Adaptive physical education based on a functional-digital approach and football tools for children with intellectual disabilities

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Abstract

Objective of the study is to provide a theoretical justification for applying the functional-digital (phygital) approach in the process of adaptive physical education, with an emphasis on creating individualized and motivating conditions for the development of motor and cognitive skills in children with intellectual disabilities and autism spectrum disorder (ASD).

Methodology and organization of the study. The study is grounded in the analysis of scientific and methodological literature and regulatory documents, the description of modern digital and interactive technologies (VR, AR, MR) in adaptive physical education, as well as a structured examination of algorithms within digital platforms that implement the principles of adaptability, individualization, visualization, and progress monitoring for children with intellectual disabilities and autism spectrum disorder.

Results and conclusions. The implementation of the functional-digital approach in the process of adaptive physical education contributes to the formation of a controlled, personalized, and predictable learning environment for children with intellectual disabilities and autism spectrum disorders. The use of digital technologies such as VR, AR, and MR makes it possible not only to individualize the workload and exercise complexity but also to provide visual support and instant feedback, which enhances motivation, engagement, and the frequency of motor action repetitions.

The analysis demonstrates that the use of the functional-digital approach ensures the comprehensive development of physical qualities, cognitive and social skills, contributes to the prevention of secondary disabilities, and provides conditions for safe, gradual, and motivating acquisition of new motor abilities. The digital environment becomes an effective tool for supporting a child along an individual developmental trajectory and facilitating social integration. Overall, the phygital approach in adaptive physical education confirms its high effectiveness and promise for working with children with ID and ASD.

Keywords: *adaptive physical culture, phygital approach, intellectual disabilities, autism spectrum disorder, children, social adaptation.*

Introduction. Modern society places increased demands on the social adaptation and independence of individuals with developmental disabilities. Intellectual developmental disabilities and ASD are accompanied by difficulties in cognitive, communicative, sensorimotor, and behavioral domains, which limit physical activity, participation in sociocultural life, and overall quality of life. Under these circumstances, adaptive physical education (APE) promotes not only motor and cognitive development but also purposefully ensures the formation of functional skills necessary for daily living and social integration.

The digital component enables objective analysis of motor activity, cognitive and behavioral indicators, timely program adjustments, and the construction of individual personal development trajectories for children with disabilities.

The combination of real and virtual tasks promotes the development of coordination, attention, executive functions, emotional regulation, and social communication in a predictable, gentle, and manageable format that meets the needs of children with ASD. The institutional prerequisites and regulatory framework for the introduction of phygital sports have already been established; these documents include Strategy

2030 (Decree of the Government of the Russian Federation No. 3081-r) and the approved federal standard for sports training in the discipline of 'phygital sport (functional-digital sport)' (Order of the Ministry of Sports of the Russian Federation No. 628 dated 02.07.2024), which opens up opportunities for scaling the approach within the system of adaptive physical education and adaptive sports at sports schools and educational institutions.

To date, a considerable body of scientific and methodological material has been accumulated that substantiates the effectiveness and importance of physical activity for children with disabilities [3, 4].

Objective of the study is to provide a theoretical justification for applying the functional-digital (phygital) approach in the process of adaptive physical education, with an emphasis on creating individualized and motivating conditions for the development of motor and cognitive skills in children with intellectual disabilities and autism spectrum disorder (ASD).

Methods and structure of the study. The study is grounded in the analysis of scientific and methodological literature and regulatory documents, the description of modern digital and interactive technologies (VR, AR, MR) in adaptive physical education, as well as a structured examination of algorithms within digital platforms that implement the principles of adaptability, individualization, visualization, and progress monitoring for children with intellectual disabilities and autism spectrum disorder.

Results of the study and discussion. Overcoming sensorimotor deficits, manifested in the inconsistency between brain signals and motor responses, and developing proprioception – the sense of body position in space – are among the primary objectives of adaptive physical education for children with intellectual disabilities and ASD.

Traditional methods of adaptive physical culture for children with intellectual disabilities (ID) and autism spectrum disorders (ASD) fail to increase motivation for participation, as these children are characterized by rapid satiation, difficulties in comprehending verbal instructions, and limited transfer of skills to everyday life [1, 2, 4].

Today's children, including those with intellectual developmental disabilities, can be described as a 'digital generation' that absorbs information more effectively through digital channels.

Digital technologies first entered adaptive physical culture in the form of biofeedback systems (fitness trackers, smart watches, and smart rings), which were designed to collect real-time information about the body's condition [2].

The functional-digital approach helps to resolve this contradiction by transforming abstract instructor demands ('smoothly bend your arm,' 'shift your body weight') into specific, interactive visual-kinesthetic tasks. In this way, the digital environment serves as a universal translator, where body movement directly affects the visual output. For example, the task of developing coordination is accomplished not through verbal instructions but through the need to physically stop a virtual object projected onto the floor in real time with one's foot, which creates a direct and comprehensible cause-and-effect link between the action and the visible result for the child, bypassing the stage of verbal processing.

A crucial aspect is the ability of the phygital environment to provide visual structuring of space and activity (visual scaffolding) in the face of motor planning and spatial orientation difficulties characteristic of children with ASD. This is compensated through the creation of digital movement "frameworks," while interactive projections, augmented reality (AR), and motion capture systems provide clear visual markers: movement trajectories, activation zones, and points of force application, enabling the child to follow a visual plan rather than an abstract instruction, thereby reducing anxiety and the cognitive load associated with independent movement planning. This visual predictability of the environment is a critical factor in reducing sensory overload, as it focuses attention on the relevant stimulus (a trigger, signal, or information directly related to the current task, goal, or behavioral context), minimizing the influence of destabilizing external factors (noise, movement of other people).

The functional-digital approach helps to improve social skills, develop new competencies, and is effective in promoting inclusion and enabling the participation of individuals with disabilities.

A key principle in organizing effective instructional impact is the concept of the zone of proximal development (hereinafter ZPD), introduced by L.S. Vygotsky. According to this approach, a child's development occurs through solving tasks that they cannot accomplish independently but can master with the help of an adult or a more competent peer. The digital environment based on phygital technologies offers unique opportunities for precise and individualized implementation of this principle in the adaptive physical

education of children with autism spectrum disorders (ASD) and intellectual disabilities (ID).

First and foremost, the digital platform acts as an automated and non-judgmental 'experienced mentor.' It possesses the ability for adaptive dosing of workload and task complexity in real time. The algorithms underlying interactive simulators continuously analyze the user's performance; thus, if a child demonstrates consistent failure, the system does not register a defeat but automatically simplifies the task: it enlarges the virtual target, slows the pace of object appearance, and reduces the amplitude of the required movement. Conversely, consistently successful performance leads to a gradual increase in difficulty, allowing the child to remain within their ZPD, where each subsequent action requires a slight degree of effort, ensuring continuous forward progress and preventing the emergence of frustration and negative emotional states associated with chronic failure.

The most important mechanism of support within the ZPD is the system's provision of timely hints and 'assistance.' Unlike socially colored correction from a teacher, which may be perceived as a negative evaluation, the game simulator provides help instrumentally and neutrally. For example, when a child has difficulty performing a movement, the system can visually highlight the trajectory of an arm or leg movement, mark the target object, or demonstrate a model performance in a simplified animation. This function creates conditions for positive reinforcement: the child does not receive a negative assessment for an error but instead receives a resource for self-correction, which strengthens their self-confidence and sustains intrinsic motivation.

The use of the functional-digital approach transforms rehabilitation from an intuitive process into an evidence-based, measurable, and personalized one, significantly increasing the effectiveness of working with children with intellectual disabilities and ASD.

Conclusions. The integration of digital technologies into the process of adaptive physical education opens fundamentally new opportunities for unlocking the potential of individuals with ASD and ID by creating a controlled, personalized, and predictable environment aimed at developing physical abilities and cognitive skills. The phygital environment does not serve as a trigger for children with autism spectrum disorder; on the contrary, it becomes a means of managing the primary condition and preventing secondary disabilities.

The application of the functional-digital approach in APE for children with intellectual developmental disabilities and ASD represents a promising research endeavor that combines purposeful practical skills training with the capabilities of digital technologies. This approach enhances diagnostic accuracy, learning individualization, children's motivation, and the effectiveness of sports rehabilitation activities, contributing to the improvement of quality of life and the social adaptation and integration of children with ID and ASD.

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