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DIGITAL TRANSFORMATION OF THE HEALTHCARE SYSTEM: NEW APPROACHES TO TRAINING REHABILITATION PROFESSIONALS

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Abstract. *This article examines current trends in the training of prosthetics and orthotics specialists within the context of the ongoing digital transformation of medical rehabilitation. The study highlights key directions in the development of the field, with particular emphasis on the integration of advanced digital technologies - such as 3D scanning, additive manufacturing, virtual modeling, and intelligent motion analysis systems - which are substantially reshaping both the content and structure of professional education. The importance of comprehensive biomechanical knowledge is emphasized, as biomechanical analysis plays a central role in ensuring the quality, functionality, and patient-specific suitability of prosthetic and orthotic devices.*

The article substantiates the necessity of integrating fundamental medical disciplines with contemporary digital methodologies to develop a holistic professional competency profile for future prosthetists and orthotists. The introduction of the specialized academic course "Digitalization of the Prosthetics and Orthotics System" is underscored as a critical component for developing digital literacy, modeling skills, parametric design optimization, and proficiency in digital workflows.

The article concludes that continued modernization of educational standards, expansion of digital components, and support for innovative pedagogical approaches are essential for preparing competitive professionals capable of meeting the challenges of contemporary prosthetics and

orthotics practice.

***Keywords**: digital transformation; healthcare; medical education; prosthetics and orthotics; digital technologies; 3D-scanning; additive manufacturing; digital modeling.*

Introduction.

The contemporary prosthetics and orthotics sector is undergoing a profound transformation driven by a combination of global socio-medical and technological factors. Both worldwide and in Ukraine, the number of patients with traumatic injuries and congenital musculoskeletal disorders continues to increase, accompanied by a rise in combat-related trauma directly associated with military actions, as well as a noticeable growth in domestic injuries. These trends are further intensified by demographic shifts, characterized by an expanding proportion of older adults who require sustained orthopedic and rehabilitation support. Against this background, rapid advancements in innovative medical and engineering technologies are fundamentally reshaping approaches to the design, fabrication, and clinical application of prosthetic and orthotic devices [1,2].

In response to these challenges, the prosthetics and orthotics field is gradually shifting from traditional craft-based methods to a high-technology, scientifically grounded, and integrated model of practice. Modern clinical workflows increasingly rely on biomechanical assessment, engineering principles, digital modeling technologies, additive manufacturing, biocompatible materials, and sensor systems incorporating elements of artificial intelligence. These innovations enable the creation of highly individualized solutions with a high degree of precision and predictable clinical performance. Under such conditions, preparing a new generation of specialists capable of operating in a digital, technologically advanced environment - and applying contemporary tools throughout all stages of clinical care, from initial patient assessment to device fabrication, adjustment, and long-term monitoring - becomes a strategic objective for the healthcare system and a key prerequisite for improving population-wide rehabilitation outcomes [2,3].

The training of future prosthetics and orthotics professionals requires a coherent and well-structured educational model that integrates fundamental biomedical disciplines with technological components essential for practical clinical work. A deep

understanding of joint mechanics, load distribution, muscle function, and compensatory mechanisms enables future specialists to analyze clinical cases, justify the configuration of prosthetic and orthotic devices, and assess their integration into the patient's kinetic chain [4]. An equally important component of training is materials science. Mastery of material characteristics is essential for designing devices that meet requirements of strength, flexibility, user comfort, and safety [5]. Another critical area is the study of musculoskeletal pathology: only by understanding the clinical manifestations of injuries and deformities can specialists design functionally sound solutions for compensation and support [5,6]. This is complemented by knowledge of hygiene standards and regulatory requirements governing the fabrication, use, and maintenance of prosthetic and orthotic devices to ensure their safety and durability. However, these components alone are no longer sufficient. The rapid digital transformation of healthcare necessitates expanding educational curricula through the inclusion of a new interdisciplinary component - the course "Digitalization of the Prosthetics and Orthotics System." This module serves as a pivotal link that unites foundational knowledge with practical digital competencies essential for modern professional activity [2,7].

Mastering this discipline involves learning to use a broad range of contemporary digital tools, including: 3D scanning and photogrammetry of anatomical segments; computer systems for biomechanical and kinematic motion analysis; CAD/CAM platforms for prosthetic and orthotic design; additive manufacturing technologies (3D printing of polymer and composite structures); digital load and deformation simulators; systems for processing and analyzing biomechanical, clinical, and sensor data; software environments with automated optimization capabilities [4,8].

Acquisition of these competencies enables future specialists to work with state-of-the-art tools aligned with international standards and modern clinical practice. Students gain experience in creating digital models, performing personalized functional simulations, predicting device behavior under various loading conditions, and optimizing designs prior to physical fabrication. This substantially improves the precision of device customization, reduces the likelihood of errors, and streamlines

clinical decision-making processes.

Thus, integrating the discipline “Digitalization of the Prosthetics and Orthotics System” into the structure of professional training is a logical and necessary step that corresponds to current industry demands. This approach ensures the development of comprehensive professional competence, encompassing both classical biomedical knowledge and advanced digital skills, thereby fostering the preparation of a new generation of highly qualified specialists.

Considering these trends, the aim of this article is to substantiate the importance of training specialists in prosthetics and orthotics under conditions of digital modernization of the healthcare system, as well as to define the role of key foundational disciplines - biomechanics, pathology of the musculoskeletal system, and hygiene standards - in forming the professional competence of future practitioners. An additional objective is to analyze the relevance and educational necessity of implementing the discipline “Digitalization of the Prosthetics-Orthotics System” as an integrative element of modern training for specialists who will work in a digital, technologically intensive environment [2,6].

Presentation of the Main Material.

Mastering biomechanical principles provides not only a fundamental basis for analyzing human motor function but also serves as an essential starting point for acquiring digital modelling methods that are now widely applied in global prosthetics and orthotics practice. The use of computer simulations enables reproduction of mechanical load distribution, assessment of structural behavior across different phases of movement, and prediction of device performance under real operating conditions. Analysis of centers of mass, directions and magnitudes of force vectors, deformation patterns, and other parameters allows for technically justified selection of design solutions. Thus, biomechanical training is no longer a purely theoretical component of education - it becomes a key instrument for engineering - clinical decision-making in the digital era [5,8].

Under modern conditions, the prosthetist-orthotist is no longer confined to performing manual fabrication tasks. The specialist now works with digital models,

analyzes biomechanical parameters, uses numerical simulations, and makes decisions based on a comprehensive digital profile of the patient. The discipline “Digitalization of the Prosthetics-Orthotics System” plays a pivotal role in developing these competencies. It includes training in 3D scanning, CAD environments, motion-analysis software, parametric modelling systems, and load-simulation tools. This enables students to create complete digital models, optimize structural designs, and predict the clinical performance of the final device. The introduction of this discipline into the curriculum - particularly at Kharkiv National Medical University (KhNMU) - is aligned with international standards and contemporary trends in the field.

KhNMU has become one of the pioneers among Ukrainian medical institutions to launch a comprehensive program for training prosthetics and orthotics specialists. The creation of this program was a response to societal demand intensified by demographic trends and the growing number of patients requiring rehabilitation due to military injuries. The educational curriculum integrates medical, biomechanical, engineering, and digital components, meeting international requirements for the preparation of specialists in this field. The program structure includes fundamental disciplines as well as core professional courses such as biomechanics, materials science, neurology, orthopedics, prosthetic-orthotic manufacturing technologies. Significant emphasis is placed on practical training: students work with contemporary instruments, perform modelling tasks, master biomechanical measurement techniques, and participate in clinical practicums. The combination of theoretical and practical preparation fosters skills necessary for working with real patients and complex clinical cases.

A distinctive feature of training at KhNMU is the systematic integration of digital technologies into the educational process. Students gain experience using 3D scanners, digital shape-capture systems, additive manufacturing technologies, and laboratory complexes for motion analysis. In 2024, the program was expanded with the specialized discipline “Digitalization of the Prosthetics-Orthotics System”, which became a crucial step toward compliance with international educational trends. This expansion enabled students to work across the entire digital workflow - from initial

scanning to parametric optimization and simulation of mechanical behavior.

The increasing demand for this specialty is confirmed by admissions data. In the 2025/2026 academic year, KhNMU enrolled its second cohort of master's students in specialty 224 "Medical Diagnostic and Treatment Technologies", specialization "Prosthetic-Orthotics". The number of applicants significantly increased compared to the previous year, reflecting strong interest in the profession as well as trust in the quality of education provided by the university. The rising competition underscores the program's perception as innovative and promising with regard to employability and societal importance.

A crucial factor in the program's success is the high professional level of the teaching staff. The educational process involves specialists in orthopedics, rehabilitation, biomechanics, engineering design, digital modelling, and materials science. They continuously improve educational content, introduce new methodologies, follow contemporary international recommendations, and involve students in scientific work. Collaboration with clinical facilities and prosthetic-orthotic centers ensures continuity between theoretical, practical, and digital components of training.

Thus, the educational and professional program in prosthetics and orthotics at KhNMU is one of the most advanced in Ukraine. It combines fundamental medical education, professional competencies, and innovative digital technologies, ensuring high-quality training that meets European standards. The increasing number of applicants confirms the effectiveness of this model and its importance for preparing a new generation of specialists capable of delivering high-technology care in Ukraine.

Conclusions.

An overview of contemporary development vectors in the prosthetics and orthotics sector clearly demonstrates that the professional training of specialists within medical universities is becoming one of the key components in strengthening the national medical system. Effective formation of professional competencies is possible only when fundamental medical and biological education is combined with an in-depth understanding of the biomechanical principles governing the musculoskeletal system,

comprehensive knowledge of clinical pathology, and mastery of modern requirements for the design and safety of rehabilitation devices. At the same time, the rapid expansion of digital technologies makes proficiency in digital tools not merely a desirable element of training but a decisive factor in professional readiness.

The introduction of the specialty “Prosthetics-Orthotics” at Kharkiv National Medical University has established a modern educational platform aligned with international standards and real clinical needs. The positive dynamics of the admission process over two consecutive years confirms the growing interest in this profession and underscores the relevance of the educational direction selected by the university. The inclusion of the discipline “Digitalization of the Prosthetics-Orthotics System” strengthens the technological dimension of training and equips students with competencies that will determine their future competitiveness.

The development of digital solutions - 3D scanning, additive manufacturing, virtual modelling tools, machine-learning algorithms, and artificial-intelligence systems - is transforming professional requirements, making skills in digital design, personalized structural development, and optimization of clinical–technological workflows indispensable. The effectiveness of a future specialist’s work directly depends on their ability to integrate digital approaches into everyday practice and to adapt to a dynamically changing technological environment.

In summary, modern training of prosthetics and orthotics specialists requires further enhancement of interdisciplinary integration, renewal of educational content, and systematic improvement of students’ digital literacy. The results of this study confirm the importance of expanding educational modules focused on the digital transformation of the field and highlight the need to support innovative educational and scientific initiatives. Such an approach will enable the formation of a new generation of professionals capable of confidently operating within a high-technology rehabilitation infrastructure and ensuring the effective integration of digital solutions into prosthetic-orthotic practice.

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Анотація. *Стаття присвячена аналізу сучасних тенденцій підготовки фахівців з протезування та ортезування в умовах цифрової трансформації медичної реабілітації. У роботі розглянуто ключові напрями розвитку галузі, зокрема впровадження цифрових технологій - 3D-сканування, адитивного виробництва, віртуального моделювання та інтелектуальних систем аналізу руху, що істотно змінюють зміст і структуру професійної*

освіти. Акцентовано увагу на важливості глибоких біомеханічних знань, оскільки саме біомеханічний аналіз визначає якість проєктування протезно-ортезних виробів та їх відповідність функціональним потребам пацієнтів.

У статті обґрунтовано необхідність інтеграції фундаментальних медичних дисциплін із сучасними цифровими підходами, що забезпечує формування комплексної професійної компетентності майбутніх ортезистів-протезистів. Окремо підкреслено значення впровадження дисципліни «Цифровізація системи протезування-ортезування», яка спрямована на формування цифрової грамотності, навичок моделювання, параметричної оптимізації конструкцій та роботи в цифрових робочих потоках.

Стаття підкреслює необхідність подальшого оновлення освітніх стандартів, розширення цифрових модулів та підтримки інноваційних освітніх підходів як ключових умов формування конкурентоспроможних фахівців у галузі протезування й ортезування.

Ключові слова: *цифрова трансформація; охорона здоров'я; медична освіта; протезування та ортезування; цифрові технології; 3D-сканування; адитивні технології; цифрове моделювання.*

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