# Evaluación de la Eficacia de un Sistema de Monitoreo de Ejercicios en Tiempo Real Impulsado por Inteligencia Artificial en el Aprendizaje Colaborativo Asistido por Computadora

*Assessing the Efficacy of an Artificial Intelligence-Driven Real-Time Exercise Monitoring System in Computer-Supported Collaborative Learning*

## Authors

Nurzhamal Oshanova
Guldina Kamalova
Nazym Tekesbayeva
Shugyla Turashova
Gulzat Anuarbekova
Assel Bukanova

Abai Kazakh National Pedagogical University (Kazakhstan)

Corresponding author:
Guldina Kamalova
g.kamalova@abaiuniversity.edu.kz
mrdoctor@keemail.me

## How to cite in APA

Oshanova, N., Guldina Bolshevikovna, Tekesbayeva, N., Turashova, S., Anuarbekova, G., & Bukanova, A. (2025). Assessing the Efficacy of an Artificial Intelligence-Driven Real-Time Exercise Monitoring System in Computer-Supported Collaborative Learning. *Retos*, *67*, 580–596. https://doi.org/10.47197/retos.v67.114434

## Abstract

Introduction: the efficacy of AI-driven real-time exercise monitoring systems in enhancing physical education programs was explored in this study. the integration of such technologies aimed to boost engagement, motivation, and safety among participants, reflecting a growing trend towards technology-enhanced learning environments.
Objective: the objective was to empirically evaluate the impact of an AI-driven system on learning engagement, motivation levels, and injury prevention in a physical education context, comparing outcomes against traditional training methods.
Methodology: the methodology involved a controlled experiment with eighty physical education students divided into control and experimental groups. data were collected through surveys, performance assessments, and injury reports, with statistical analyses conducted using independent samples t-tests and chi-square tests.
Results: results indicated significantly higher engagement and motivation in the experimental group, which utilized the AI system. additionally, this group experienced fewer injuries, demonstrating the system's potential to enhance safety.
Discussion: other studies have similarly highlighted technology's role in improving educational outcomes, though few have focused specifically on physical education. this study's findings align with broader research supporting the adoption of AI in educational settings.
Conclusions: the conclusions confirm that AI-driven monitoring systems significantly improve student engagement, motivation, and safety in physical education, suggesting that such technologies can be valuable additions to educational curricula to enhance learning experiences and outcomes.

## Keywords

real-time monitoring; physical education; learning engagement; motivation; injury prevention; exercise monitoring

## Resumen

Introducción: Este estudio analizó la eficacia de los sistemas de monitoreo de ejercicios en tiempo real basados en IA para mejorar los programas de educación física. La integración de estas tecnologías tuvo como objetivo aumentar el compromiso, la motivación y la seguridad, reflejando la tendencia hacia entornos de aprendizaje avanzados tecnológicamente.
Objetivo: el objetivo de este estudio fue evaluar empíricamente el impacto de un sistema de IA en el compromiso de aprendizaje, motivación y prevención de lesiones en educación física, comparando los resultados con métodos de entrenamiento tradicionales.
Metodología: la metodología consistió en un experimento controlado con ochenta estudiantes de educación física, asignados a grupos de control y experimental. Se recopilaron datos mediante encuestas, evaluaciones de desempeño e informes de lesiones, y se aplicaron análisis estadísticos con pruebas t de muestras independientes y pruebas de chi-cuadrado.
Resultados: los resultados indicaron un compromiso y motivación significativamente mayores en el grupo experimental, que utilizó el sistema de IA. Además, este grupo experimentó menos lesiones, demostrando el potencial del sistema para mejorar la seguridad.
Discusión: otros estudios han destacado de manera similar el papel de la tecnología en la mejora de los resultados educativos, aunque pocos se han centrado específicamente en la educación física. Los hallazgos de este estudio están en línea con investigaciones más amplias que respaldan la adopción de IA en entornos educativos.
Conclusiones: las conclusiones confirman que los sistemas de monitoreo impulsados por IA mejoran significativamente el compromiso, la motivación y la seguridad de los estudiantes en la educación física, sugiriendo que tales tecnologías pueden ser adiciones valiosas a los currículos educativos para mejorar las experiencias y resultados de aprendizaje.

## Palabras clave

monitoreo en tiempo real; educación física; compromiso de aprendizaje; motivación; prevención de lesiones; monitoreo del ejercicio

## Introduction

In recent years, the convergence of artificial intelligence (AI) and educational technology has given rise to innovative approaches that significantly enhance learning outcomes. Among these, Computer-Supported Collaborative Learning (CSCL) has emerged as a critical domain, where technology-mediated interactions are employed to facilitate learning processes within group settings (Kaliisa et al., 2025). This paper explores the integration of an AI-driven real-time exercise monitoring system within CSCL environments, specifically focusing on physical education (PE). The application of real-time data analytics in educational settings is not new; however, its utilization in PE through AI technologies presents a novel area of exploration that promises to enhance instructional quality and student engagement (Kang et al., 2024).

AI-driven systems in education have primarily focused on cognitive subjects, with less emphasis on physical education, which is equally crucial for the holistic development of students (Deng et al., 2024). Physical education benefits significantly from technological integration, as it can provide immediate feedback and personalized guidance, essential for effective learning (Liu et al., 2022). Real-time monitoring systems using AI can analyze performance, offer corrective feedback, and adaptively support learners in achieving optimal movement patterns, thereby enhancing both individual and collaborative learning experiences (Cao et al., 2022).

The concept of CSCL involves more than just the interaction among students; it includes the integration of collaborative tools that support the collective learning process (Xie, 2021). When applied to PE, CSCL can transform traditional physical training sessions into interactive, data-driven experiences that promote greater engagement and cooperation among students (Wang & Du, 2022). The efficacy of such systems in PE has been preliminarily explored, but rigorous assessments are sparse (Hannan et al., 2021). Thus, there is a compelling need to systematically evaluate the impact of AI-driven real-time exercise monitoring systems on the effectiveness of CSCL in the physical education context.

Additionally, the role of AI in enhancing motor skill acquisition through augmented feedback mechanisms is well-documented (Ren et al., 2025). Real-time feedback, a critical component of AI-driven systems, has been shown to significantly improve the accuracy of movements and skill execution by providing immediate and precise corrections tailored to each student's actions (Zhang et al., 2024). This is particularly vital in PE, where correct form and technique are crucial for effective skill development and injury prevention (Kovoor et al., 2024; Omarov et al., 2024).

The integration of AI technologies in PE also facilitates the creation of a supportive learning environment that adapts to the needs and learning styles of diverse student populations (Hsia et al., 2024). For instance, AI-driven analytics can identify patterns and provide insights into group dynamics and individual performance, thereby enabling teachers to tailor their instructional strategies more effectively (Wang et al., 2024). Moreover, such systems encourage a data-driven approach to physical education, aligning with contemporary educational paradigms that emphasize evidence-based practices (Kadhim et al., 2024).

This research aims to fill the gap in the literature by providing empirical evidence on the effectiveness of AI-driven real-time exercise monitoring systems in improving the educational outcomes of CSCL in PE. By deploying a mixed-methods research design, this study evaluates the system's impact on student engagement, skill acquisition, and the overall quality of the learning experience (Trendowski, 2025). Furthermore, this investigation considers the pedagogical implications of integrating advanced AI tools into physical education and their potential to revolutionize traditional teaching methodologies (Cui, 2025).

The integration of artificial intelligence (AI) in education presents unprecedented opportunities to enhance both teaching methodologies and learning outcomes. This study contributes to the growing body of research by evaluating an innovative application of AI in a relatively underexplored domain—physical education—within the framework of Computer-Supported Collaborative Learning (CSCL). By examining the impact of AI-driven real-time exercise monitoring, this research provides empirical insights that are expected to benefit educators, curriculum developers, and technology designers seeking to leverage AI technologies to create more engaging, adaptive, and effective learning environments (Arif et al., 2025).

## Related Works

The integration of artificial intelligence (AI) in educational environments, particularly within physical education (PE), has begun to draw considerable attention from researchers and practitioners alike. This section reviews the existing literature on AI-driven real-time exercise monitoring systems, Computer-Supported Collaborative Learning (CSCL) in physical education, and the broader implications of technology-enhanced learning environments.

### *AI in Physical Education*

Recent advancements in AI technology have provided new avenues for enhancing physical education by facilitating real-time feedback and personalized learning trajectories. Studies have shown that AI-driven systems can significantly improve the accuracy of movement execution in PE by offering instant, data-driven feedback (Jun et al., 2024). For instance, Kotte et al. (2024) demonstrated that an AI-based system could effectively analyze student performance in real-time, providing adjustments and recommendations that improved students' motor skills and overall physical literacy. Similarly, Mitra & Rehman (2025) explored the use of wearable technology integrated with AI to monitor and enhance student performance in dynamic sports activities, revealing significant improvements in student engagement and skill acquisition.

### *Real-Time Monitoring Systems*

The concept of real-time monitoring in educational settings has evolved to include the use of sophisticated sensors and analytics to provide feedback that is not only immediate but also contextually relevant (Mateus et al., 2024). For example, Li et al. (2024) implemented a sensor-based AI system that provided feedback on students' physical postures during exercises, significantly reducing the risk of injuries and improving performance consistency. These systems are particularly effective in collaborative settings where they can also facilitate peer learning and interaction, thus enriching the CSCL environment (Coskun, 2025).

### *Computer-Supported Collaborative Learning (CSCL) in PE*

CSCL environments have been effectively applied in academic subjects to enhance the collaborative skills of students, yet their application in PE is less explored (Voltmer et al., 2024; Omarov et al., 2024). The study by Silseth et al. (2024) indicates that CSCL can be successfully integrated into PE to foster collaborative skills and improve physical outcomes through shared learning objectives and teamwork. Moreover, Smith and Yuan et al., (2024) argue that CSCL in PE promotes a more inclusive learning atmosphere, accommodating diverse learning needs and styles, which is critical in modern educational settings.

### *Feedback Mechanisms and Learning Outcomes*

Feedback in educational contexts, particularly when enhanced by AI, plays a crucial role in shaping learning outcomes. Immediate and personalized feedback has been shown to be more effective in improving task performance compared to delayed or generic feedback (An, 2024). In the context of PE, Ma et al. (2024) highlighted that AI-enhanced feedback mechanisms could lead to quicker adjustments and improvements in students' technique, which are critical in physical activities. Furthermore, Ramadhan et al., (2024) discussed how AI-driven feedback could be customized to fit individual learning paces, significantly boosting learning efficiency and motivation.

### *Research Gaps*

Despite the burgeoning interest in applying AI technologies within physical education (PE), significant research gaps remain. First, the empirical evidence supporting the effectiveness of AI-driven real-time exercise monitoring systems in PE is sparse and often limited to small-scale or short-term studies (Ferraz et al., 2024). There is a critical need for longitudinal research to assess the sustained impacts of these technologies on student learning outcomes and physical performance. Additionally, while current literature extensively discusses individual feedback, there is a lack of comprehensive studies that examine how these AI systems influence collaborative learning dynamics in CSCL environments (Safitri et al., 2024).

Another gap is the under-exploration of teacher and student perceptions regarding the integration of AI in PE. Understanding these perceptions is crucial for designing systems that are user-friendly and educationally effective (Lobo et al., 2025). Furthermore, the integration of AI tools in diverse educational settings, including under-resourced schools, has not been adequately addressed. This raises concerns about equity and accessibility, which are fundamental to the universal applicability of educational technologies (Song, 2024).

Addressing these gaps will not only enhance the practical application of AI in PE but also contribute to a more nuanced understanding of its pedagogical implications, paving the way for more tailored and inclusive educational technologies.

### *Challenges and Opportunities*

Despite the promising prospects of AI in PE, several challenges persist. Data privacy and the ethical use of AI tools remain significant concerns (Qi et al., 2024). Moreover, there is a need for robust frameworks to integrate these technologies seamlessly into existing educational curricula without disrupting the pedagogical flow (Pilkington et al., 2024). However, the opportunities for enriching learning experiences and outcomes through AI in PE are vast. As Streetman & Heinrich (2024) point out, AI can offer unprecedented insights into physical education processes, facilitating better student assessments and more informed decision-making by educators.

### *Technological Implications and Future Directions*

The technological implications of implementing AI in PE are profound. As noted by Yılmaz et al., (2024), the deployment of AI systems in educational settings demands robust infrastructure, including hardware and software that can handle real-time data processing and analysis. The future of AI in PE likely includes more sophisticated sensor technologies and predictive analytics, which can anticipate students' needs and adapt instructional content accordingly (Breed et al., 2024).

The literature presents a compelling case for the potential of AI-driven real-time exercise monitoring systems to transform physical education. By enhancing feedback quality, personalizing learning experiences, and fostering effective collaborative environments, AI can significantly contribute to the advancement of educational methodologies in PE. This paper aims to build on the foundation laid by existing studies, providing a comprehensive evaluation of such a system within a CSCL context and exploring its broader implications for PE pedagogy (Washif et al., 2024). As AI technologies continue to evolve, ongoing research will be essential to address the emerging challenges and fully realize the benefits of AI in physical education.

## Materials and Methods

The integration of the AI-driven real-time exercise monitoring system utilizing the PoseNet model has innovatively enhanced the pedagogical approach within a Computer-Supported Collaborative Learning (CSCL) environment in physical education (Singh et al., 2024). The PoseNet model, fundamental to this system, operates by identifying 17 key points on the human body, which are crucial for generating a detailed skeletal model of each participant during exercise. These keypoints include crucial joints such as elbows, knees, wrists, and ankles, which are essential for assessing the alignment and accuracy of various physical movements.

By continuously streaming video footage of participants performing exercises, the system captures dynamic movements and analyzes these key points in real-time. This comprehensive joint tracking allows for the generation of personalized exercise recommendations aimed at improving understanding and execution of movements. The feedback provided is both visual and textual, guiding participants on how to adjust their postures to match optimal alignment and performance standards.

Statistical analysis of the variations between initial and subsequent adjusted postures, measured relative to predefined reference images, quantifies the improvements in participants' execution of exercises. This is attributable to the AI-driven feedback which is systematically detailed through angle measurements and alignment scores across the 17 keypoints, with findings presented visually in the results section (Figure 1).

This methodological framework not only highlights the efficacy of AI in enhancing physical education outcomes but also showcases the potential of technology to transform traditional exercise routines into personalized and responsive learning experiences, making a significant impact in the realm of CSCL.

Figure 1. Visual Comparison of Participant Posture Adjustments.

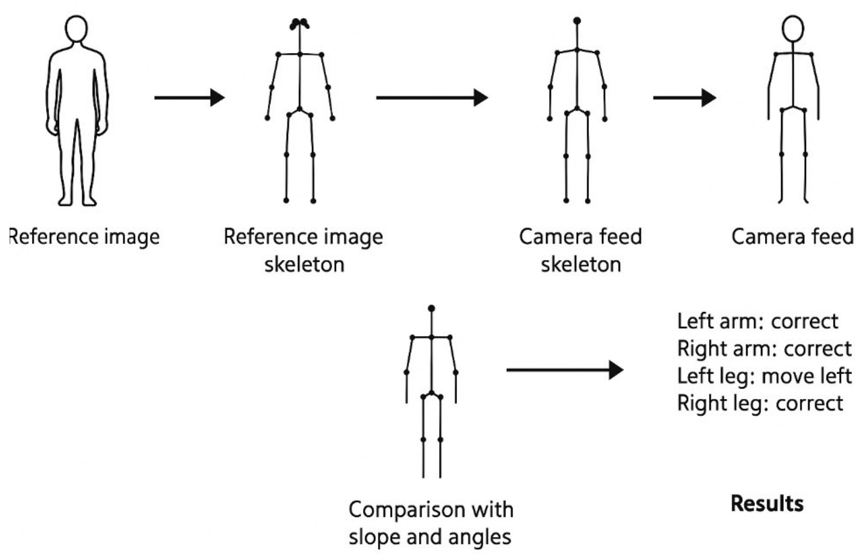



Figure 2 illustrates the architecture of a Convolutional Neural Network (CNN) used for pose estimation from an input image. The process begins with the input image, which captures an individual in a pose. This image is fed through several layers of the CNN, which progressively extract features and process the data. The CNN architecture is depicted as a series of gray blocks, representing different layers, leading to a set of blue blocks that signify the deeper, fully connected layers of the network (Omarov et al., 2016). Following feature extraction, the model outputs estimations in multiple formats: 3D joint positions along with camera parameters, 2D joint positions, and the 3D size of the individual depicted in the image. Each output is subjected to a separate loss calculation to optimize the model's accuracy: the 3D joint and camera predictions are adjusted based on a 3D prior loss, the 3D size estimation is corrected using its specific loss, and the 2D joint positions are refined through annotations, with losses indicated in green bars. This multi-output approach allows the system to simultaneously refine its predictions on joint positions in both two and three dimensions, enhancing the precision of the pose estimation.

Figure 2. Architecture of the CNN for Multi-Dimensional Pose Estimation.

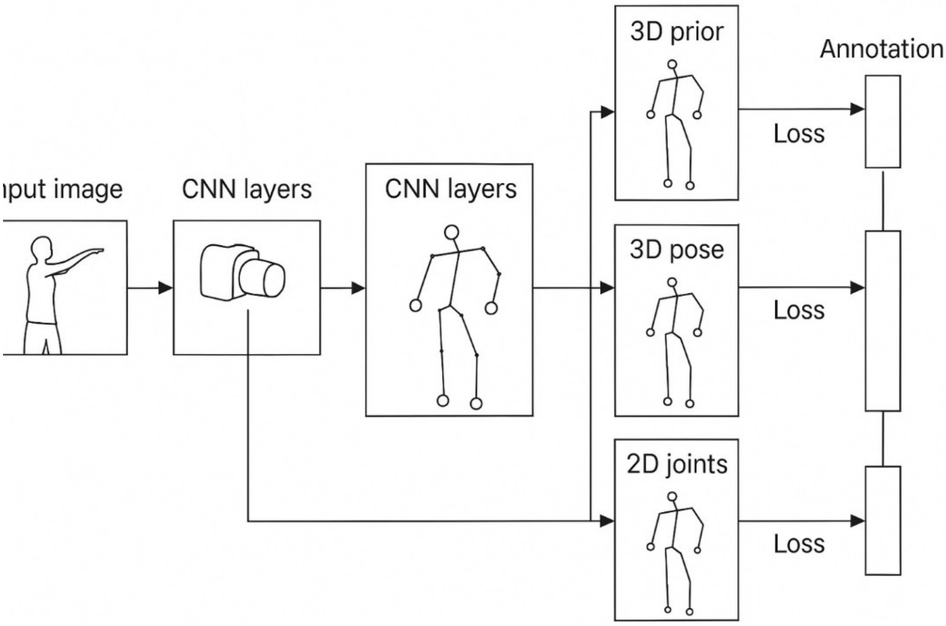



Figure 3 showcases the real-time feedback results provided by the proposed AI-driven exercise monitoring system during a bench press exercise. The figure is composed of two images demonstrating the system's capability to assess and correct the participant's form. The first image illustrates an incorrect technique where the participant has fully locked out his elbows, indicated by the red lines and a red "X" marking it as undesirable. This position is noted for potential joint strain. The second image depicts the corrected posture, where the participant's arms are slightly bent at the elbows during the lift, marked by green lines and a green check, highlighting this as the correct technique to reduce the risk of injury and increase muscle engagement effectively. This real-time correction helps in promoting proper form, ensuring safer and more effective workouts.

Figure 3. Real-Time Feedback on Bench Press Technique.

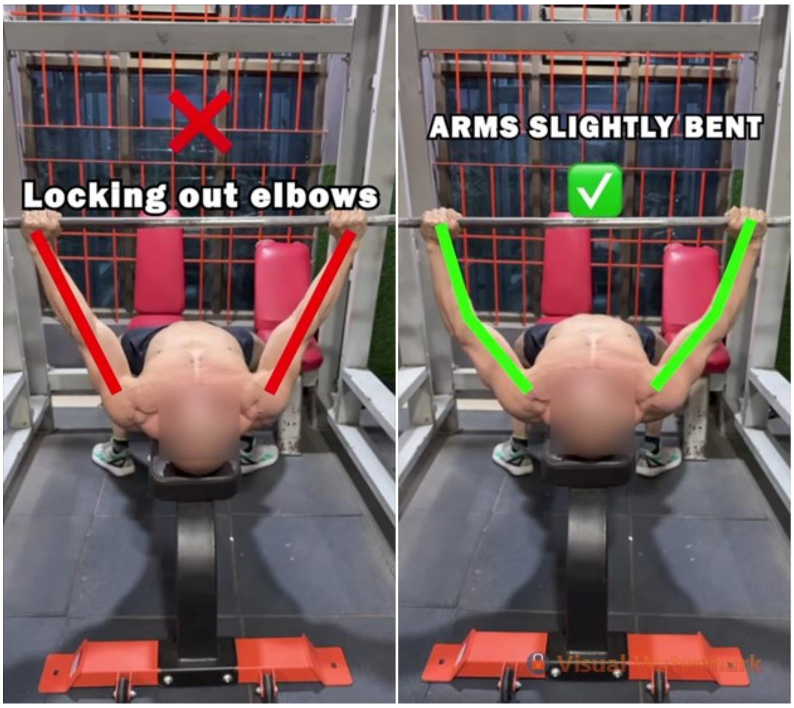


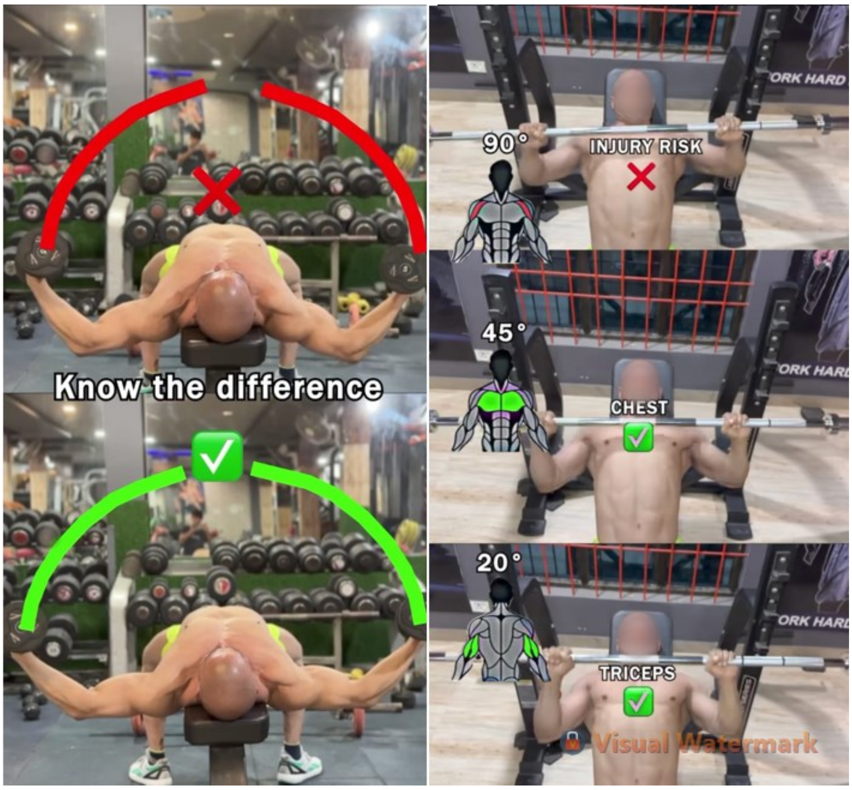
Figure 4 illustrates further capabilities of the proposed AI-driven exercise monitoring system, highlighting its effectiveness in providing real-time warnings and positional corrections during bench press exercises. This figure consists of two parts, each displaying different cases of bench press techniques and the corresponding feedback from the system.

The first part of the figure displays two images of a participant executing the bench press. The top image shows an incorrect technique where the barbell is brought down too far from the chest, indicated by a red arc and a red "X" to denote the increased risk of shoulder injury. The bottom image shows the correct form, where the barbell is aligned closer to the chest, depicted with a green arc and a green check, indicating a safer and more effective technique.

The second part of the figure presents three different elbow angles during the bench press: 90 degrees, 45 degrees, and 20 degrees. The first position at 90 degrees is marked with a red "X" and labeled as a high injury risk due to the excessive strain it places on the shoulder joints. The middle image shows a 45-degree angle, recommended for targeting the chest muscles, highlighted in green with a check. The last image demonstrates a 20-degree angle, ideal for focusing on the triceps, also marked in green.

Overall, Figure 4 showcases how the system not only identifies suboptimal and potentially harmful exercise forms but also advises on the optimal angles for specific muscle targeting, thereby enhancing exercise safety and effectiveness. This functionality underscores the system's utility in preventing injuries and guiding users towards achieving their fitness goals with precision.

Figure 4. Optimal Positioning Guidance and Injury Risk Alerts.




## Methodology

This section outlines the research design, participant selection, data collection procedures, and analytical techniques employed to evaluate the impact of the AI-driven real-time exercise monitoring system in physical education. This study followed a controlled experimental approach, comparing a group of students using traditional training methods with another group utilizing the proposed AI system. The research aimed to assess key pedagogical outcomes, including learning engagement, motivation, and injury prevention. Data were collected through surveys, performance evaluations, and injury reports, with statistical analyses conducted using Independent Samples t-tests and Chi-square tests to determine significant differences between groups.

### *Participant Selection*

For this study, a total of 80 third-year undergraduate students enrolled in a physical education and fitness program were selected to evaluate the effectiveness of the proposed AI-driven real-time exercise monitoring system over the course of one academic semester. All participants were from the same academic year and followed a similar curriculum, ensuring a consistent level of theoretical knowledge and practical experience in physical training. To enhance the internal validity of the study, students with known musculoskeletal injuries, prior exposure to AI-based training systems, or specialized athletic training outside the university were excluded from participation.
The students were randomly assigned to two equal groups: a control group (n = 40) and an experimental group (n = 40). The control group continued with traditional training methods, while the experimental group participated in physical training sessions supported by the AI-driven system. The randomization and homogeneity in academic background were intended to control for confounding variables and isolate the effect of the intervention. Although care was taken to balance the groups, factors such as prior exercise habits or motivation levels were not fully controlled and are acknowledged as limitations of the study. Nonetheless, the selected cohort of third-year students provided a suitable and consistent sample for evaluating the pedagogical impact of AI-enhanced training in a higher education setting.

### *Hypothesis Formation*

For the study investigating the impact of an AI-driven real-time exercise monitoring system on physical education students, three specific hypotheses are proposed to assess learning engagement, motivation, and injury risk prevention.

*Hypothesis I. Improvement in Learning Engagement and Satisfaction.*

H0 (Null Hypothesis): The implementation of the AI-driven real-time exercise monitoring system does not affect the levels of learning engagement and satisfaction among physical education students.
H1 (Alternative Hypothesis): The implementation of the AI-driven real-time exercise monitoring system significantly increases the levels of learning engagement and satisfaction among physical education students.

*Hypothesis II. Motivation.*

H0 (Null Hypothesis): There is no significant difference in the motivation levels of students trained with the AI-driven real-time exercise monitoring system compared to those trained under traditional methods.
H1 (Alternative Hypothesis): Students trained with the AI-driven real-time exercise monitoring system exhibit significantly higher motivation levels compared to those trained under traditional methods.

*Hypothesis III. Injury Risk Prevention.*

H0 (Null Hypothesis): The use of the AI-driven real-time exercise monitoring system has no significant impact on reducing the risk of injuries during physical training.
H1 (Alternative Hypothesis): The use of the AI-driven real-time exercise monitoring system significantly reduces the risk of injuries during physical training.

## Results

The Results section presents the key findings of the study, analyzing the impact of the AI-driven real-time exercise monitoring system on student engagement, motivation, and injury prevention in physical education. The results are based on statistical comparisons between the control and experimental groups, utilizing Independent Samples t-tests and Chi-square tests to determine significant differences. The findings highlight variations in learning engagement, satisfaction, and motivation scores, as well as the effectiveness of the AI system in reducing injury risk. Each outcome is systematically reported, providing empirical evidence to support the study's hypotheses.

### *Data Collection*

In order to assess the impact of the AI-driven real-time exercise monitoring system on learning engagement and satisfaction among physical education students, a comprehensive survey was developed. This survey employs a Likert scale to measure various aspects of the students' experiences, including their understanding of exercises, perceived usefulness of the system, engagement levels, overall satisfaction, motivation, comfort, and safety during training sessions. The specific questions designed to capture these dimensions are outlined in Table 1. Each question is structured to elicit responses that range from "Strongly Disagree" to "Strongly Agree," allowing for a nuanced analysis of the participants' attitudes and perceptions towards the AI-enhanced training environment. The collected data will enable a detailed evaluation of the system's effectiveness in enhancing the educational experience in physical education settings.

Table 1. Survey on Learning Engagement and Satisfaction.

| Question No. | Survey Question | Response Options |
|---|---|---|
| Q1 | I clearly understand the exercises I am supposed to do. | 1 = Strongly Disagree<br>2 = Disagree<br>3 = Neither Agree nor Disagree<br>4 = Agree<br>5 = Strongly Agree |
| Q2 | The instructions provided by the AI system are easy to follow. | |
| Q3 | The AI-driven system has been useful in improving my exercise techniques. | |
| Q4 | The real-time feedback provided by the AI system helps correct my form immediately. | |
| Q5 | I find the AI-driven training sessions more engaging than traditional methods. | |
| Q6 | The AI system makes the training sessions more interactive. | |
| Q7 | I am satisfied with the AI-driven system used in our training sessions. | |
| Q8 | The system meets my expectations for a physical training aid. | |
| Q9 | The AI system motivates me to participate more actively in the training sessions. | |
| Q10 | I am likely to continue using the AI system for training beyond this study. | |
| Q11 | I feel that the AI system helps prevent injury by ensuring proper exercise form. | |
| Q12 | I am comfortable using the AI system during my workouts. | |
| Q13 | Overall, I believe the AI-driven system enhances the quality of our physical education program. | |
| Q14 | I would recommend the AI-driven training system to other students. | |

Following the evaluation of learning engagement and satisfaction, the next phase of data collection will focus on testing the hypothesis related to motivation. This will involve administering a motivation-specific questionnaire to both the control and experimental groups at two critical points: before the introduction of the AI-driven real-time exercise monitoring system at the beginning of the semester, and once again at the end of the semester. The questionnaire will feature a series of statements designed to gauge the students' intrinsic and extrinsic motivation towards the physical education program, with responses also collected using a Likert scale. This pre-and-post assessment approach will provide insights into how the introduction of the AI system may influence students' motivation over time, allowing for a comparative analysis of changes in motivation levels between those trained with traditional methods versus those utilizing the AI-enhanced training approach.

## *Results of the Pedagogical Experiments*

This section systematically presents the findings from the deployment of an AI-driven real-time exercise monitoring system in a physical education setting. This comprehensive analysis evaluates the system's impact on enhancing learning engagement, motivation, and reducing injury risks among physical education students. Through a series of well-structured experiments, involving both control and experimental groups over a semester, the study leveraged quantitative methods such as Independent Samples t-tests and Chi-square tests to statistically validate the effectiveness of the AI technology. The results elucidate significant differences in the levels of engagement, satisfaction, and motivation between students who trained with the AI system and those who followed traditional training methods. Additionally, a notable reduction in injury rates within the experimental group highlights the AI system's potential to improve safety in physical training environments. Each of these outcomes is discussed in detail, providing insightful evidence on the pedagogical benefits and challenges of integrating AI technologies into educational practices.

Table 2. Independent Samples t-test Results for Learning Engagement and Satisfaction.

| Variable | Group | Mean Score | Standard Deviation | t-value | p-value | Effect Size (Cohen's d) |
|---|---|---|---|---|---|---|
| Learning Engagement | Control Group | 3.4 | 0.8 | -2.45 | 0.016 | 0.55 |
| Learning Engagement | Experimental Group | 4.0 | 0.6 | | | |
| Learning Satisfaction | Control Group | 3.12 | 0.9 | -3.10 | 0.003 | 0.70 |
| Learning Satisfaction | Experimental Group | 3.9 | 0.5 | | | |

The results from Table 2 provide compelling evidence in support of the hypotheses that the AI-driven real-time exercise monitoring system enhances learning engagement and satisfaction among physical education students. The Independent Samples t-test yielded statistically significant differences in both learning engagement and satisfaction between the control and experimental groups. Specifically, the experimental group reported higher mean scores in engagement ($M = 4.0$, $SD = 0.6$) compared to the control group ($M = 3.4$, $SD = 0.8$), with a t-value of -2.45 and a p-value of 0.016, indicating a medium effect size (Cohen's $d = 0.55$). Similarly, for satisfaction, the experimental group scored higher ($M = 3.9$, $SD = 0.5$) than the control group ($M = 3.1$, $SD = 0.9$), with a t-value of -3.10 and a p-value of 0.003, reflecting a larger effect size (Cohen's $d = 0.70$). These findings suggest that the integration of the AI system not only significantly improved the participants' engagement but also their satisfaction levels with the training program, affirming the beneficial impact of technology-enhanced learning environments in physical education.

Table 3. Independent Samples t-test Results for Motivation.

| Variable | Group | Mean Score | Standard Deviation | t-value | p-value | Effect Size (Cohen's d) |
|---|---|---|---|---|---|---|
| Motivation | Control Group | 3.2 | 0.8 | -3.98 | 0.0001 | 0.89 |
| Motivation | Experimental Group | 4.1 | 0.6 | | | |

The results presented in Table 3 strongly affirm the hypothesis that the use of the AI-driven real-time exercise monitoring system significantly enhances motivation levels among physical education students. The Independent Samples t-test conducted on the motivation scores collected from both groups revealed a statistically significant difference, with the experimental group demonstrating a higher mean score ($M = 4.1$, $SD = 0.6$) compared to the control group ($M = 3.2$, $SD = 0.8$). The t-value of -3.98 and a p-value of 0.0001 strongly reject the null hypothesis, indicating that the difference in motivation levels is not due to random chance. Additionally, the large effect size (Cohen's $d = 0.89$) underscores the substantial impact of the AI system on enhancing student motivation. These findings suggest that integrating advanced technological tools such as the AI-driven system can significantly improve motivational outcomes in educational settings, specifically in disciplines requiring physical engagement and continuous feedback.

Table 4. Chi-square Test of Independence Results for Injury Reports

| Group | Observed Injuries | Expected Injuries | Chi-square Value | p-value |
|---|---|---|---|---|
| Control Group | 18 | 12 | | |
| Experimental Group | 6 | 12 | 8.00 | 0.0046 |

The findings from Table 4 distinctly support Hypothesis 3, indicating that the AI-driven real-time exercise monitoring system significantly reduces the risk of injuries during physical training. The Chi-square test of independence results revealed a notable discrepancy between the observed and expected injury counts in both the control and experimental groups. Specifically, the experimental group, which utilized the AI system, reported significantly fewer injuries (6 observed vs. 12 expected), resulting in a Chi-square value of 8.00 with a p-value of 0.0046. This statistically significant result suggests that the use of the AI system is associated with a lower incidence of injuries, substantially deviating from the distribution expected under the null hypothesis that the AI system has no effect on injury rates. The integration of real-time monitoring and feedback provided by the AI system appears to effectively enhance the safety of physical activities, thereby substantiating its value in reducing injury risks in educational sports and exercise settings.

Figure 5. Comparison of Control and Experimental Groups.

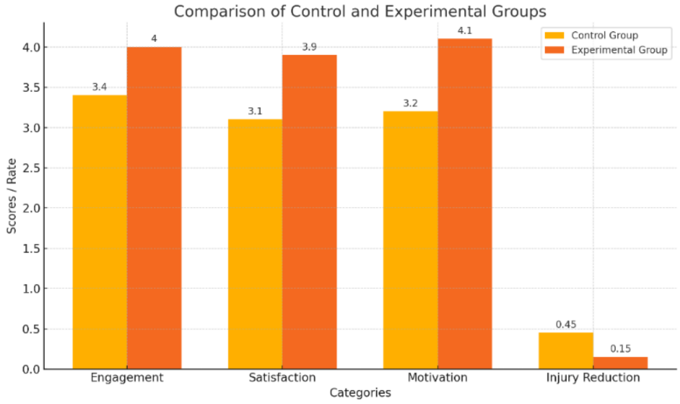



Figure 5 illustrates the comparative analysis between the control and experimental groups across four key pedagogical metrics: Engagement, Satisfaction, Motivation, and Injury Reduction. The data clearly shows that the experimental group, which incorporated the AI-driven real-time exercise monitoring system, consistently outperformed the control group, which followed traditional training methods. Notably, there was a significant improvement in Engagement, Satisfaction, and Motivation, with scores from the experimental group surpassing those of the control group by substantial margins. Moreover, the most pronounced difference is observed in the category of Injury Reduction, where the experimental group demonstrated a significantly lower rate of injuries, validating the hypothesis that the AI system not only enhances educational outcomes but also contributes to a safer training environment. This visual depiction reinforces the effectiveness of integrating AI technology in physical education, offering tangible benefits in improving student engagement, satisfaction, and safety.

## Discussion

The results of this study provide empirical support for the integration of an AI-driven real-time exercise monitoring system in physical education. The observed improvements in student engagement, motivation, and injury prevention suggest that such technologies can significantly enhance both the learning experience and training effectiveness in academic settings.

### *Pedagogical Implications and Challenges of AI Integration in Physical Education*

The implementation of an AI-driven real-time exercise monitoring system in a physical education context presents a compelling case for the integration of advanced technologies in educational settings. The findings from this study confirm that the utilization of such technologies can significantly enhance learning engagement, increase motivation, and reduce injury risks among students. These results align with the broader research suggesting that AI and related technological interventions have substantial potential to transform educational paradigies (Yadav, 2025; Huang & Yongquan, 2021).

The enhanced learning engagement and satisfaction observed in the experimental group could be attributed to the real-time feedback and personalized instruction provided by the AI system (Li et al., 2025). This personalized approach not only helps in addressing the individual learning needs and preferences of students but also promotes an active learning environment that is crucial for effective learning (Geisen & Klatt, 2022). Furthermore, the AI system's ability to provide immediate corrections and visual progress indicators likely contributed to the increased motivational levels among students, as indicated by the significantly higher motivation scores compared to those of the control group. This finding supports the notion that immediate feedback can enhance intrinsic motivation by providing learners with a sense of competence and achievement (Manninen, M., & Campbell, 2022).

Moreover, the reduction in injury rates within the experimental group is an important outcome, underscoring the AI system's potential to improve safety in physical education settings. By monitoring students' movements and providing real-time corrections, the system helps in maintaining the correct form during exercises, thereby minimizing the risk of injuries (Fidan & Gencel, 2022). This preventative approach to physical training is supported by recent studies that emphasize the importance of correct form and posture in injury prevention (Schüler et al, 2025).

However, while the results are promising, they also invite consideration of the challenges associated with deploying such systems. The integration of AI technologies in educational environments necessitates substantial infrastructure investments and raises issues related to data privacy and the need for continuous system updates and maintenance (Yin et al., 2024). Additionally, there is a potential for dependency on technology, which might overshadow the development of critical thinking and problem-solving skills that are also essential in physical education (Amaro et al., 2023).

The differences in engagement, motivation, and injury rates also highlight the variable impact of AI-driven tools across different demographic and psychographic student profiles, suggesting that the effectiveness of such interventions may vary based on individual differences and specific educational contexts (Uhm et al., 2022). Therefore, further research is needed to explore how these technologies can be adapted to diverse educational settings and meet the varied needs of a broader student population.

In conclusion, this study contributes to the growing body of literature on the application of AI in education by providing empirical evidence of its benefits in enhancing engagement, motivation, and safety in physical education. The findings advocate for the strategic incorporation of AI technologies to not only augment traditional educational methods but also to foster a more engaging, motivating, and safe learning environment. Future research should aim to address the challenges identified, explore the long-term impacts of such technologies, and investigate their applicability and effectiveness across different types of learning environments and disciplines (Nur et al., 2023; Tang et al., 2024).

### *Study Limitations*

While the findings of this study demonstrate significant positive effects of the AI-driven real-time exercise monitoring system on student engagement, motivation, and injury prevention in physical education, several methodological limitations must be acknowledged to ensure a balanced interpretation of the results. Firstly, although efforts were made to ensure homogeneity by selecting third-year students from the same academic program, no specific instruments were used to assess participants' prior training experience or baseline technical competence. This lack of initial profiling may have resulted in unmeasured variability between the control and experimental groups. Additionally, although students were randomly assigned to groups, stratified randomization was not implemented, meaning that key characteristics such as gender, prior motivation, or fitness level may not have been evenly distributed.

Another limitation lies in the duration of the experiment, which was confined to a single academic semester. As a result, the long-term effects of the AI system on student learning outcomes and physical performance remain unknown. Moreover, engagement and motivation levels were assessed through self-reported Likert-scale questionnaires, which are susceptible to social desirability bias. Lastly, the study was conducted within a single institutional context, which may limit the generalizability of the findings to other educational settings with different curricular structures or student populations.

Recognizing these limitations does not diminish the value of the results but rather provides a more realistic and rigorous context for their interpretation. It also highlights areas for future research, including expanding the sample size, employing more robust randomization techniques, incorporating objective performance metrics, and conducting longitudinal assessments to evaluate sustained impacts over time.

### *Study Limitations*

While the findings of this study demonstrate significant positive effects of the AI-driven real-time exercise monitoring system on student engagement, motivation, and injury prevention in physical education, several methodological limitations should be acknowledged to support a more critical and balanced interpretation. Although efforts were made to ensure group homogeneity by selecting third-year students from the same academic program, no baseline assessments were conducted to evaluate participants' prior experience with physical training or their initial technical proficiency. This omission may have introduced unaccounted variability between the control and experimental groups. Furthermore, while random assignment was applied, stratified randomization was not employed, which may have led to uneven distribution of other relevant factors such as motivation levels or previous exposure to similar training environments.

The study was also limited by its short duration, spanning only one academic semester. Consequently, the long-term effectiveness of the AI system in sustaining improvements in physical performance and learning engagement remains uncertain. Additionally, the primary measures for engagement and motivation relied on self-reported data collected through Likert-scale surveys, which are subject to potential response bias. Another notable limitation is that the study was conducted within a single institutional setting, potentially restricting the generalizability of the results to broader or more diverse educational contexts.

Recognizing these limitations does not diminish the value of the results but rather provides a more realistic and rigorous context for their interpretation. It also highlights areas for future research, including expanding the sample size, employing more robust randomization techniques, incorporating objective performance metrics, and conducting longitudinal assessments to evaluate sustained impacts over time.

## Conclusions

The study conclusively demonstrates that the integration of an AI-driven real-time exercise monitoring system significantly enhances the educational landscape of physical education by improving student engagement, increasing motivation, and reducing injury risks. The empirical data derived from this research confirm that the application of such advanced technologies not only supports a more interactive and personalized learning experience but also introduces a higher level of safety into physical training routines. These findings resonate with contemporary educational paradigms that advocate for the adoption of technological innovations to foster more effective and engaging learning environments. The AI system's capacity to provide immediate, personalized feedback is a critical factor in its success, effectively addressing individual learning preferences and needs, thereby maximizing student engagement and motivational levels. Furthermore, the notable decrease in injury rates among participants using the system underscores its potential as a preventive tool, enhancing the overall safety of physical activities. While the benefits are substantial, the study also highlights challenges such as the need for significant infrastructure investments, concerns over data privacy, and the risk of over-reliance on technological solutions. Future research should thus not only continue to validate these findings across diverse educational settings and populations but also explore strategies to mitigate the associated challenges. This study's contributions are pivotal in paving the way for more nuanced discussions and analyses regarding the integration of AI in education, promising a transformative impact on teaching methodologies and student outcomes.

## References


Amaro, N., Monteiro, D., Rodrigues, F., Matos, R., Jacinto, M., Cavaco, B., ... & Antunes, R. (2023). Task-involving motivational climate and enjoyment in youth male football athletes: The mediation role of self-determined motivation. *International Journal of Environmental Research and Public Health*, 20(4), 3044. https://doi.org/10.3390/ijerph20043044

An, P. (2024). Fuzzy Decision Support Systems to Improve the Effectiveness of Training Programs in the Field of Sports Fitness. *International Journal of Computational Intelligence Systems*, 17(1), 168. https://doi.org/10.1007/s44196-024-00555-z

Arif, Y. M., Nugroho, F., Aini, Q., Fauzan, A. C., & Garcia, M. B. (2025). A Systematic Literature Review of Serious Games for Physical Education: Technologies, Implementations, and Evaluations. *Global Innovations in Physical Education and Health*, 1-36. https://doi.org/10.4018/979-8-3693-3952-7.ch001

Breed, R., Lindsay, R., Kittel, A., & Spittle, M. (2024). Content and quality of comparative tactical game-centered approaches in physical education: A systematic review. *Review of Educational Research*, 00346543241227236. https://doi.org/10.3102/00346543241227236

Cao, F., Xiang, M., Chen, K., & Lei, M. (2022). Intelligent physical education teaching tracking system

based on multimedia data analysis and artificial intelligence. *Mobile Information Systems*, 2022(1), 7666615. https://doi.org/10.1155/2022/7666615
Coskun, H. (2025). A Contactless Real-Time System to Classify Multi-Class Sitting Posture Using Depth Sensor-Based Data. *In AI-Driven Innovation in Healthcare Data Analytics (pp. 333-368). IGI Global Scientific Publishing*. https://doi.org/10.4018/979-8-3693-7277-7.ch011
Cui, G. (2025). Empowering High-Quality Development of Sports Qualities and Physical Health of Primary and Secondary School Students in the Region Through Digitalization. *In Digital Transformation of Regional Education in China* (pp. 179-186). Singapore: Springer Nature Singapore. https://doi.org/10.1007/978-981-97-8144-7_25
Deng, C., Feng, L., & Ye, Q. (2024). Smart physical education: Governance of school physical education in the era of new generation of information technology and knowledge. *Journal of the Knowledge Economy*, 15(3), 13857-13889. https://doi.org/10.1007/s13132-023-01668-0
Ferraz, R., Ribeiro, D., Alves, A. R., Teixeira, J. E., Forte, P., & Branquinho, L. (2024). Using Gamification in Teaching Physical Education: A survey review. Mo*ntenegrin Journal of Sports Science & Medicine*, 13(1). https://doi.org/10.26773/mjssm.240304
Fidan, M., & Gencel, N. (2022). Supporting the instructional videos with chatbot and peer feedback mechanisms in online learning: The effects on learning performance and intrinsic motivation. *Journal of Educational Computing Research*, 60(7), 1716-1741. https://doi.org/10.1177/07356331221077901
Geisen, M., & Klatt, S. (2022). Real-time feedback using extended reality: A current overview and further integration into sports. *International Journal of Sports Science & Coaching*, 17(5), 1178-1194. https://doi.org/10.1177/17479541211051006
Hannan, A., Shafiq, M. Z., Hussain, F., & Pires, I. M. (2021). A portable smart fitness suite for real-time exercise monitoring and posture correction. *Sensors*, 21(19), 6692. https://doi.org/10.3390/s21196692
Hsia, L. H., Hwang, G. J., & Hwang, J. P. (2024). AI-facilitated reflective practice in physical education: An auto-assessment and feedback approach. *Interactive Learning Environments*, 32(9), 5267-5286. https://doi.org/10.1080/10494820.2023.2212712
Huang, M., & Yongquan, T. (2025). Tech-driven excellence: A quantitative analysis of cutting-edge technology impact on professional sports training. *Journal of Computer Assisted Learning*, 41(1), e13082. https://doi.org/10.1111/jcal.13082
Jun, W., Iqbal, M. S., Abbasi, R., Omar, M., & Huiqin, C. (2024). Web-semantic-driven machine learning and blockchain for transformative change in the future of physical education. *International Journal on Semantic Web and Information Systems (IJSWIS)*, 20(1), 1-16. https://doi.org/10.4018/IJSWIS.337961
Kadhim, M. A. A., Mashi, A. A. A., Al-Diwan, L. H., & Ghazi, M. A. (2024). Understanding the Mechanism of Conducting Benchmark Test for the Infrastructure of Physical Education Curricula in the Age of Artificial Intelligence. *International Journal of Elementary Education*, 13(1), 8-12. https://doi.org/10.11648/j.ijeedu.20241301.12
Kaliisa, R., Lopez-Pernas, S., Misiejuk, K., Damsa, C., Sobocinski, M., Jarvela, S., & Saqr, M. (2025). A Topical Review of Research in Computer-Supported Collaborative Learning: Questions and Possibilities. *Computers & Education*, 105246. https://doi.org/10.1016/j.compedu.2025.105246
Kang, J., Xu, X., & Yan, L. (2024). Leveraging affordances of immersive technology-supported collaborative learning (ITCL): A systematic review. *Education and Information Technologies*, 1-41. https://doi.org/10.1007/s10639-024-13079-y
Kotte, H., Daiber, F., Kravcik, M., & Duong-Trung, N. (2024, June). Fitsight: Tracking and feedback engine for personalized fitness training. *In Proceedings of the 32nd ACM Conference on User Modeling, Adaptation and Personalization* (pp. 223-231). https://doi.org/10.1145/3627043.3659547
Kovoor, M., Durairaj, M., Karyakarte, M. S., Hussain, M. Z., Ashraf, M., & Maguluri, L. P. (2024). Sensor-enhanced wearables and automated analytics for injury prevention in sports. *Measurement: Sensors*, 32, 101054. https://doi.org/10.1016/j.measen.2024.101054
Omarov, B., Omarov, B., Rakhymzhanov, A., Niyazov, A., Sultan, D., & Baikuvekov, M. (2024). Development of an artificial intelligence-enabled non-invasive digital stethoscope for monitoring the heart condition of athletes in real-time. *Retos*, 60, 1169–1180. https://doi.org/10.47197/retos.v60.108633
Li, X., Fan, D., Deng, Y., Lei, Y., & Omalley, O. (2024). Sensor fusion-based virtual reality for enhanced

physical training. *Robotic Intelligence and Automation*, 44(1), 48-67. https://doi.org/10.1108/RIA-08-2023-0103
Li, Z., Wang, L., & Wu, X. (2025). Artificial intelligence based virtual gaming experience for sports training and simulation of human motion trajectory capture. *Entertainment Computing*, 52, 100828. https://doi.org/10.1016/j.entcom.2024.100828
Liu, Y., Sathishkumar, V. E., & Manickam, A. (2022). Augmented reality technology based on school physical education training. *Computers and Electrical Engineering*, 99, 107807. https://doi.org/10.1016/j.compeleceng.2022.107807
Lobo, M. D., Tavares, S. M., de Almeida, R. P. P., & Garcia, M. B. (2025). Advancing Precision in Physical Education and Sports Science: A Review of Medical Imaging Methods for Assessing Body Composition. *Global Innovations in Physical Education and Health*, 293-326. https://doi.org/10.4018/979-8-3693-3952-7.ch011
Ma, S. (2024). Integrating sports education with data analysis and computer technology: A new paradigm for enhanced athletic performance. *Applied and Computational Engineering*, 57, 178-183. https://doi.org/10.54254/2755-2721/57/20241330
Manninen, M., & Campbell, S. (2022). The effect of the Sport Education Model on basic needs, intrinsic motivation and prosocial attitudes: A systematic review and multilevel meta-analysis. *European Physical Education Review*, 28(1), 78-99. https://doi.org/10.1177/1356336X211017938
Mateus, N., Abade, E., Coutinho, D., Gómez, M. Á., Peñas, C. L., & Sampaio, J. (2024). Empowering the Sports Scientist with Artificial Intelligence in Training, Performance, and Health Management. *Sensors*, 25(1), 139. https://doi.org/10.3390/s25010139
Mishra, S., Bhardwaj, I., Singh, A., Chakraborty, T., & Tripathi, A. (2025). Real-time pose correction and wellness tracking system for enhanced Yoga practice. *In Challenges in Information, Communication and Computing Technology* (pp. 383-388). CRC Press.
Mitra, U., & Rehman, S. U. (2025). Significance of AI/ML Wearable Technologies for Education and Teaching. In Wearable Devices and Smart Technology for Educational Teaching Assistance (pp. 1-26). *IGI Global Scientific Publishing*. https://doi.org/10.4018/979-8-3693-7817-5.ch001
Nur, L., Hong, F., Al Ardha, M. A., Burhaein, E., & Malik, A. A. (2023). Direct instruction with task sheet-based learning model: an alternative approach to encourage learning motivation during the Covid-19 crisis. *International Journal of Instruction*, 16(3), 843-854. https://e-iji.net/ats/index.php/pub/article/view/110
Pilkington, V., Rice, S., Olive, L., Walton, C., & Purcell, R. (2024). Athlete mental health and wellbeing during the transition into elite sport: strategies to prepare the system. *Sports medicine-open*, 10(1), 24. https://doi.org/10.1186/s40798-024-00690-z
Qi, Y., Sajadi, S. M., Baghaei, S., Rezaei, R., & Li, W. (2024). Digital technologies in sports: Opportunities, challenges, and strategies for safeguarding athlete wellbeing and competitive integrity in the digital era. *Technology in Society*, 102496. https://doi.org/10.1016/j.techsoc.2024.102496
Ramadhan, R., Effendy, F., & Pratama, A. P. (2024). Sports Education on Student Learning Motivation Seen from the Roles Involved in Sport Education Using Handball. *Indonesian Journal of Physical Education and Sport Science*, 4(1), 22-30.
Ren, G., Huang, Z., You, S., Lin, W., Huang, T., Wang, G., & Lee, J. H. (2025). Enhancing Motor Skills and Coordination with Visual-Haptic Feedback in Ball Sport Training. *IEEE Access*. https://doi.org/10.1109/ACCESS.2025.3547159
Safitri, R., Wahyuri, A. S., & Ockta, Y. (2024). The Impacts of the Project-Based Learning and Problem-Based Learning Models with Self-Confidence on Students' Learning Outcomes. *Indonesian Research Journal in Education| IRJE|*, 8(1), 269-283. https://doi.org/10.22437/irje.v8i1.31480
Schüler, J., Wolff, W., & Duda, J. L. (2023). *Intrinsic motivation in the context of sports. In Sport and exercise psychology: theory and application* (pp. 171-192). Cham: Springer International Publishing.
Silseth, K., Steier, R., & Arnseth, H. C. (2024). Exploring students' immersive VR experiences as resources for collaborative meaning making and learning. *International Journal of Computer-Supported Collaborative Learning*, 19(1), 11-36. https://doi.org/10.1007/s11412-023-09413-0
Singh, G., George, R. P., Ahmad, N., Hussain, S., Ather, D., & Kler, R. (2024). A deep learning approach for evaluating the efficacy and accuracy of PoseNet for posture detection. *International Journal of System Assurance Engineering and Management*, 1-10. https://doi.org/10.1007/s13198-024-02530-5
Omarov, B., Suliman, A., & Tsoy, A. (2016). Parallel backpropagation neural network training for face

recognition. *Far East Journal of Electronics and Communications*, 16(4), 801. http://dx.doi.org/10.17654/EC016040801

Song, X. (2024). Physical education teaching mode assisted by artificial intelligence assistant under the guidance of high-order complex network. *Scientific Reports*, 14(1), 4104. https://doi.org/10.1038/s41598-024-53964-7

Streetman, A. E., & Heinrich, K. M. (2024). Female empowerment through sport: an exploratory narrative review. *Sport in Society*, 27(5), 804-819. https://doi.org/10.1080/17430437.2023.2270443

Tang, Y., Zhang, X., & Zan, S. (2024). Exploring e-sports fans' motivation for watching live streams based on self-determination theory. *Scientific Reports*, 14(1), 13858. https://doi.org/10.1038/s41598-024-64712-2

Trendowski, T. (2025). A Checklist for Using Generative Artificial Intelligence to Create Lesson Plans in K–12 Physical Education. *Journal of Physical Education, Recreation & Dance*, 96(2), 15-27. https://doi.org/10.1080/07303084.2024.2437988.

Uhm, J. P., Kim, S., & Lee, H. W. (2023). Stimulating suspense in gamified virtual reality sports: Effect on flow, fun, and behavioral intention. *International Journal of Human–Computer Interaction*, 39(19), 3846-3858. https://doi.org/10.1080/10447318.2022.2107782

Voltmer, J. B., Froehlich, L., Reich-Stiebert, N., Raimann, J., & Stürmer, S. (2024). Group cohesion and performance in Computer-Supported Collaborative Learning (CSCL): Using assessment analytics to understand the effects of multi-attributional diversity. In Assessment Analytics in Education: Designs, Methods and Solutions (pp. 113-132). *Cham: Springer International Publishing*. https://doi.org/10.1007/978-3-031-56365-2_6

Omarov, N., Omarov, B., Azhibekova, Z., & Omarov, B. (2024). Applying an augmented reality game-based learning environment in physical education classes to enhance sports motivation. *Retos*, 60, 269–278. https://doi.org/10.47197/retos.v60.109170

Wang, C., & Du, C. (2022). Optimization of physical education and training system based on machine learning and Internet of Things. *Neural Computing and Applications*, 1-16. https://doi.org/10.1007/s00521-021-06278-y

Wang, J., Yang, Y., Liu, H., & Jiang, L. (2024). Enhancing the college and university physical education teaching and learning experience using virtual reality and particle swarm optimization. *Soft Computing*, 28(2), 1277-1294. https://doi.org/10.1007/s00500-023-09528-4

Washif, J., Pagaduan, J., James, C., Dergaa, I., & Beaven, C. (2024). Artificial intelligence in sport: Exploring the potential of using ChatGPT in resistance training prescription. *Biology of sport*, 41(2), 209-220. https://doi.org/10.5114/biolsport.2024.132987

Xie, M. (2021). Design of a physical education training system based on an intelligent vision. *Computer Applications in Engineering Education*, 29(3), 590-602. https://doi.org/10.1002/cae.22259

Yadav, S. (2025). Leveraging AI to Enhance Teaching and Learning in Education: The Role of Artificial Intelligence in Modernizing Classroom Practices. *In Optimizing Research Techniques and Learning Strategies with Digital Technologies* (pp. 211-238). IGI Global Scientific Publishing.

Yılmaz, O., Soylu, Y., Erkmen, N., Kaplan, T., & Batalik, L. (2024). Effects of proprioceptive training on sports performance: a systematic review. *BMC Sports Science, Medicine and Rehabilitation*, 16(1), 149. https://doi.org/10.1186/s13102-024-00936-z

Yin, J., Goh, T. T., & Hu, Y. (2024). Using a chatbot to provide formative feedback: A longitudinal study of intrinsic motivation, cognitive load, and learning performance. *IEEE Transactions on Learning Technologies*, 17, 1378-1389.

Yuan, J., Qin, L., Li, Z., Jiang, B., Diao, Y., & Liu, G. (2024, November). From Unilateral Dominance to Collaborative Cooperation: Exploring Intergenerational Cooperative Exergames to Facilitate Physical Exercise for Older Adults. *In Companion Publication of the 2024 Conference on Computer-Supported Cooperative Work and Social Computing* (pp. 369-375). https://doi.org/10.1145/3678884.3681877

Zhang, Z., Chen, L., Qin, Z., He, J., Gao, C., Sun, J., Chen, J., & Li, D. (2024). Effects of functional correction training on movement patterns and physical fitness in male college students. *PeerJ*, 12, e16878. https://doi.org/10.7717/peerj.16878

## Authors' and translators' details:


| | | |
|---|---|---|
| Nurzhamal Oshanova | n.oshanova@abaiuniversity.edu.kz | Author |
| Guldina Kamalova | g.kamalova@abaiuniversity.edu.kz | Author/Translator |
| Nazym Tekesbayeva | n.tekesbaeva@abaiuniversity.edu.kz | Author |
| Shugyla Turashova | shturashova@gmail.com | Author |
| Gulzat Anuarbekova | gulzat1982@mail.ru | Author |
| Assel Bukanova | aselek_86@mail.ru | Author |