of the difficulties in learning the given subject and therefore may be better equipped to help students overcome these difficulties [18, 25].

The creation of a positive atmosphere is important for students who are beginning their studies in combination with higher level of teaching would give rise to considerations of introducing peer student assistance from older colleagues permanently into the medical school curriculum.

It has been proven that NPT is perceived positively by educated students. It offers the opportunity to improve educational outcomes while reducing the teaching load of teachers. Therefore, when integrated with other teaching methods, peer teaching can be a viable resource in the pursuit of excellence in future teaching of anatomy [1].

CONCLUSIONS

It has been shown that retaking the exam in a similar format increases the chances of passing the learned anatomical material. It has been also proved that the introduction of workshops based on the demonstration of anatomical structures by NPT significantly affects the results obtained by trainees. In conclusion, this project has confirmed the important role of student contact with the anatomical specimen. Additionally, the usefulness of NPT as a support in the didactic process carried out by experts – University employees – was confirmed. The study indirectly suggests that weeks of restricted access to dissection-based teaching or even anatomical demonstration may have a negative impact on the development of future physicians.

LIMITATIONS OF THE STUDY

The study has some important limitations:

1. Covid-19 pandemic constraints contributed to the need to limit the study and control groups.
2. Time constraints contributed to limiting the scope of the material discussed and the duration of the workshop.
3. the nature of the study was related to only one anatomical topic.
4. only selected topics from the anatomy course were discussed.
5. the theoretical knowledge of the students was not assessed

ETHICAL STATEMENT

Approval from the local bioethics committee was obtained for the purpose of the study.

ACKNOWLEDGMENTS

The authors of the study would like to thank Mr Andrzej Mrozek for his selfless work and knowledge,

with which he supported the realization of the project. Thanks to the members of the Clinical and Dissecting Anatomy Students Scientific Club and the members of "Vertex" Scientific Club for organizing the workshop for younger colleagues.

According to the new recommendations [21] all authors sincerely thank those who donated their bodies to the science so that anatomical research could be performed. Results from such research can potentially increase mankind/s overall knowledge that can then improve patient care. Therefore, these donors and their families deserve our highest gratitude.

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