Development of an Electronic Archive "Rehabilitation after Soft-Tissue Lesions of the Knee Complex" for the Post-Graduate Medical and Health Professions Education

Radoslav R. Yoshinov[1], Borislav R. Yoshinov[2], Ivet B. Koleva[3, 4, 5][0000-0002-1511-9632]

[1] University of Library Studies and Information Technologies, 119 Tsarigradsko Shose Blvd., 1784 Sofia, Bulgaria
[2] University Hospital for Active Care St Ivan Rilski, 15 Acad. Ivan Evstratiev Geshov Blvd., 1431 Sofia, Bulgaria
[3] Medical University of Sofia, 15 Acad. Ivan Evstratiev Geshov Blvd., 1431 Sofia, Bulgaria
[4] Specialized Hospital for Long-Term Care and Rehabilitation Serdika, 5 Nikola Gabrovski Street, 1172 Sofia, Bulgaria
[5] National Heart Hospital, 65 Konovitsa Street, 1331 Sofia, Bulgaria
radoslav.yoshinov@gmail.com, borislavyoshinov@gmail.com, yvette@cc.bas.bg

Abstract. The objectives of the current article include the preservation of the scientific heritage of Bulgarian Ortho-rehabilitation school through development of an electronic archive in the field of "Orthopedic Rehabilitation of soft-tissue lesions of the knee complex", and analysis of the efficacy of its application in the post-graduate medical and healthcare education.

Keywords: Digital Medical Resources, Electronic Archive, Knee Soft-tissue Injuries, Orthopedic Rehabilitation, Post-graduate Medical Education.

1 Introduction

1.1 Electronic Learning and Electronic Archives

Electronic learning (e-learning) is defined as "the use of modern multi-media technologies and Internet, to enhance the quality of education" (Dochev et al., 2000). The terms distance learning, web-based learning, computer-based training and Internet-based training are often used interchangeably in the literature.

The development of e-learning, initially supported by electronic libraries, began in the late twentieth century. However, the COVID-19 pandemic significantly accelerated the digital transformation of education (Zhao, 2024; Zou et al., 2025). As a result, e-learning adoption has expanded rapidly, with projections suggesting growth of up to 250% by 2026 (Peck, 2025).

Commonly used digital learning resources in contemporary education include: online educational videos, educational applications and software, digital libraries, web-

assisted courses, blended (hybrid) learning formats, fully online courses, research-oriented websites, e-books, simulations and virtual reality environments, augmented reality tools, skill-oriented educational games, etc. (Zou et al., 2025; Cahyani & Aminudin, 2025).

1.2 Post-graduate Education in Medicine and Healthcare

Education in the medical field is an extremely complex process that requires the integration of theoretical knowledge and practical clinical skills (World Federation for Medical Education, 2015).

Recently, we observe an increasing interest to the post-graduate medical education in the areas of clinical medicine and healthcare (Guraya et al., 2025). We moved from the traditional paradigm of reproduction of the undergraduate strategies to a more practical approach of adaptation to the needs of clinical practice, integrating illness script-formation, problem-solving learning, improvement of clinical reasoning and clinical decision-making of learners (Lubarsky et al., 2015; Parsons et al., 2020). For evaluation of competencies, we apply test-enhanced learning and direct observation of trainees' performance (Lubarsky et al., 2015; Parsons et al., 2020). The contemporary evaluation of competencies incorporates modern assessment strategies, including test-enhanced learning and direct observation of trainees' clinical performance (Baker et al., 2015; Singh et al., 2025). The actual globalization of the information facilitates the scientific exchange and the development of a practice-targeted learning and skill gaining. Educators transfer their interest to the development of competencies, integrating the knowledge to clinical care. An individualization of the approach is observed – trainee-centered education, as well as a patient-centered care.

Fig. 1. Specific characteristics of post-graduate education in clinical rehabilitation for medical specialists and healthcare professionals.

In the field of rehabilitation practice, we shift the paradigm with innovations of educational concepts, development of under-graduate and post-graduate education (including electronic learning and use of digital libraries), and changes in the evaluation methods (Fig. 1).

1.3 Specificity of the Bulgarian Ortho-rehabilitation School

The Bulgarian Rehabilitation School was established in the mid-twentieth century, alongside the creation of the medical specialty "Physiotherapy and Rehabilitation" (later renamed to "Physical and Rehabilitation Medicine" in 2004), as well as the corresponding scientific society. Over the past five decades, numerous medical doctors – specializing in Physical and Rehabilitation Medicine (PRM) and in Orthopedics and Traumatology (OT), have contributed to the field of functional recovery in patients with orthopedic diseases and traumatic conditions, with emphasis in the post-operative period. These specialists laid the clinical foundations of the Bulgarian School of Orthopedic Rehabilitation in the late 1960s. By the end of the twentieth century, the introduction of modern minimally invasive orthopedic techniques (such as arthroscopy and robotic surgery) for the treatment of soft tissue injuries, led to the corresponding adaptation and advancement of the approaches in rehabilitation.

Traditionally, the Bulgarian Ortho-Rehabilitation School demonstrates a strong interest in the functional anatomy of the locomotor system and emphasizes detailed pathokinesiological analysis of the consequences of musculoskeletal lesions (Fig. 2). Detailed functional assessment of the affected structures serves as the basis for developing individualized rehabilitation programs that integrate both traditional and contemporary physical modalities, including active exercises, soft-tissue techniques, cryotherapy, underwater gymnastics, and preformed physical modalities (electric currents, magnetic field, laser therapy, etc.).

Fig. 2. Ortho-rehabilitation algorithm for soft-tissue lesions of the knee complex.

The aim of the present work is to preserve the scientific traditions and clinical experience of the Bulgarian Ortho-Rehabilitation School through the development of a digitalized repository intended for postgraduate education of medical doctors – residents in Physical and Rehabilitation Medicine (PRM), as well as for physiotherapists, working in this field.

2 Exposition of the Investigation

2.1 Objective

The objective of this study was to develop an electronic archive entitled "*Rehabilitation in Soft-tissue Lesions of the Knee Complex*" and to assess its impact on the professional competencies of PRM-trainees and physiotherapists, involved in the rehabilitation of such patients.

2.2 Design of the Study

A digital archive was developed, based on the traditions of Bulgarian Orthopedic School and our own clinical experience. Parallel to this, an electronic postgraduate educational course was designed for PRM-trainees and physiotherapists, working in this field.

The course was conducted twice, with adaptation to accommodate different professional levels and clinical roles within the interdisciplinary orthopedic rehabilitation team: first for medical doctors (PRM residents), and subsequently for health professionals. These postgraduate courses were incorporated into the Long-Life-Learning (LLL) educational plan of the Bulgarian Association of Healthcare Professionals. In addition, courses for medical doctors – PRM trainees, were included in the postgraduate residency training in Physical and Rehabilitation Medicine – at the Specialized Hospital for Long-Term Care and Rehabilitation "Serdika" in Sofia. The project and its outcomes were presented at national scientific forums organized by the Bulgarian Association of Physical Medicine and Rehabilitation.

Both the educational courses and the digital repository were delivered through the corresponding electronic learning platforms of the Medical University of Sofia and the Bulgarian Association of Healthcare Professionals.

Participation in the courses and access to the digital archive were provided *free-of-charge* for learners.

Each course concluded with an **online test** assessing theoretical knowledge (scored from 0 to 100 points) and a **practical examination** evaluating practical clinical skills (graded on a scale from *Poor 2* to *Excellent 6*). At the end of each course, and prior to the release of examination results, participants were invited to complete an **anonymous online questionnaire** evaluating their feedback regarding the course and the electronic archive.

Statistical analysis of the results was performed using IBM SPSS Statistics.

2.3 Structure and Contents of the Electronic Archive

As mentioned, one of our primary objectives was to integrate the traditional clinical approach of the Bulgarian school of Orthopedic rehabilitation, developed over the last five decades, into the educational process of members of the ortho-rehabilitation team, including medical doctors and physiotherapists. Initially, this content formed a part of

a general archive in Physical and Rehabilitation Medicine (Koleva et al., 2025-b); however, with the expansion of materials, a dedicated library of specialized resources was subsequently established. The aforementioned electronic archive integrates traditional scientific resources, contemporary clinical guidelines, and educational materials related to the topic "*Rehabilitation after Soft-Tissue Lesions of the Knee Complex*" (Fig.3). The content included information on the normal anatomy and biomechanics of the knee (Tria & Klein, 1992; Chhabra et al., 2002), as well as kinesiological analysis and pathokinesiological abnormalities associated with knee disorders (Toutoungi et al., 2000). Fundamental aspects of functional assessment were also addressed (Petty & Moore, 2003; Shankman, 2004; Laver Fawcet, 2007). In terms of management, we incorporated the core principles of orthopedic and rehabilitation treatments (Beynnon et al., 2005a; Beynnon et al., 2005b; De Lisa, 2005; Koleva et al., 2020). Particular emphasis was placed on both traditional and contemporary rehabilitation methods (Londono, 2001; Plaja, 2003; Hebgen, 2013; Tapanez, 2012; Koleva et al., 2025-a).

Presentations of selected clinical cases were also included in the archive.

In addition, the archive contains our own books on the topics "*Orthopedic Rehabilitation*" and "*Rehabilitation in Soft-Tissue Lesions of the Knee Complex*" (Fig.4).

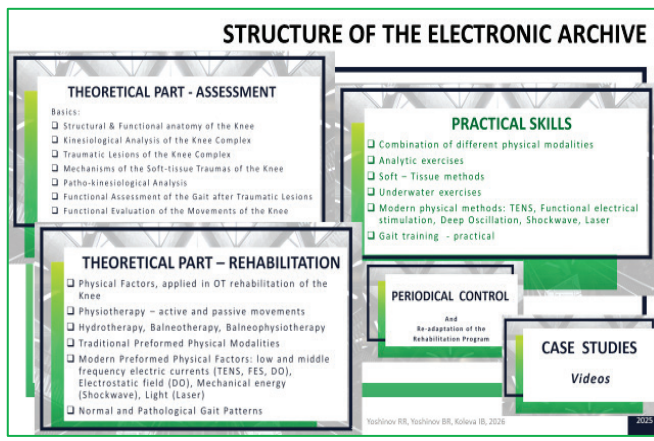

Fig. 3. Structure of the electronic archive.

Fig. 4. Some books on the topic of the digital library.

2.4 Structure of the Electronic Archive from a Technological Perspective

From a technological perspective, the developed electronic archive represents a **web-based modular system**, designed to ensure accessibility, scalability, and interoperability - within modern e-learning environments.

The system architecture follows a **three-tier model**, consisting of:

- ***Presentation layer*** – user interface accessible via standard web browsers, optimized for desktop and mobile devices;
- ***Application layer*** – responsible for content management, user authentication, and course logic;
- ***Data layer*** – structured repository storing educational materials, clinical cases, and user-generated data.

The archive is implemented using a **relational database model**, enabling structured storage of heterogeneous medical content, including:

- ***Textual resources*** *(scientific publications, guidelines, manuals);*
- ***Multimedia elements*** *(images, videos, presentations);*
- ***Structured clinical case data*** *(diagnosis, intervention, rehabilitation protocol, outcomes);*
- ***Assessment data*** *(test results, user performance metrics).*

Metadata standards are applied to ensure efficient indexing and retrieval of resources, supporting **search, filtering, and categorization by pathology, intervention type, and rehabilitation approach**.

The platform supports **role-based access control**, distinguishing between administrators, educators, and learners. This ensures secure content management and personalized learning pathways.

Integration with existing educational platforms of the Medical University of Sofia and the Bulgarian Association of Healthcare Professionals is achieved through **web-based protocols and standardized authentication mechanisms**, allowing seamless access to the archive within broader e-learning ecosystems.

The system also incorporates **assessment modules**, including:

- ***automated online testing*** (scored quantitatively);
- ***practical evaluation tracking*** (qualitative grading scale);
- ***feedback collection through anonymized questionnaires***.

Statistical processing of learner performance and feedback data was conducted using **IBM SPSS Statistics**, enabling objective evaluation of educational outcomes.

2.5 Material and Methods

The impact of the electronic archive on learners' professional competencies was assessed by comparing competency levels before and after completion of the respective educational course.

The analysis included only participants who successfully completed the course and submitted fully completed questionnaires.

The distribution of the 102 participants included in the study is presented in Figure 5.

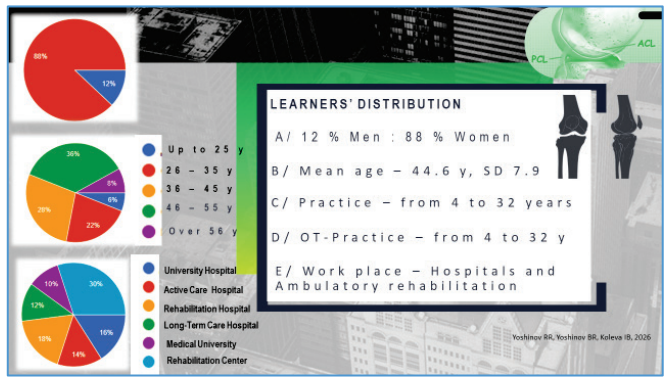

Fig. 5. Learners' distribution.

2.6 Assessment of Professional Competencies (Measurement Model)

Professional competencies were evaluated using a **standardized test-based assessment system**, with total scores ranging from 0 to 100 points. The assessment instrument consisted of **20 multiple-choice questions (MCQs)**, each carrying equal weight (5 points per question). The test covered five key competency domains: (1) functional assessment, (2) rehabilitation of knee soft-tissue injuries, (3) application of preformed physical modalities, (4) gait training, and (5) pain management. Each domain was represented by **four questions**, ensuring balanced coverage across all areas.

The same test structure and level of difficulty were applied in both the **pre-course (baseline)** and **post-course (final)** assessments in order to ensure comparability of results. To minimize recall bias, equivalent question variants were used in the post-test, assessing the same competencies, but with modified clinical scenarios.

The final score was calculated as the **sum of correctly answered questions**, converted directly into a percentage scale (0–100 points). No negative marking was applied.

2.7 Database Model of the Electronic Archive

The electronic archive is based on a **relational database model**, designed to support structured storage, retrieval, and analysis of both educational and clinical data. The conceptual data model follows an **Entity–Relationship (ER) structure**, integrating core entities related to users, educational content, clinical cases, and assessment processes (Figures 6 and 7).

The primary entities include:

- ***Users*** *(learners, educators, administrators),* storing demographic and professional data;
- ***Courses****,* representing structured educational modules;
- ***Clinical Cases****,* containing structured medical information (diagnosis, intervention, rehabilitation protocol, outcomes);
- ***Resources****,* including multimedia and textual educational materials;
- ***Assessments****,* representing pre- and post-course evaluations;
- ***Questions and Answers****,* defining the structure of competency tests;
- ***Results****,* storing user performance and calculated scores.

Relationships between entities ensure traceability of the learning process, enabling linkage between users, accessed resources, completed courses, and achieved competency outcomes.

The database design supports:

- **Many-to-many relationships** (e.g., users enrolled in multiple courses);
- **Hierarchical categorization** (e.g., resources by pathology and rehabilitation type);
- **Longitudinal tracking** (pre/post assessment comparisons).

This structure enables efficient querying, statistical analysis, and future integration with intelligent systems for personalized learning and clinical decision support.

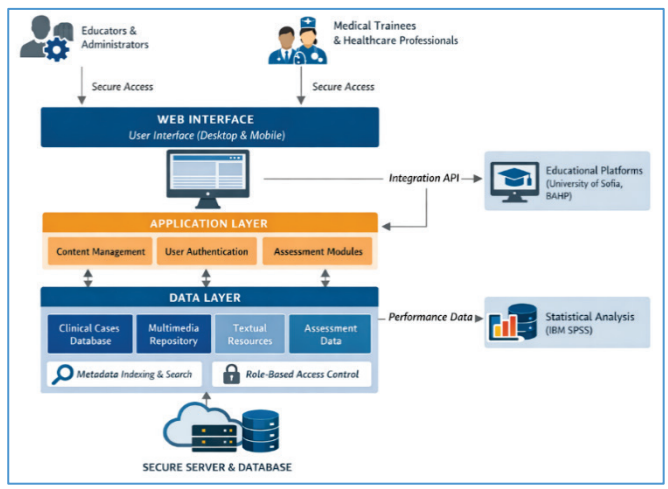

Fig. 6. System architecture of the Electronic Archive.

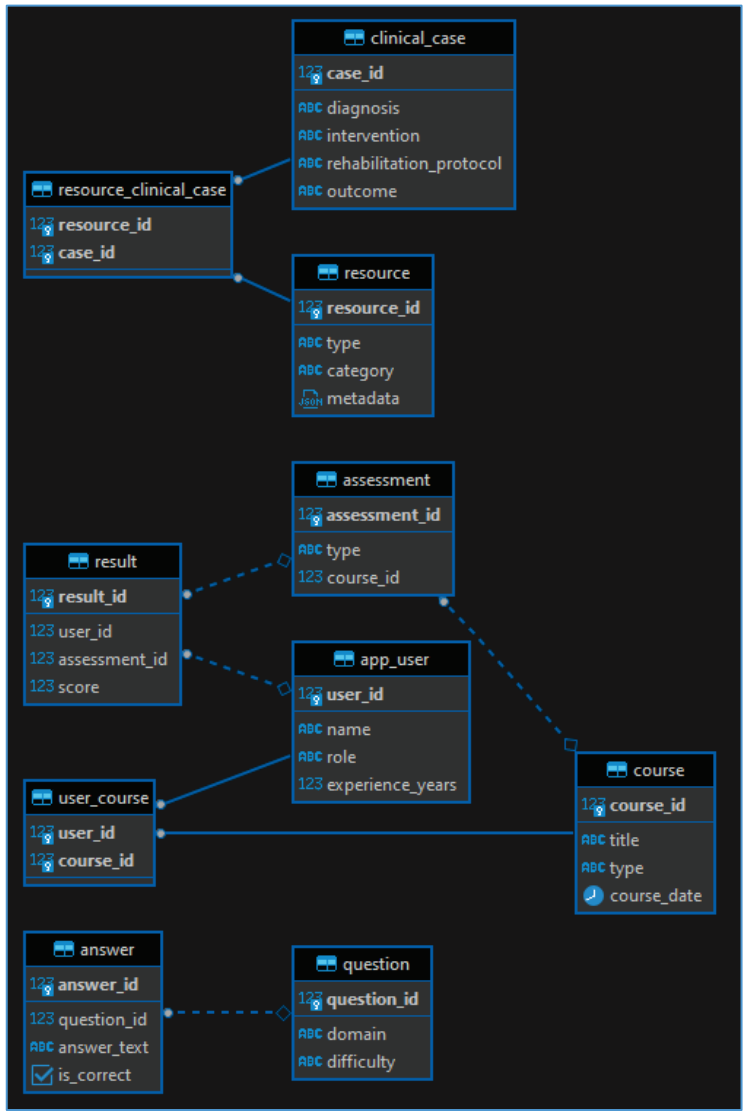

Fig. 7. ER diagram of the database.

3 Results

The educational course was conducted twice: once for medical doctors (MD) - PRM trainees, and once for physiotherapists.

3.1 Analysis of Professional Competencies

Figure 8 presents the comparative evaluation of participants' professional competencies - before and after the use of the electronic archive (0-100 points). A significant improvement in competencies was observed in the areas of functional assessment, knee trauma rehabilitation with application of preformed physical modalities, gait training, and pain management.

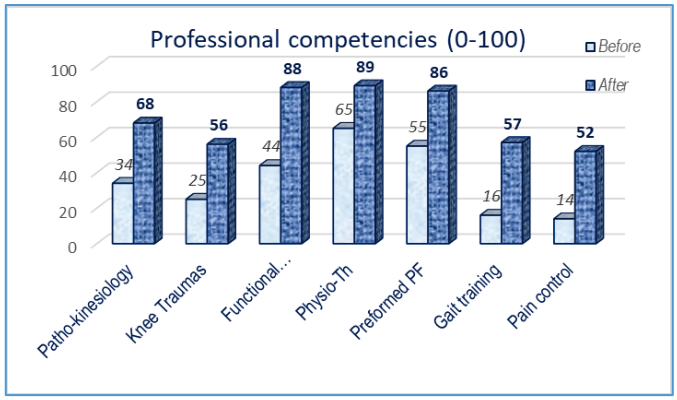

Fig. 8. Professional competencies – before and after the completion of the course.

3.2 Analysis of Learners' Opinion

Participants' opinions regarding the educational course and the electronic archive were assessed using an anonymous questionnaire, based on a Likert Scale (Fig. 9). We used a traditional 5-levels Likert scale (Likert, 1932) and the results were analyzed according guidelines, traditionally used in medical education (Sullivan, 2013).

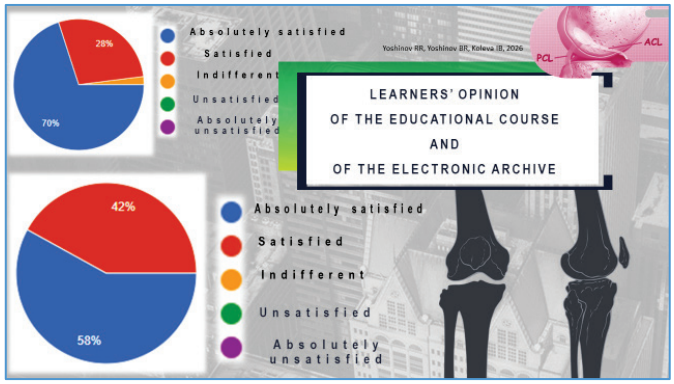

Fig. 9. Learners' evaluation using a Likert scale (1-5).

4 Discussion and Conclusion

The observed improvement in learners' professional competencies following the use of the electronic archive is relevant to domains, associated with the quality of care and quality of life of patients with traumatic soft-tissue lesions of the knee complex.

The implementation of electronic archives in postgraduate medical education allows for long-life learning and improvement among medical specialists and healthcare professionals. In this way, digital libraries support professional development and contribute to the overall betterment of quality of care for orthopedic patients with knee soft-tissue injuries.

A limitation of the present study is its focus on a single pathological condition - soft-tissue knee trauma. Future development of the archive could broaden its horizon to include rehabilitation strategies for other socially significant conditions within Orthopedics and Traumatology.

The e-repository remains open to expansion of new data in line with evolving recommendations. Currently, the archive includes presentation of typical clinical cases (covering major types of traumatic soft tissue conditions and corresponding arthroscopic interventions), as well as a limited number of rare cases. In the future, additional unique and complex clinical cases may be incorporated.

Ongoing technological advancements suggest further development in e-learning, including the integration of virtual reality, augmented reality, and artificial intelligence. These immersive technologies are expected to provide enhanced hands-on learning opportunities, enabling medical specialists and health professionals in rehabilitation to practice and refine their skills within simulated and data-driven virtual environments.

The development of the system toward **intelligent and immersive learning environments** includes:

- Integration of **artificial intelligence** for personalized learning and decision support;
- Implementation of **virtual reality (VR)** and **augmented reality (AR)** modules for simulation-based training;
- Expansion toward **predictive analytics**, supporting clinical reasoning and rehabilitation planning.

Digital libraries represent an important tool for preserving the scientific heritage and clinical experience of the pioneers and founders of the Bulgarian School of Orthopedic Rehabilitation.

Acknowledgements

Part of the electronic archive, related to rehabilitation following anterior cruciate ligament alloplasty, was developed within the framework of the project "**Co**llaborative lea**r**ning for enhancing practical **skills** for patient-focused interventions in gait rehabilitation after orthopaedic surgery /*COR-skills*/"; Project 2015-1-RO01-KA202-015230, funded by the European Commission under the Erasmus Plus program, Key Action 2.

The remaining components of the archive (including the fundamentals of physical medicine and rehabilitation approaches for other traumatic knee lesions) were developed without external financial support.

Conflict of Interest

The authors declare no conflict of interests.

Use of Artificial Intelligence

The authors declare that no Generative Artificial Intelligence tools were used in the creation of this manuscript.

References

Baker, E. A., Ledford, C. H., Fogg, L., Way, D. P., & Park, Y. S. (2015). The IDEA assessment tool: Assessing the reporting, diagnostic reasoning, and decision-making skills demonstrated in medical students' hospital admission notes. *Teaching and Learning in Medicine*, *27*(2), 163–173. https://doi.org/10.1080/10401334.2015.1011654

Beynnon, B. D., Johnson, R. J., Abate, J. A., Fleming, B. C., & Nichols, C. E. (2005a). Treatment of anterior cruciate ligament injuries, part I. *The American Journal of Sports Medicine*, *33*, 1579–1602. https://doi.org/10.1177/0363546505279913

Beynnon, B. D., Johnson, R. J., Abate, J. A., Fleming, B. C., & Nichols, C. E. (2005b). Treatment of anterior cruciate ligament injuries, part II. *The American Journal of Sports Medicine*, *33*(10), 1751–1767. https://doi.org/10.1177/0363546505279922

Cahyani, D., & Aminudin. (2025). Digital transformation in education in the post pandemic COVID 19: Bibliometric analysis (2020–2025). *Journal of General Education and Humanities*, *4*(3), 719–732. https://doi.org/10.58421/gehu.v4i3.450

Chhabra, A., Elliot, C., & Miller, M. D. (2002). Normal anatomy and biomechanics of the knee. *Sports Medicine and Arthroscopy Review*, *9*(3), 166–177. https://doi.org/10.1097/00132585-200107000-00002

DeLisa, J. A. (2005). *Physical medicine and rehabilitation: Principles and practice* (4th ed.). Lippincott Williams & Wilkins.

Dochev, D., Yoshinov, R. D., & Pavlov, R. (2000). An open distributed computer environment for educational telematics. In *Proceedings of the European Distance and E-Learning Network (EDEN) Annual Conference: Open classrooms in the digital age* (pp. 247–252).

Guraya, S. S., Rajalingam, P., & Zary, N. (2025). Editorial: Navigating complexity in postgraduate/graduate health professions education: Innovative pedagogical approaches and assessment strategies. *Frontiers in Medicine*, *12*, 1734397. https://doi.org/10.3389/fmed.2025.1734397

Hebgen, E. (2013). *Points gachettes myofasciaux: Traiter la douleur par l'ostéopathie et les thérapies manuelles* [Myofascial trigger points: Treating pain through osteopathy and manual therapies]. Maloine.

Koleva, I. B., Yoshinov, B. R., & Yoshinov, R. R. (2020). *Ortopedichna rehabilitazija (lekzii) [Orthopedic rehabilitation (lectures)]*. SIMEL Press.

Koleva, I. B., Yoshinov, B. R., & Yoshinov, R. R. (2025a). *Rehabilitazionen algoritam pri mekotakanni travmi na kolennija complex [Rehabilitation algorithm in soft-tissue trauma of the knee complex]*. SIMEL Press.

Koleva, I. B., Yoshinov, B. R., & Yoshinov, R. R. (2025b). Effectiveness of the application of a digitalized repository on the quality of graduate and post-graduate education in the field of physical medicine and rehabilitation. *Frontiers in Medicine*, *11*, 1521959. https://doi.org/10.3389/fmed.2024.1521959

Laver-Fawcett, A. J. (2007). *Principles of assessment and outcome measurement for occupational therapists and physiotherapists: Theory, skills and application*. John Wiley & Sons.

Likert, R. (1932). A technique for the measurement of attitudes. *Archives of Psychology*, *140*, 1–55.

Londono, G. R. (2001). Dolor agudo: Guia de practica clinica [Acute pain: Clinical practice guide]. *Revista Columbiana de Ortopedia y Traumatologia*, *15*(3), 34–36.

Lubarsky, S., Dory, V., Audétat, M. C., Custers, E., & Charlin, B. (2015). Using script theory to cultivate illness script formation and clinical reasoning in health professions education. *Canadian Medical Education Journal*, *6*(2), e61–e70. https://cmej.ca/index.php/cmej/article/view/36631

Parsons, A. S., Wijesekera, T. P., & Rencic, J. J. (2020). The management script: A practical tool for teaching management reasoning. *Academic Medicine*, *95*(8), 1179–1185. https://doi.org/10.1097/ACM.0000000000003465

Peck, D. (2025). *What is eLearning? ELearning explained*. https://www.devlinpeck.com/content/what-is-elearning

Petty, N. J., & Moore, A. P. (2003). Exploracion fisica [Physical examination]. In N. J. Petty & A. P. Moore, *Exploracion y evaluacion neuro-musculo-esqueletica: Un manual para terapeutas* [Neuromusculoskeletal examination and assessment: A manual for therapists] (2nd ed., pp. 35–112). McGraw-Hill.

Plaja, J. (2003). *Analgesia por medios fisicos* [Analgesia by physical means]. McGraw-Hill Interamericana.

Shankman, G. A. (2004). *Fundamental orthopedic management for the physical therapist assistant* (2nd ed.). Elsevier Mosby.

Singh, P. K., Singh, S., Ahmad, S., Singh, V. K., & Kumar, R. (2025). Navigating power dynamics and hierarchies in medical education: Enhancing faculty experiences and institutional culture. *Journal of Postgraduate Medicine*, *71*(2), 82–90. https://doi.org/10.4103/jpgm.jpgm_728_24

Sullivan, G. M., & Artino, A. R., Jr. (2013). Analyzing and interpreting data from Likert-type scales. *Journal of Graduate Medical Education*, *5*(4), 541–542. https://doi.org/10.4300/JGME-5-4-18

Tapanez, S. H. (2012). *Terapia con oscilaciones profundas: Experiencias en cervicalgias, lumbalgias y epicondylitis* [Therapy with deep oscillations: Experiences in cervicalgia, lumbalgia and epicondylitis]. EdiReh Latina.

Toutoungi, D. E., Lu, T. W., Leardini, A., Catani, F., & O'Connor, J. J. (2000). Cruciate ligament forces in the human knee during rehabilitation exercises. *Clinical Biomechanics*, *15*(3), 176–187. https://doi.org/10.1016/s0268-0033(99)00063-7

Tria, A. J., & Klein, K. S. (1992). *An illustrated guide to the knee*. Churchill Livingstone.

World Federation for Medical Education. (2015). *Global standards for quality improvement: The 2015 revision*. http://wfme.org/standards/bme/78-new-version-2012-quality-improvement-in-basic-medical-education-english/file

Zhao, H. (2024). Digital technology in education: Navigating the challenges and opportunities for the 21st century learner. *Transactions on Comparative Education*, *6*(3), 139–143. https://doi.org/10.23977/trance.2024.060319

Zou, Y., Kuek, F., Feng, W., & Cheng, X. (2025). Digital learning in the 21st century: Trends, challenges, and innovations in technology integration. *Frontiers in Education*, *10*, 1562391. https://doi.org/10.3389/feduc.2025.1562391

Received: March 14, 2026
Reviewed: April 15, 2026
Finally Accepted: April 24, 2026