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Trends in Teaching Human Anatomy in Russian Medical Universities Based on Publications from 2015 to 2024

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ABSTRACT

BACKGROUND: Over the past decade, the teaching of human anatomy in Russian medical universities has undergone significant changes due to several factors. The collapse of the Soviet system for supply of anatomical materials for educational purposes is the most important in this series. It resulted in a significant reduction in the visual clarity of teaching and has relegated practical dissection skills to the background. The second remarkable factor was the COVID-19 pandemic in 2019–2021, which disrupted traditional teaching formats and accelerated the adoption of distance learning methods. The third factor is a widespread integration of modern diagnostic imaging techniques into the curriculum, including X-ray, computed tomography, magnetic resonance imaging, multislice computed tomography, ultrasound, and positron emission tomography. The fourth trend is the implementation of advanced technologies for the preparation and preservation of anatomical specimens, such as polymer embalming, plastination, and corrosion casting. It is also important to consider the characteristics of today's students, shaped by the specifics of their school education, the influence of the internet industry, and a generally high standard of living.

AIM: The work aimed to analyze current features in teaching human anatomy in Russian medical universities based on Russian scientific publications from 2015 to 2024.

METHODS: Information on the teaching of human anatomy in Russian medical universities from 2015 to 2024 was obtained through an analysis of available published sources indexed in the Russian Science Citation Index. A total of 438 keywords and 96 publications were analyzed.

RESULTS: A shift in focus has been observed: away from the discussion of traditional aspects such as the use of cadaveric anatomical specimens, dissection, Latin terminology, and the significance of the instructor's personality, and toward innovative teaching methods, psychological aspects of learning, and the role and position of students in the educational process.

CONCLUSION: Based on the publication analysis, the authors propose that, alongside traditional approaches, the development of education using multimedia platforms (particularly interactive anatomy tables) as well as the expanded use of anatomical museum resources may represent a promising area of growth in the teaching of human anatomy.

Keywords: anatomical museum; human anatomy; interactive anatomy table; medical university; scientometrics; teaching of human anatomy; educational process.

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Тенденции преподавания анатомии человека в медицинских вузах России по данным публикаций за 2015–2024 годы

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АННОТАЦИЯ

Обоснование. За последнее десятилетие в преподавании учебной дисциплины «Анатомия (человека)» в медицинских вузах произошли существенные изменения, обусловленные целым рядом причин. На первое место следует поставить разрушение советской системы обеспечения учебного процесса анатомическим материалом, что привело к значительному снижению наглядности преподавания и смещению на второй план практических навыков препарирования. Второе место занимают последствия пандемии новой коронавирусной инфекции в 2019–2021 годах, которая изменила традиционные направления преподавания и способствовала развитию дистанционных форм обучения. На третьем месте стоит широкое внедрение в учебный процесс по дисциплине современных методов исследования: рентгенографии, компьютерной томографии, магнитно-резонансной томографии, мультиспиральной компьютерной томографии, ультразвукового исследования, позитронно-эмиссионной томографии и др. На четвертом месте находится внедрение новых технологий изготовления и хранения анатомических препаратов — полимерное балъзамирование, пластинация, коррозия и др. Не стоит исключать из рассмотрения и особенности нынешних студентов, которые обусловлены спецификой базовой подготовки в школе, влиянием интернет-индустрии и высоким уровнем жизнеобеспеченности.

Цель исследования — проанализировать особенности преподавания анатомии человека в медицинских вузах на основе отечественных научных публикаций за период с 2015 по 2024 год.

Материалы и методы. Сведения о преподавании анатомии человека в медицинских вузах в период с 2015 по 2024 год были собраны путём анализа доступных литературных источников, проиндексированных в базе данных Российского индекса научного цитирования. Анализировали ключевые слова, всего использовано 438 ключевых слов и 96 публикаций.

Результаты. Выявлено смещение фокуса внимания от обсуждения вопросов преподавания с использованием натуральных анатомических препаратов, диссекции, латинской терминологии и важности личности преподавателя в сторону инновационных методов обучения, психологии, а также роли и места студентов в образовательном процессе.

Заключение. Опираясь на результаты анализа публикаций, авторы предполагают, что одной из новых точек роста в области преподавания анатомии человека, наряду с традиционными формами, может стать развитие обучения с использованием мультимедийных платформ (в частности, интерактивного анатомического стола), а также более широкое привлечение ресурсов анатомических музеев.

Ключевые слова: анатомический музей; анатомия человека; интерактивный анатомический стол; медицинский вуз; наукометрия; преподавание анатомии человека; учебный процесс.

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2015–2024年俄罗斯医科大学人体解剖学教学趋势：基于学术出版物的数据

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摘要

论证。过去十年间，俄罗斯医科大学《人体解剖学》课程的教学体系发生了显著变化，主要由多方面因素所致。首先，苏联时期解剖教学中用于保障教学的标本供应体系被瓦解，导致教学直观性明显下降，解剖操作技能训练的地位也随之下降。其次，2019—2021年新冠疫情的影响改变了传统教学方式，推动了远程教学的发展。第三，在解剖学课程教学过程中广泛引入现代医学影像技术，如X线检查、计算机断层扫描、磁共振成像、多层螺旋计算机断层扫描、超声检查、正电子发射断层扫描等。第四，在教学过程中引入了新型的解剖标本制作与保存技术，如聚合物防腐、塑化、腐蚀法等。此外，不容忽视的还有当前医学生的特点，其形成受到基础教育特点、互联网产业影响以及生活水平提高等因素的影响。

目的。基于2015—2024年间俄罗斯学术出版物，分析医科大学人体解剖学教学的特点。

材料与方法。通过分析2015—2024年间被俄罗斯科学引文索引收录的公开文献，收集医科大学人体解剖学教学的相关信息。共纳入96篇文章，提取并分析438个关键词。

结果。研究发现，当前解剖学教学的关注重点逐渐由传统的解剖标本教学、尸体解剖训练、拉丁术语应用及教师角色等，转向对教学创新方法、学习心理因素以及学生在教学过程中的参与度与主导地位的探讨。

结论。根据文献分析结果，作者认为，在保留传统教学形式的同时，发展基于多媒体平台的教学（特别是交互式解剖台）以及更广泛地利用解剖学博物馆资源，可能成为人体解剖学教学的新增长点。

关键词：解剖学博物馆；人体解剖学；交互式解剖台；医科大学；科学计量；人体解剖学教学；教学过程。

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BACKGROUND

The post-COVID-19 period has set new tasks for the discipline of Human Anatomy, requiring an in-depth study of the following aspects: anatomical variations; congenital malformations; individual, age-related, sex-specific, and typological features of various anatomical structures. In addition, up-to-date information on microscopic anatomy and modeling of structural-functional relationships in health and disease is needed [1]. Forecasting the development of the discipline is extremely important and should be based on evidence, which will help reduce the risk of errors in assessing trends in educational practice and clarify the role and place of the discipline in the system of comprehensive medical training. This goal requires a detailed analysis of current teaching practices, primarily by reviewing publications devoted to this topic.

This work aimed to assess the specific features of teaching human anatomy in Russian medical universities based on the analysis of Russian scientific publications over the past 10 years.

METHODS

Study Design

This study was based on an analysis of 96 full-text Russian-language articles published between January 2015 and June 2024. The search was conducted in the Russian Science Citation Index (RSCI) database using keywords related to *anatomy* and *education*.

Eligibility Criteria

Exclusion criteria: authorship or source affiliation with nonmedical universities or with departments of topographic anatomy or anatomic pathology within medical universities. A total of 96 publications were included in the final analysis.

For each selected publication, combinations of keywords were recorded. Single-occurrence terms and combinations were excluded from further analysis, as their presence may have been occasional and not reflective of trends in the field.

Statistical Analysis

The statistical analysis was conducted using Microsoft Excel spreadsheets. Graphs were plotted using the obtained results. Developmental trends were evaluated by constructing a distance matrix of keywords in Excel, with conceptual proximity defined as co-occurrence within the same publication [2]. Visualization of keyword networks was performed using Gephi 0.10.1 (Université de Technologie de Compiègne, France). Terms with only a single link to *human anatomy* were excluded. The Force Atlas layout algorithm was applied to construct keyword networks for 2015–2024. In order to assess the changes in the frequency of keywords and combinations, results were calculated separately for 2 intervals: 2015–2019 (59%, 57 publications) and 2020–2024

(41%, 39 publications). The network analysis allowed for the synthesis of data from the reviewed studies.

RESULTS

Primary Results

A total of 438 analyzed keywords and phrases (terms), 1054 paired combinations were analyzed. On average, each publication contained 4.6 terms and 11 combinations. A total of 45 terms and 75 combinations occurred more than once. Table 1 presents the terms that appeared 4 or more times.

As 2020 became a turning point for all Russian medical universities, and the subsequent changes during and after the COVID-19 period substantially modified the methodology of teaching human anatomy, particularly through the increased use of innovative computer technologies, we further focused on the 2020–2024 interval.

All analyzed terms can be divided into 3 groups. Group 1 includes terms that were more frequently encountered in 2020–2024 ($\geq 75\%$ of occurrences). These terms include *innovative learning*, *pedagogy*, *psychology*, *practical method*, and *students*. Based on this trend, it may be expected that the frequency of these terms in publications devoted to teaching *human anatomy* will continue to increase.

Group 2 includes terms less frequently encountered in 2020–2024 ($\leq 40\%$ of occurrences): *Latin terms*, *3D anatomy*, *dissection*, *interactive learning*, *clinical reasoning*, *instructor's personality*, *curriculum*, *human anatomy*, and *anatomical specimens*. The observed trends suggest that, unfortunately, the frequency of this group of terms in publications addressing the educational process in human anatomy is likely to decrease.

Group 3 represents the main body of terms (words and phrases) whose frequency remained relatively stable throughout the study period. The structure of interrelationships among key concepts (words and phrases) is shown in Fig. 1.

DISCUSSION

Summary of Primary Results

Our study demonstrated that some substantial changes have occurred in the teaching of human anatomy in recent years. Innovative methods involving computer technologies are replacing classical approaches based on cadaveric anatomical specimens.

Discussion of Primary Results

The changes observed in the teaching of human anatomy after 2020 were partly associated with the coronavirus disease 2019 (COVID-19) pandemic, which is consistent with the findings of other authors [3, 4]. In March 2020, all Russian universities shifted to distance learning because of the epidemiological situation. However, the experience gained in this format has shown that no remote learning platform can fully substitute in-person training. The main reason

Table 1. Frequency of keywords in the analyzed publications

Term (keyword or phrase)	Occurrence			
	Number of cases			Percentage
	Total	2015–2019	2020–2024	2020–2024
Human anatomy #	60	37	23	38
Higher education	22	12	10	45
Teaching	21	11	10	48
Anatomical specimens #	13	8	5	38
Teaching methods	10	5	5	50
Distance learning	9	4	5	56
International students	9	5	4	44
Innovative learning *	7	1	6	86
Pedagogy *	6	1	5	83
Psychology *	6	1	5	83
Surveying	5	3	2	40
3D anatomy #	4	3	1	25
Dissection #	4	3	1	25
Interactive learning	4	3	1	25
Quality of education	4	2	2	50
Clinical reasoning #	4	3	1	25
Latin terminology #	4	4	0	0
Instructor's personality #	4	3	1	25
Curriculum #	4	3	1	25
Polymer embalming (plastination)	4	2	2	50
Practice-oriented learning *	4	1	3	75
Problem-based learning	4	2	2	50
Modern approaches to learning	4	2	2	50
Students *	4	1	3	75

Note. * Terms with increased frequency in 2020–2024 ($\geq 75\%$); # Terms with decreased frequency in 2020–2024 ($\leq 40\%$).

is the need to work with cadaveric anatomical specimens [1, 5–8]. At the same time, our analysis revealed a decline in the frequency of the term *anatomical specimen* in the Russian scientific publications since 2015.

Currently, the acquisition, preparation, and storage of anatomical specimens, as well as religious, cultural, and ethical restrictions, have contributed to the decreasing emphasis on traditional approaches to teaching human anatomy [9, 10]. According to Federal Law of the Russian Federation No. 323-FZ *On the Fundamentals of Health Protection of Citizens*, dated November 21, 2011, the use of human remains for medical, scientific, and educational purposes is permitted only under the following conditions:

- The body is unclaimed or there is notarized lifetime consent.
- The identity of the deceased is established.
- Permission is granted by the authorities that ordered the forensic examination.

In practice, however, full compliance with these requirements is challenging [7, 8]. Nevertheless, according to E.S. Ershova [11], assistant professor at the Department of Human Anatomy, Kursk State Medical University, “there is a revival of the traditional method of cadaveric dissection in anatomy education” [11], which highlights the importance of the systematic scientometric analysis to evaluate the development of human anatomy.

It should also be noted that as interest in cadaveric specimens has declined, the frequency of terms such as *innovative technologies*, *polymer embalming*, and *plastination* has increased.

Our findings also indicate a growing frequency of terms such as *pedagogy*, *psychology*, and *students* in publications. Over the past decade, the practice of surveying students to evaluate their satisfaction with the educational process has made it possible to consider learners’ perceptions of faculty competence and the organization of teaching activities. The

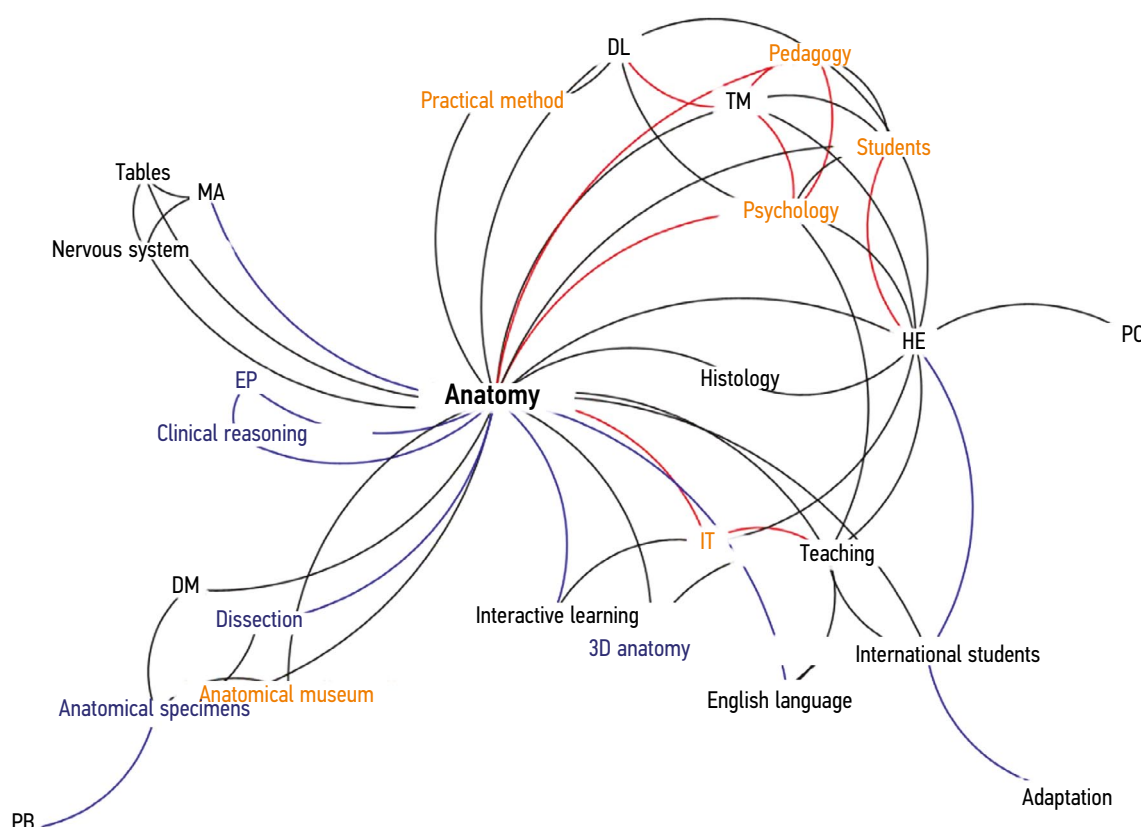


Fig. 1. Relationships between keywords: HE, higher education; PC, professional competencies; IT, innovative teaching; DL, distance learning; TM, teaching methods; EP, educational program; DM, dissection methods; PB, polymer embalming; MA, modern approaches to teaching. The terms most frequently encountered in the publications are highlighted in bold; the terms with increasing frequency and their associations are marked in red; those with decreasing frequency and their associations are marked in blue.

analysis of various surveys has revealed psychological difficulties associated with the study of human anatomy [12].

The data from Kursk State Medical University indicate that students may have attention deficit, hyperactivity, dyslexia, and difficulties with correct pronunciation of Latin terms [13]. Additionally, challenges are observed in formulating detailed responses, providing arguments, and reading large volumes of text. During lectures, students often find it difficult to identify the key points [3].

It has been suggested that the ability for abstract logical thinking emerges in students only after the age of 20 years. Therefore, for first-year students, cadaveric anatomical specimens and high-quality visual teaching aids are essential [1, 3]. The preferred standard of contemporary education is textbooks and manuals that present material in the form of the most common and universal patterns [14].

We noted that after 2020, the term *anatomical museum* has become more common in publications. The use of anatomical museums remains a traditional method of teaching human anatomy in Russian medical universities, as nearly every department of human anatomy maintains such a collection. Authors of nearly all publications mentioning this term emphasize that the most valuable feature of anatomical museums for teaching is the availability of specimens illustrating individual, sex-specific, and typological variations in human anatomy. For instance, the

authors from the Russian State Medical University reported that anatomical museum displays are filled with unusual and unique exhibits, including specimens illustrating pathological changes, congenital malformations, and other abnormalities [15]. At the Department of Human Anatomy, Prof V.F. Voyno-Yasenetsky Krasnoyarsk State Medical University, the museum houses a collection of specimens illustrating developmental anomalies [16]. The Fundamental Museum of the Department of Normal Anatomy at the Military Medical Academy contains both the specimens representing systematic anatomy and a unique teratological collection of approximately 150 exhibits, including more than 50 rare specimens that illustrate individual anatomical features, age-related changes in various organs, and striking examples of typical pathologic processes [1]. The exhibition hall of the Department of Normal Anatomy at the Military Medical Academy is also popular among medical students and high school students; it presents specimens that comparatively demonstrate normal anatomy, pathologic anatomy, and the effects of harmful habits on the human body.

We assume that in the context of limited access to cadaveric material for teaching, combining the resources of anatomical museums with innovative educational technologies, helping students overcome psychological barriers, may become a breakthrough direction in the development of anatomy education in Russia. To some

extent, this is supported by the growing use of the interactive Pirogov anatomical table (Synergy Research and Production Association, Russia), which has been the focus of several recent publications [9, 17].

The uniqueness of the interactive anatomical table lies in its ability to simulate the structural organization of male and female bodies at different levels. In addition, the virtual environment allows simulating surgical approaches used in operative procedures, as well as analyzing the imaging data from computed tomography and magnetic resonance imaging, which are of great significance for applied anatomy education. The interactive table increases student engagement and enables learners to model their own approaches to studying the material [17].

To further enhance visualization in teaching, the Department of Normal Anatomy at the Military Medical Academy, in collaboration with RedFab (Russia), has begun developing original 3D models using 3D printing technologies. These models are based on digital processing of cadaveric specimens and classical teaching aids, as well as the creation of virtual anatomical models employing augmented reality and VR technologies [18].

It should be emphasized that despite the growing use of innovative technologies, the demonstration of anatomical variation in educational and fundamental museums remains a classical method for studying individual differences in organs as well as anomalies and congenital malformations.

According to Nikolenko [19], there is a need to “synchronize” traditional instruction with modern educational technologies, including the use of new visual and teaching tools, ranging from standard smartphones to advanced devices. However, it is important to note that even the most advanced interactive technologies cannot replace cadaveric dissection, which remains an essential component of high-quality medical education [1, 20].

CONCLUSION

Over the past decade, the teaching of human anatomy in Russian medical universities has shifted its focus away from the use of cadaveric specimens, mandatory dissection of human body regions, and the mastery of Latin terminology, toward the adoption of innovative educational technologies.

The authors firmly believe that traditional methods of anatomy teaching, including the obligatory use of cadaveric specimens and dissection, must be revitalized, as these practices distinguished the Russian anatomical school and ensured the training of highly qualified physicians. The preparation of anatomical specimens also enriched the collections of anatomical museums, which display rare exhibits illustrating typical and variant anatomy, congenital anomalies, and developmental defects.

At the same time, the integration of modern educational technologies, such as interactive anatomical tables and various digital and multimedia formats, into the teaching of

human anatomy will undoubtedly enhance student motivation and foster the development of clinical reasoning skills.

ADDITIONAL INFORMATION

Author contributions: I.V. Gaivoronsky: conceptualization, data curation, writing—review & editing; V.V. Krishtop: conceptualization, data curation, writing—original draft; G.I. Nichiporuk: data analysis, writing—original draft; M.G. Gaivoronskaya: writing—original draft, writing—review & editing; A.A. Semenov: investigation, writing—original draft; P.S. Paschenko: investigation, writing—original draft. All the authors approved the version of the manuscript to be published and agreed to be accountable for all aspects of the work, ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Data availability: All data obtained in the present study are presented in the article.

Generative artificial intelligence: No generative artificial intelligence technologies were used in the creation of this article.

Review and peer review: This work was submitted to the journal on an unsolicited basis and reviewed through the standard procedure. The review process involved two external peer reviewers, a member of the editorial board, and the journal's scientific editor.

ДОПОЛНИТЕЛЬНАЯ ИНФОРМАЦИЯ

Вклад авторов. И.В. Гайворонский — определение концепции, работа с данными, пересмотр и редактирование рукописи; В.В. Кришток — определение концепции, работа с данными, написание черновика рукописи; Г.И. Ничипорук — анализ данных, написание черновика рукописи; М.Г. Гайворонская — написание черновика рукописи, пересмотр и редактирование рукописи; А.А. Семенов — проведение исследования, написание черновика рукописи; П.С. Пашенко — проведение исследования, написание черновика рукописи. Все авторы одобрили рукопись (версию для публикации), а также согласились нести ответственность за все аспекты настоящей работы, гарантируя надлежащее рассмотрение и решение вопросов, связанных с точностью и добросовестностью любой её части.

Источники финансирования. Отсутствуют.

Раскрытие интересов. Авторы заявляют об отсутствии отношений, деятельности и интересов за последние три года, связанных с третьими лицами (коммерческими и некоммерческими организациями), интересы которых могут быть затронуты содержанием статьи.

Доступ к данным. Все данные, полученные в настоящем исследовании, представлены в статье.

Генеративный искусственный интеллект. При создании настоящей статьи технологии генеративного искусственного интеллекта не использовались.

Рассмотрение и рецензирование. Настоящая работа подана в журнал в инициативном порядке и рассмотрена по обычной процедуре. В рецензировании участвовали два внешних рецензента, член редакционной коллегии и научный редактор издания.

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