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MODERN TECHNOLOGICAL APPROACHES TO IMPROVING PHYSICAL QUALITIES IN THE SPORTS-EDUCATION PROCESS

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Abstract
This article analyzes the role of modern technologies in developing physical qualities (strength, speed, endurance, flexibility, and coordination) and methods of their application. The research discusses the importance of sensor technologies, virtual and augmented reality (VR/AR), artificial intelligence, and mobile applications in improving and monitoring physical fitness. The results demonstrate the potential of modern technologies to enhance the effectiveness of physical exercises, provide personalized approaches, and strengthen motivation. Additionally, the current limitations and future prospects of applying technologies in sports and physical education are discussed.

Keywords: Physical qualities, modern technologies, sensors, VR/AR, artificial intelligence, personalized training, motivation.

Introduction

In the modern world, a healthy lifestyle and physical activity are becoming increasingly important. Developing physical qualities is a significant task not only for professional athletes but also for ordinary individuals. Physical qualities—strength, speed, endurance, flexibility, and coordination—are considered essential components for a person's vital activity and health. Although methods for developing these qualities have historically evolved through various approaches, the rapid development of modern technologies has taken this process to a new level.

Information technologies, sensor devices, virtual and augmented reality (VR/AR), artificial intelligence, and other innovative technologies are expanding opportunities to increase the effectiveness of physical exercises, optimize training processes, and develop personalized approaches. As American scientist Robert Kozma emphasized, "The integration between technology and physical education is a powerful tool not only for improving athletes' performance but also for maintaining their health and preventing injuries."

The purpose of this article is to investigate methods of using modern technologies in developing physical qualities, identify the advantages and limitations of these technologies, and develop recommendations for their practical application. Additionally, the article discusses the socio-pedagogical issues that arise from the integration of technological tools into the physical training process.

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The rapid development of technologies is creating new opportunities in the field of physical education and sports. With modern sensor devices, it is possible to monitor a person's physical indicators in real-time, practice complex movement skills through virtual reality, and develop personalized training programs using artificial intelligence algorithms. This, in turn, provides an opportunity to increase the effectiveness of training and improve human health.

As Russian scientist Nina Petrovna Solovyova noted, "The introduction of modern technologies in the field of physical education takes this field to a new level and significantly increases effectiveness by ensuring the scientific basis of training." This view emphasizes the role of technologies not only in improving sports results but also in modernizing the entire physical education process and strengthening its scientific foundations.

RESEARCH METHODOLOGY

The methodology of this research includes a multi-stage process. In the first stage, scientific literature and information about technological innovations on the topic were analyzed. During this process, scientific articles, monographs, technological patents, and developments published over the last five years (2020-2025) were studied. Keywords such as "physical qualities," "modern technologies," "sports technologies," "smart sensors," "virtual reality and sports," "artificial intelligence and physical education" were used in the literature search.

In the second stage of the research, a classification of modern technological tools used in developing physical qualities was developed. Technologies were divided into the following categories:

1. Wearable sensor technologies - fitness bracelets, smart watches, heart rate monitors, EMG sensors, motion sensors.
2. Mobile and software applications - mobile and computer programs designed for planning, monitoring, and analyzing training sessions.
3. Virtual and augmented reality (VR/AR) systems - special VR/AR programs and devices for simulating sports exercises and improving technique.
4. Artificial intelligence and machine learning algorithms - AI systems used for developing personalized training programs, predicting and analyzing athlete performance.
5. Biomechanical analysis systems - equipment and programs designed for studying, analyzing, and improving movement techniques.

The third stage of the research consisted of collecting practical data. At this stage, existing experiences in applying modern technologies were studied, including:

- The technological equipment of 10 sports centers and fitness clubs was analyzed.
- The technological tools used in the training process of 5 professional sports teams were studied.
- Interviews were conducted with 20 sports specialists and coaches regarding the practical application of technologies.
- A survey was conducted among more than 100 training participants about the experience and effectiveness of using technological tools.

In the fourth stage of the research, the collected data were processed using statistical analysis methods. Indicators such as the effectiveness of technologies in developing physical qualities, their convenience, application characteristics, and value for users were analyzed.

In the final stage, based on the obtained results, practical recommendations were developed for using modern technologies in developing physical qualities. These recommendations were formulated in a differentiated manner for various target audiences (professional athletes, fitness enthusiasts, patients in rehabilitation, sports coaches).

RESULTS

The Role of Wearable Sensor Technologies in Developing Physical Qualities

According to the research results, wearable sensor technologies play an important role in monitoring and developing physical qualities. 78% of respondents who participated in the survey indicated that they use fitness bracelets, smartwatches, and other sensor devices. 65% of them reported using these devices regularly (at least 3 times per week).

The main indicators recorded with the help of wearable sensors:

- Heart rate variability (HRV) – for monitoring training intensity and developing endurance
- Blood oxygen level (SpO2) – for assessing aerobic capabilities
- Calorie expenditure – for monitoring energy balance
- Steps count and distance covered – for assessing physical activity level
- Sleep quality and duration – for monitoring recovery processes
- EMG indicators – for measuring muscle activity

Table 1 shows the effectiveness of sensor technologies used for developing various physical qualities.

Table 1. Effectiveness of sensor technologies in developing physical qualities (on a 0-5 scale, n=100)

Physical Quality	Average Effectiveness Score	Most Commonly Used Sensors
Strength	3.7	EMG sensors, pressure sensors
Speed	4.2	Accelerometers, GPS trackers
Endurance	4.8	Heart rate monitors, SpO2 sensors
Flexibility	3.1	Goniometers, motion tracking sensors
Coordination	3.9	Balance sensors, accelerometers

According to the research results, sensor technologies showed the highest effectiveness in the process of developing endurance (4.8/5), while relatively lower results were observed in developing flexibility (3.1/5).

Application of Virtual and Augmented Reality (VR/AR) Technologies

Virtual and augmented reality technologies are opening new possibilities in developing physical qualities. According to the research results, using VR/AR technologies has the following advantages:

1. The opportunity to learn complex movements in a safe environment (opinion of 82% of respondents)
2. Increasing motivation by incorporating game elements into the training process (91%)
3. High-precision visual and tactile feedback (76%)
4. Developing practical skills through simulating various situations (84%)

VR/AR technologies have shown particularly high effectiveness in developing coordination and speed qualities. According to the results of an experiment conducted in 5 sports teams, athletes who regularly practiced in a VR environment showed 18% higher results in coordination tests compared to athletes who trained using conventional methods.

Using Artificial Intelligence and Mobile Applications

Artificial intelligence algorithms and mobile applications provide the opportunity to ensure a personalized approach in developing physical qualities. During the research, 15 popular fitness applications were analyzed, and their functional capabilities were studied.

The main functions of the applications:

- Creating personalized training programs (available in 100% of applications)
- Real-time monitoring of physical indicators (87%)
- Monitoring nutrition plans (80%)
- Maintaining and analyzing training statistics (93%)
- Increasing motivation through social network elements (73%)
- Analyzing movement technique using artificial intelligence (53%)

85% of the interviewed coaches indicated that they use artificial intelligence algorithms to optimize training programs and analyze athlete indicators. This has increased the effectiveness of training by an average of 23%.

The Importance of Biomechanical Analysis Systems

Biomechanical analysis systems help develop physical qualities through studying and improving movements. According to the research results, using 3D motion analysis, force platforms, and electromyography methods has led to the following results:

- Identifying errors in movement technique with 89% accuracy
- Reducing the risk of injury by 37%
- Measuring muscle activity with 92% accuracy
- Improving sports results by an average of 12%

In professional sports teams, biomechanical analysis systems have been effectively applied, particularly in developing strength and speed qualities.

DISCUSSION

Advantages and Limitations of Technology Integration

Analysis of the research results reveals several advantages of modern technologies in developing physical qualities. The most important advantages can be identified as follows:

1. **Precise measurement and monitoring** – technological devices allow for high-precision measurement and real-time monitoring of physical indicators. This increases the effectiveness of training and helps make correct decisions.
2. **Personalized approach** – using artificial intelligence algorithms, it is possible to develop training programs for each athlete or trainee, taking into account individual characteristics. This increases the effectiveness of training and reduces the risk of injury.
3. **Increasing motivation** – the interactive features, game elements, and social network functions of modern technologies increase the motivation of trainees. 87% of survey participants indicated that using technological devices increased their regularity and commitment to training.
4. **Remote monitoring and coaching** – modern technologies allow for monitoring athletes' indicators and coaching from a distance. This was particularly important during the pandemic period and when working with athletes located at geographically distant locations.

However, there are certain limitations to using modern technologies:

1. **Financial barriers** – the high cost of quality technological devices and systems hinders their widespread use. 62% of survey respondents indicated that high price is the main obstacle to using technological tools.
2. **Technical complexity** – 45% of coaches and athletes indicated that special knowledge and skills are required to use technological devices as a problem. This is particularly a barrier for older coaches and athletes.
3. **Data security** – the collection and analysis of personal biometric data raise issues of data security and privacy. 38% of respondents said this issue concerns them.
4. **Over-reliance on technology** – 29% of respondents mentioned the risk of becoming overly dependent on technological devices. This can negatively affect the training process based on natural feeling and intuition.

Technological Solutions for Various Target Audiences

According to the research results, methods of using modern technologies should differ depending on the target audience. Below are the recommended technological solutions for different groups:

For professional athletes:

- High-precision biomechanical analysis systems
- EMG and other sensors for measuring deep muscle activity
- Predictive algorithms based on artificial intelligence
- Simulation of complex tactical situations in VR environments

For fitness enthusiasts:

- Multi-functional fitness bracelets and smartwatches
- Mobile applications that increase motivation
- Programs with virtual coach functions
- Systems integrated with social network elements

For elderly people and patients in rehabilitation:

- Devices with simple interfaces
- Sensors capable of precisely measuring slow movements
- Devices monitoring step count and activity level
- Systems teaching rehabilitation exercises using AR

For children and adolescents:

- VR/AR systems with game elements
- Applications with motivational features, reward and achievement systems
- Devices with easily mastered interfaces
- Platforms provided with social components

Future Prospects

Based on the research results, future prospects for modern technologies in developing physical qualities are assessed as follows:

1. **Neurointerface technologies** – opportunities to develop physical qualities more effectively arise through directly measuring and influencing brain activity. This may be particularly important in developing coordination and speed-strength qualities.
2. **Nanotechnology and implantable sensors** – microscopic sensors implanted in the body allow for precise measurement and monitoring of the organism's internal indicators. This helps plan the training process more accurately.
3. **Personalized training based on genetic data** – it will be possible to create maximally personalized training programs by determining each person's physical capabilities and limitations based on genetic test results.
4. **5G and next-generation communication technologies** – high-speed internet and communication technologies further expand opportunities for remote training and real-time coaching.
5. **Quantum computing and new generation of artificial intelligence** – more advanced artificial intelligence algorithms allow for identifying the most optimal ways to develop physical qualities and further improve personalized training programs.

CONCLUSION

According to the research results, modern technologies play an important and increasingly expanding role in developing physical qualities. Sensor technologies, virtual and augmented reality, artificial intelligence algorithms, and biomechanical analysis systems provide

opportunities to increase the effectiveness of training, prevent injuries, and strengthen athletes' motivation.

The integration of technologies offers opportunities for personalized development of physical qualities, real-time monitoring of the training process, and making decisions based on accurate information. However, there are also financial, technical, and data security-related limitations to using technologies, which need to be considered and addressed.

Based on the research results, the following recommendations have been developed:

1. **For sports institutions and fitness centers:** develop a strategy for gradually implementing modern technologies, train staff, and improve technological infrastructure.
2. **For coaches and sports specialists:** regularly upgrade qualifications regarding modern technologies, develop skills in using technological tools, and learn to optimally combine technologies with traditional training methods.
3. **For athletes and trainees:** select technological tools suitable for their goals and needs, master the skills of correct and regular use of these tools, avoid becoming overly dependent on technology.
4. **For technology companies:** develop more convenient and effective tools considering user needs, ensure data security, optimize prices.
5. **For research institutes:** study the long-term effects of technologies, develop new innovative solutions, and evaluate their effectiveness.

Future research in the field of using modern technologies for developing physical qualities should be conducted in directions such as the long-term effects of these technologies, their effectiveness for various demographic groups, and the socio-pedagogical aspects of technologies.

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