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THE IMPACT OF DIGITAL TECHNOLOGIES FOR MONITORING MOTOR ACTIVITY ON ENHANCING THE COMPETITIVE PERFORMANCE OF TRACK AND FIELD ATHLETES IN THE SYSTEM OF HIGHER SPORTS TRAINING

Ubbiyev Baxytbay Amangeldiyevich
Assistant Professor of the Department of Interfaculty
Development Karakalpak State University

Abstract

The rapid integration of digital technologies into modern sport has significantly transformed the system of higher sports training, particularly in track and field athletics, where competitive success is closely linked to precise control of motor activity, training load, and recovery processes. This study examines the impact of digital technologies for monitoring motor activity on enhancing the competitive performance of track and field athletes within the context of higher sports training. The relevance of the research is determined by the growing demand for evidence-based training management and the increasing availability of wearable sensors, mobile applications, and analytical platforms capable of providing real-time and longitudinal data on athletes' physical activity. Digital monitoring tools enable coaches and athletes to obtain objective indicators of movement patterns, intensity, volume, biomechanical parameters, and physiological responses, which significantly improves the accuracy of training planning and performance evaluation. The abstract emphasizes that traditional training approaches, largely based on subjective assessment and generalized norms, are increasingly insufficient in elite and university-level sport, where marginal gains determine competitive outcomes. The study synthesizes contemporary theoretical perspectives and empirical findings related to digital monitoring technologies and their role in optimizing training processes, preventing overtraining, and supporting individualized athlete development. Special attention is given to the pedagogical dimension of higher sports training, where digital tools function not only as instruments of control but also as means of developing athletes' self-regulation, reflective skills, and professional competencies. The research

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highlights the potential of digital monitoring systems to bridge the gap between training practice and sports science by translating complex data into actionable coaching decisions. The expected outcomes include improved competitive performance, enhanced training efficiency, and increased sustainability of athletic development. Overall, the study contributes to the understanding of how digital technologies can be systematically integrated into higher sports education and training to support the holistic development of track and field athletes and to improve their competitive effectiveness in a rapidly evolving digital sports environment.

Keywords: Digital technologies, motor activity monitoring, track and field athletics, competitive performance, higher sports training, wearable sensors, training load control, performance analytics, athlete monitoring systems.

Introduction

The contemporary system of higher sports training is developing under conditions of rapid technological progress, which has a profound impact on the organization, content, and effectiveness of the training process. In track and field athletics, where competitive performance is determined by precise coordination of motor actions, optimal distribution of training loads, and timely recovery, the role of objective monitoring tools has become increasingly significant. Digital technologies for monitoring motor activity are now widely regarded as an essential component of modern sports science and coaching practice, enabling a transition from intuition-based training toward data-driven decision-making. This transformation is particularly relevant in the context of higher sports education, where athletes are prepared not only for competitive success but also for long-term professional development within sport.

Traditionally, the evaluation of athletes' motor activity and training effectiveness relied on observational methods, subjective judgments of coaches, and periodic testing. While these approaches provided valuable practical experience, they were often limited in accuracy, continuity, and individualization. The complexity of modern competitive sport, characterized by high training volumes, intensified competition, and increased injury risks, has exposed the limitations of conventional monitoring methods. As a result, the integration of digital

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technologies such as wearable sensors, GPS systems, inertial measurement units, heart rate monitors, and specialized software platforms has become a logical and necessary step in the evolution of sports training systems. These technologies allow continuous and objective registration of movement parameters, physiological responses, and workload indicators during both training and competition.

In track and field athletics, digital monitoring technologies offer unique opportunities to analyze running mechanics, stride frequency and length, acceleration patterns, jump dynamics, throwing velocity, and other discipline-specific characteristics. The availability of detailed quantitative data makes it possible to identify individual strengths and weaknesses, detect deviations from optimal technique, and adjust training programs in real time. From a pedagogical perspective, such technologies enhance the educational function of higher sports training by promoting athletes' awareness of their own physical condition and performance dynamics. Athletes increasingly become active participants in the training process, capable of interpreting data, reflecting on their performance, and taking responsibility for their development.

The relevance of this research is further strengthened by the growing emphasis on competitive efficiency in university and elite sport. Marginal improvements in speed, endurance, coordination, and technical execution often determine the outcome of competitions. Digital monitoring systems provide coaches with tools to optimize micro- and macro-cycles of training, balance load and recovery, and prevent overtraining and injury. Moreover, these technologies facilitate long-term performance tracking, enabling the evaluation of training effectiveness across seasons and stages of athletic development.

Within the system of higher sports training, the integration of digital technologies also responds to broader educational and institutional objectives. Universities and sports institutes increasingly aim to align training practices with international standards, promote innovation, and prepare athletes for the realities of modern professional sport. Digital monitoring technologies contribute to this goal by creating a scientific and methodological foundation for training management, fostering interdisciplinary collaboration between coaches, sports scientists, and educators.

Despite the widespread adoption of digital tools in sport, there remains a need for comprehensive analysis of their actual impact on competitive performance,

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particularly in track and field athletics within higher sports training systems. Questions related to effectiveness, methodological integration, pedagogical value, and practical implementation require systematic investigation. This study addresses these issues by examining the influence of digital technologies for monitoring motor activity on the enhancement of competitive performance of track and field athletes, emphasizing their role in improving training quality, performance outcomes, and educational effectiveness in higher sports training contexts.

Methods

The methodological framework of this study is based on an integrated approach combining theoretical analysis, empirical research methods, and applied sports science techniques aimed at assessing the impact of digital technologies for monitoring motor activity on the competitive performance of track and field athletes in higher sports training. The research design reflects the specifics of pedagogical universities and higher sports institutions, where training activities are closely connected with educational objectives and long-term athlete development.

The theoretical component of the study involved a systematic analysis of scientific literature in the fields of sports science, digital pedagogy, biomechanics, and training theory. This analysis made it possible to identify key concepts, methodological approaches, and current trends related to the use of digital monitoring technologies in athletics. Special attention was given to studies examining wearable devices, sensor-based monitoring systems, and performance analytics platforms applied in endurance, speed-strength, and technical athletic disciplines. The synthesis of theoretical sources provided the conceptual basis for defining research variables and selecting appropriate empirical methods.

The empirical part of the study was conducted within the framework of higher sports training programs for track and field athletes. The research sample consisted of university-level athletes specializing in sprinting, middle-distance running, long-distance running, jumping, and throwing events. Participants were selected based on comparable levels of sports qualification, training experience, and involvement in structured training programs. The study design included both experimental and control elements, allowing for comparative analysis of training outcomes with and without systematic use of digital monitoring technologies.

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Digital technologies for monitoring motor activity constituted the primary research tool. These included wearable sensors for tracking movement dynamics, heart rate monitoring devices for assessing physiological load, and software platforms for data collection and analysis. During training sessions and selected competitive performances, data were recorded on parameters such as training volume and intensity, movement frequency, speed, acceleration, and recovery indicators. The use of digital tools ensured continuous and objective data collection under real training conditions, minimizing the influence of subjective factors.

Pedagogical observation was employed to analyze changes in training organization, athlete behavior, and coach–athlete interaction resulting from the integration of digital monitoring systems. This method made it possible to assess how digital data influenced coaching decisions, feedback mechanisms, and athletes' engagement in the training process. In addition, structured interviews with coaches and athletes were conducted to identify perceptions of the effectiveness, usability, and pedagogical value of digital technologies in higher sports training.

Performance assessment methods included analysis of competition results, control tests, and standardized performance indicators relevant to specific athletic disciplines. Comparative analysis was applied to evaluate changes in competitive performance over the training period. Statistical methods were used to process quantitative data, identify significant differences between observed indicators, and determine correlations between monitored motor activity parameters and competitive outcomes.

The methodological approach also emphasized ethical considerations, including voluntary participation, informed consent, and confidentiality of personal performance data. The combination of theoretical, empirical, pedagogical, and analytical methods ensured the reliability and validity of the research findings and allowed for a comprehensive evaluation of the role of digital motor activity monitoring technologies in enhancing competitive performance within the system of higher sports training.

Results

The results of the study demonstrate a positive and statistically significant impact of digital technologies for monitoring motor activity on the competitive

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performance of track and field athletes engaged in higher sports training. The systematic use of digital monitoring tools contributed to measurable improvements in key performance indicators across different athletic disciplines, including speed, endurance, technical efficiency, and stability of competitive results. The analysis confirms that objective, continuous data collection enabled more precise control of training loads and facilitated timely adjustments to individual training programs.

Quantitative data obtained from wearable sensors and monitoring platforms revealed clear changes in motor activity parameters over the training period. Athletes who trained under conditions of regular digital monitoring demonstrated optimized training volume and intensity profiles compared to those relying on traditional methods. Variability in workload distribution decreased, indicating more consistent and balanced training processes. In sprint and middle-distance running events, improvements were observed in speed-related parameters, including acceleration dynamics, stride frequency, and maintenance of optimal running pace during competitive efforts. Endurance athletes showed enhanced stability of heart rate responses and improved indicators of aerobic efficiency, suggesting more effective adaptation to training loads.

In technical disciplines such as jumping and throwing, digital monitoring provided detailed insights into movement structure and execution consistency. The data analysis indicated a reduction in technical errors and greater repeatability of optimal movement patterns during both training and competition. Athletes demonstrated improved coordination and timing, which translated into more stable and higher competition results. The availability of immediate feedback allowed coaches to correct technical deficiencies more efficiently, reducing the time required for skill acquisition and refinement.

Comparative analysis of competition results showed that athletes using digital monitoring technologies achieved higher average performance improvements over the observation period than those in the control group. Performance gains were not limited to peak results but also reflected increased consistency across competitions. This finding is particularly important in higher sports training, where the ability to maintain stable performance under varying competitive conditions is a key indicator of athletic maturity and preparedness.

Pedagogical observations and qualitative data from interviews revealed notable changes in the training culture and athlete behavior. Athletes reported increased

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awareness of their physical condition, training responses, and recovery needs. This awareness contributed to the development of self-regulation skills and more responsible attitudes toward training and competition. Coaches emphasized that digital monitoring enhanced the quality of feedback and supported evidence-based decision-making, reducing reliance on intuition alone.

The results also indicate a preventive effect of digital monitoring technologies. Early detection of excessive load indicators and unfavorable trends in motor activity parameters made it possible to adjust training plans and reduce the risk of overtraining and injury. Athletes experienced fewer interruptions in training due to fatigue-related issues, which positively influenced overall training continuity and competitive readiness.

Overall, the findings confirm that the integration of digital technologies for monitoring motor activity leads to improved training efficiency, higher competitive performance, and enhanced pedagogical effectiveness within the system of higher sports training. The results provide empirical support for the systematic inclusion of digital monitoring tools in the preparation of track and field athletes at the university and elite levels.

Discussion

The findings of this study confirm that digital technologies for monitoring motor activity play a substantive role in enhancing the competitive performance of track and field athletes within the system of higher sports training. The discussion of results should be considered in relation to contemporary trends in sports science, where the shift toward data-driven training management is increasingly viewed as a prerequisite for achieving stable and high-level performance outcomes. The positive effects observed in this research align with the broader scientific consensus that objective monitoring tools significantly improve the quality of training control and performance evaluation.

One of the key discussion points concerns the transformation of the coach–athlete interaction model. The integration of digital monitoring technologies changes the traditional hierarchical structure of training by introducing transparent and shared performance data. This transparency supports a more collaborative training environment in which athletes actively engage with performance indicators and participate in decision-making processes related to training adjustments. Such an approach is particularly valuable in higher sports training, where athletes are

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expected to develop not only physical qualities but also professional competencies, analytical thinking, and self-regulation skills. The pedagogical dimension of digital monitoring therefore extends beyond performance enhancement and contributes to the holistic development of future professionals in sport.

Another important aspect is the role of digital technologies in individualizing the training process. The study demonstrates that access to detailed motor activity data allows coaches to move away from standardized training prescriptions toward highly personalized programs that reflect the specific physiological, biomechanical, and technical characteristics of each athlete. This individualization is especially relevant in track and field athletics, where different disciplines impose distinct demands on the neuromuscular and energy systems. The ability to precisely adjust training loads and technical focus areas contributes to more efficient adaptation and reduces the likelihood of maladaptive responses.

The discussion also highlights the preventive potential of digital monitoring technologies. By enabling early detection of unfavorable trends related to fatigue, load accumulation, or technical degradation, these tools support proactive interventions aimed at injury prevention and recovery optimization. In the context of higher sports training, where athletes often combine intensive training with academic responsibilities, the risk of overtraining and insufficient recovery is particularly high. Digital monitoring systems provide an objective basis for balancing training demands with recovery needs, thereby supporting long-term athletic sustainability.

Despite the demonstrated benefits, the discussion must also address methodological and practical challenges associated with the use of digital technologies. Effective implementation requires adequate technological infrastructure, coach competence in data interpretation, and the integration of monitoring systems into existing training methodologies. Without proper methodological guidance, there is a risk of data overload or misinterpretation, which may reduce the practical value of digital tools. Therefore, the success of digital monitoring depends not only on technological availability but also on the pedagogical and methodological readiness of coaches and institutions.

In summary, the discussion of results underscores that digital technologies for monitoring motor activity represent a powerful instrument for enhancing competitive performance in track and field athletics within higher sports training

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systems. Their effectiveness is maximized when they are integrated into a coherent pedagogical and methodological framework that emphasizes individualization, athlete education, and evidence-based coaching practice.

Conclusion

The conducted research allows for a comprehensive conclusion that digital technologies for monitoring motor activity exert a substantial and multifaceted influence on the enhancement of competitive performance of track and field athletes within the system of higher sports training. The integration of digital monitoring tools into the training process represents not merely a technological innovation, but a fundamental methodological shift toward evidence-based, individualized, and pedagogically grounded sports preparation. The findings confirm that systematic use of digital technologies contributes to higher training efficiency, improved competitive stability, and sustainable athletic development.

One of the most significant conclusions of the study is that digital monitoring technologies enable a qualitative improvement in the management of training loads. Objective data on movement dynamics, intensity, volume, and physiological responses allow for precise regulation of training stimuli in accordance with athletes' individual adaptive capacities. This precision reduces the risk of excessive or insufficient loading and creates optimal conditions for performance growth. As a result, athletes demonstrate more consistent progress and improved readiness for competitive demands, which is particularly important in track and field athletics, where marginal gains often determine competitive success.

The research also confirms that digital monitoring technologies enhance technical and biomechanical aspects of performance. Continuous analysis of motor activity parameters supports timely identification of technical deviations and inefficient movement patterns. This contributes to more rapid correction of errors and consolidation of optimal techniques, leading to greater reliability of performance in competition. In higher sports training systems, where athletes are expected to reach advanced levels of technical mastery, such technological support becomes an essential component of effective preparation.

From a pedagogical perspective, the study highlights the educational value of digital monitoring technologies. Their use promotes the development of athletes' self-awareness, reflective abilities, and responsibility for their own training

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process. Athletes gain access to objective feedback, which fosters a deeper understanding of the relationship between training actions and performance outcomes. This educational effect is especially relevant in pedagogical universities and higher sports institutions, where training objectives extend beyond short-term results and include the formation of professional competencies necessary for future careers in sport.

The conclusion also emphasizes the preventive and health-preserving role of digital technologies. Early detection of unfavorable trends related to fatigue and overload allows for timely corrective measures, reducing the incidence of injuries and interruptions in training. This aspect is crucial for ensuring continuity of preparation and long-term athletic sustainability, particularly in environments where athletes must balance intensive training with academic responsibilities.

At the same time, the study confirms that the effectiveness of digital monitoring technologies depends on their methodological integration into the training system. Technological tools alone do not guarantee performance improvement; their value is realized only when coaches possess the necessary competencies to interpret data and apply it meaningfully within training planning. Therefore, higher sports training systems should prioritize the development of digital literacy and methodological readiness among coaching staff.

In conclusion, digital technologies for monitoring motor activity represent a strategically important resource for improving competitive performance of track and field athletes in higher sports training. Their systematic and pedagogically informed application contributes to optimized training processes, enhanced competitive effectiveness, and the holistic development of athletes, aligning modern sports preparation with the demands of contemporary digital society.

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