CAUSES OF CERVICAL OSTEOCHONDROSIS RELATED TO LIFESTYLE

Abstract: Cervical osteochondrosis is one of the most common degenerative diseases of the spine and significantly reduces patients' quality of life. The modern lifestyle — characterized by physical inactivity, prolonged use of mobile gadgets and computers, chronic stress, improper sleep patterns, and unhealthy nutritional habits — plays a major role in the development and progression of cervical osteochondrosis. This article provides an expanded overview of the key etiological factors associated with lifestyle, describes the pathophysiological mechanisms of degenerative changes in cervical vertebrae and intervertebral discs, and outlines evidence-based preventive strategies. Special attention is given to ergonomic recommendations, physical activity, posture correction, stress management, and modifying daily behavioral patterns to reduce the risk and slow the progression of the disease. The review emphasizes the importance of early lifestyle correction for maintaining spinal health and preventing chronic pain syndromes.

Keywords: Cervical osteochondrosis, cervical spine, intervertebral disc degeneration, lifestyle factors, physical inactivity, posture disorders, mobile gadgets, computer use, ergonomic habits, chronic stress, sleep hygiene, preventive strategies, rehabilitation.

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ARTIFICIAL INTELLIGENCE BASED INNOVATIONS IN CEREBRAL PALSY REHABILITATION: OPPORTUNITIES FOR KAZAKHSTAN'S REHABILITATION SYSTEM

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Abstract: Cerebral Palsy (CP) is a disorder of limited functional activity and motor disorders caused by damage or developing abnormality in a prenatal or newborn child brain. Traditional methods of CP rehabilitation rely on subjective therapist assessments, lacking objective data-driven evaluations, and time efficiency. This paper reviews modern artificial intelligence (AI) based technologies that can be applied in Kazakhstan's rehabilitation system. Nineteen peer-reviewed studies were analyzed and AI-driven technologies were grouped into three main categories: automated clinical assessment, predictive and personalized machine learning models, and real-time adaptive systems. The results showed that such innovations can maintain reliability of

the treatment, increase accessibility of rehabilitation services, reduce clinician workload, and allow continuous activity monitoring. However, implementation of some innovations are limited by data quality, data quantity, additional hardware setup and ethical consideration. Overall, the integration of AI into Kazakhstan's rehabilitation system holds great potential to make rehabilitation more objective, accessible, and personalized – eventually, improving the quality of life for people with cerebral palsy.

Keywords: Cerebral palsy rehabilitation, artificial intelligence, machine learning.

Introduction. Cerebral palsy (CP), according to modern concepts, is a group of stable developmental disorders of motor skills and posture, which lead to limited functional activity and motor disorders caused by non-progressive damage and/or abnormality of the developing brain in a prenatal or newborn child [9]. Globally, cerebral palsy affects 2 to 3 newborns per 1,000 live births, making it a leading cause of long-term rehabilitation-needed childhood disabilities [15].

Speaking of Kazakhstan, up-to-date statistics on the rate of newborns with cerebral palsy during recent years remain insufficient; however, some research provides valuable information about the scale of the disability situation in the country. According to the Bureau of National Statistics, 737,430 people were registered with disabilities in Kazakhstan in 2024. In 13 years, the number of children has doubled, starting from 61,196 in 2011, reaching up to 114,727 in 2024, which is more than 15% of the whole disabled community [5][4]. A 2018 report indicated that more than 19,000 children had been diagnosed with CP in Kazakhstan, yet only 20% were actively undergoing rehabilitation, with the remainder on extensive waiting lists [18].

Undoubtedly, the community of patients with CP needs special treatment and care, specifically rehabilitation, to address the purpose of treating the disease or, at a minimum, improving quality of life and functional independence. Nowadays, improvement of technological innovations cleared the weaknesses and limitations of traditional methods. For example, therapist-dependent assessments lack objectivity and time efficiency. This claim is supported by several studies that documented that standard motor function assessments like the Gross Motor Function Measure (GMFM-88) require 40-60 minutes per patient with fully focused trained personnel [12][16]. The assessment requires and relies on the therapist's experience rather than objective data analysis – patient characteristics, previous treatment outcomes, predictive modeling – causing biased and subjective results. Other studies notice that some of rehabilitation methods remain "inconsistent" because of the wide variation of rehabilitation approaches and a lack of support by evidence-based standards [7]. Also, there is a lack of efficient tools that can track functional changes, predict rehabilitation outcomes, and adapt the treatment based on the real-time patient progress data.

Artificial Intelligence (AI) could be the next step in transforming cerebral palsy rehabilitation by applying efficient, precise and personalized treatment. In order to achieve positive outcomes, researchers have successfully applied machine learning techniques in several projects: recognizing gait phases with high accuracy, automating clinical assessments, and analyzing physical data collected from wearable sensors. These projects have an opportunity to make the rehabilitation process faster, more objective, less dependent on therapists – hence, less biased – and accessible. In addition, AI can be applied to develop predictive and adaptive models – such as estimating walking potential of patients with CP, neuro-adaptive exoskeletons controlled by neural activity, and adaptable virtual-reality environments – that can broaden the prospects of rehabilitation. Importantly, many of these methods rely on accessible sensor technologies rather than expensive robotics.

The purpose of this paper is to analyze recent AI-based technologies applied in cerebral palsy rehabilitation and determine how they deal with the limitations of traditional methods. The objectives are:

1. To review AI applications that address the limitations of cerebral palsy rehabilitation.
2. To evaluate the feasibility of introducing such technologies into Kazakhstan's existing rehabilitation practice.

Material and Methods. This paper is a literature review of the recent applications of artificial intelligence and machine learning algorithms in cerebral palsy rehabilitation. All targeted sources were collected through a Google Scholar search engine from various databases like MDPI, ResearchGate, PubMed, etc. Keywords were used to identify relevant papers: cerebral palsy rehabilitation, machine learning, artificial intelligence, personalized rehabilitation, exoskeleton, virtual reality, outcome prediction. In total, 19 studies were chosen by the criteria of being published in a peer-reviewed international journal and having clinical and experimental results. The overall analysis was structured into 3 categories of technologies:

1. Automated Clinical Assessment
2. Predictive and Personalized Machine Learning Models
3. Real-Time Adaptive Systems

Results. The shift from traditional and clinician-dependent rehabilitation can be approached through data-driven, objective and personalized artificial intelligence-based systems. This section examines three major AI-based application approaches: (1) automated clinical assessment, (2) outcome prediction and treatment optimization, and (3) real-time adaptive systems.

I. Automated Clinical Assessment

In Kazakhstan, clinical follow-ups for children with CP often rely on parental reports and subjective evaluation [6]. Machine learning-based monitoring and assessments can replace this with objective and continuous data.

A. Motor Function Assessment

Traditional motor assessments such as Gross Motor Function Measure (GMFM-88) remain the clinical standard for children with cerebral palsy but require 45-60 minutes and depend heavily on clinician expertise [16]. Duran et al. (2022) introduced a new machine learning version of the GMFM – rGMFM-66. The model addressed the main inconvenience and reduced the assessment time by 40% [8]. Despite reducing the time, the new version of the assessment maintained excellent reliability, achieving an Intraclass Correlation Coefficient (ICC) > 0.95 [8]. Moreover, the idea was supported by Schafmeyer et al. (2024) who stated that AI-based analysis can detect functional improvements with equal or higher accuracy than traditional assessments [17]. For

Kazakhstan, where only 20% of children with CP actively receive rehabilitation, these systems can reduce workload and improve accessibility of the service.

B. AI-Powered Gait Analysis

Another traditional assessment is a gait analysis. Gait evaluation typically requires specialized laboratories and motion-capture equipment. Recent AI advancements introduced high-accuracy gait assessments using portable inertial measurement units (IMUs). Pang et al. (2025) developed an IMU sensor system for real-time gait-phase recognition in children with CP. The results are remarkable, achieving 97.83% accuracy in noise-free real-time data, accurate detection of the gait phases even with unpredictable movement patterns that are common for CP [14]. This real-time recognition system works without the need for the laboratory and enables objective gait quality assessment with an ability of continuous monitoring. Also, in the future, the feedback data from the system can be used in developing exoskeletons, neuroprosthesis and other assistive devices.

C. Activity Monitoring

Ahmadi et al. (2018) demonstrated that accelerometer data collected from wearable sensors can be analyzed using machine learning algorithms and classified into different activity types in children and adolescents with CP. This approach objectively measures the daily physical activity of patients and detects sedentary patterns [3]. This AI-based technology is useful due to the ability of monitoring physical activity beyond periodic hospital assessments.

II. Predictive and Personalized Machine Learning Models

AI-driven prediction and personalized models allow clinicians to monitor functional progress of patients and design personalized treatment plans for them.

A. Individualized Machine Learning Models

In 2020, Ahmadi et al. continued their research with accelerometers and compared several machine learning models that were trained on different data: group (G), group-personalized (GP), and fully-personalized (FP). The research work showed significant results for the FP machine learning model, achieving 99% accuracy in classifying physical activities (sitting, standing/utilitarian movements, walking) [2]. Although there were some misclassifications that occurred for standing and sedentary postures, suggesting further improvements with sensors. Generally, the research shows that adjusting the system to each patient makes monitoring more accurate and helps create personalized, flexible rehabilitation programs that can even be done remotely.

B. Prediction for Individual Walking

Yiwen W. and Yonghui Y. developed a machine learning model that estimates each child's probability of achieving the ability to walk independently before age 6. The model was trained on the data collected from 807 participants. Among 11 predictor variables crucial predictor variables were identified – early GMFCS level, ability to sit independently, GMFM-88 score, MRI classification, and neonatal complications [19]. Three machine learning models were tested (logistic regression, XGBoost and MLP), each achieving AUC > 0.94. This prognosis system can be a good boost for further prediction algorithms.

III. Real-Time Adaptive Systems

Systems that adapt to the real-time patient data can be the next stage of AI-assisted cerebral palsy rehabilitation.

A. AI-Enhanced Exoskeleton Control

Recent advancements in neuro-adaptive technologies have enabled the use of brain-computer interfaces (BCIs) that translate neural activity into real-time robotic control. Ferrero et al. (2024) developed a deep-learning-based BCI system allowing asynchronous control of a lower-limb exoskeleton through motor-imagery EEG signals. The neural network accurately decoded movement intentions, enabling users to initiate or stop walking without any physical effort [10]. Similarly, the Hybrid Assistive Limb (HAL) system developed by Cyberdyne Inc., interprets myoelectric signals to assist motion. Clinical research demonstrated that repeated HAL-assisted training can enhance gait and stimulate cortical reorganization in patients with cerebral palsy [13].

B. AI Adaptation for Virtual Reality

Virtual reality (VR) technologies, although associated mostly with entertainment only, have found its implementation in rehabilitation too. The main goal of implementing VR is increasing patient motivation and engagement in physical exercises. Recent studies demonstrate virtual reality programs with AI that adapts to the user's performance and physical conditions in real-time. An example of the program is a developed system by Herrera et al. (2025). The system uses AI to modify virtual elements, such as object distance and interaction difficulty, based on the patient's movement precision, creating personalized motor training [11]. Similarly, a scoping review published in 2024 stated that such systems are used in home and community services improving rehabilitation technique accessibility [1]. These intelligent VR platforms not only enhance engagement and enjoyment to exercises but also generate continuous medical data for further studies.

Discussion. The reviewed studies confirm the effectiveness of AI-based technologies in CP rehabilitation. Automating assessments, personalizing and adapting treatment in real-time addresses many weaknesses of traditional rehabilitation techniques. Automated clinical assessments and wearable sensor systems stand out the most due to its minimal requirements in additional hardware. Also, these technologies are low-cost and can operate in out-of-laboratory or home-based settings.

On the other hand, implementation of AI systems such as exoskeletons and VR rehabilitation requires specialized infrastructure, multidisciplinary expertise and other additional investments. Thus, early transition to AI-based rehabilitation should focus on feasible systems (automated assessments, activity monitoring, predictive algorithms), while simultaneously preparing the foundation for complex robotic and neuro-adaptive technologies.

Furthermore, integration of AI into national rehabilitation programs should be simultaneously managed with the development of clinical data, ethical standards, personal data security, and specialist training. Without these measures, the AI integration process risks remaining an experimental process rather than becoming a part of the rehabilitation system. Overall, Kazakhstan holds great potential to improve long-term outcomes in cerebral palsy rehabilitation.

Limitations. The biggest issue of all mentioned AI-based technologies is the data quality and quantity. As we know, in order to train machine learning models, we need a sufficient amount of noise-free, clean and preprocessed accurate data [7][1]. The second limitation is AI trained personnel that have prior knowledge in training models, preprocessing data and maintaining the model. The third limitation touches technologies that need additional laboratories or any hardware, requiring huge financial investments [10][13]. Lastly, data privacy and patient consent to use his or her data.

Conclusion.

1. Limitations in cerebral palsy rehabilitation can be addressed by AI-based technologies in three main directions: automated assessment, predictive and personalized modeling, and real-time adaptive systems. These technologies maintain reliability, increase accessibility with accuracy, reduce clinician workload, and allow continuous activity monitoring.
2. Considering Kazakhstan's rehabilitation system, AI-based systems represent realistic first steps for transforming cerebral palsy rehabilitation. Some of the technologies require additional hardware investments, and others do not require any.
3. Overall, the integration of AI into Kazakhstan's rehabilitation system holds great potential to make rehabilitation more objective, accessible, and personalized – eventually, improving the quality of life for people with cerebral palsy.

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EFFECTS OF IODINE- BASED CONTRAST MEDIA ON THYROID FUNCTION

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Abstract.

Relevance. In modern medicine, for the purpose of diagnostic imaging, research methods related to contrast are widely used, primarily with the use of iodine-based contrast media (ICM), in particular, coronary angiography (CA), computed tomography (CT). Unfortunately, in a certain range of patients, performing this type of study is closely associated with subsequent thyroid dysfunction.

Purpose. Conduct a systematic review of the literature on disorders of the thyroid gland, in particular, thyrotoxicosis caused by the introduction of ICM during CA, CT. Determine the control points of thyroid function in patients subjected to CA, CT with the use of ICM. Investigate the influence of gender, age and initial condition of the thyroid on the risk of contrast-induced disorders on the part of the thyroid and evaluate the effectiveness of measures to overcome them.

Materials and methods. Using the method of analysis of literature data, to assess the frequency of thyroid dysfunction in adult patients and the presence of favorable risk factors in original studies for the period from 2000 to 2025.

Results: In the studies included in the analysis, the incidence of subclinical or manifest thyrotoxicosis ranged from 1% to 15%, depending on the status of the iodine