FLUORIDE

Quarterly Journal of The International Society for Fluoride Research Inc.

Campus Physical Activities as a Medium for Fluoride Risk Awareness in AI-Enabled Environment: Practical Pathways for Educational Investment and Regional Economic Alignment

Unique digital address (Digital object identifier [DOI] equivalent): https://www.fluorideresearch.online/epub/files/393.pdf

Jianbin HU[1*], Sanjay KUMAR[2**]

[1] School of Language and Culture, Anyang Preschool Education College, Anyang, 456150, Henan, China

[2] Department of Botany, D.A.V. (P.G.) College, Gorakhpur, 273001, (U.P.), India

Corresponding author:

* School of Language and Culture, Anyang Preschool Education College, Anyang, 456150, Henan, China
Email: hujianbin2025@outlook.com

** Department of Botany, D.A.V. (P.G.) College, Gorakhpur, 273001, (U.P.), India
Email: sk.botanylkouniv@gmail.com

Submitted: 2025 June 10
Accepted: 2025 Sept 19
Published as e393: 2025 Sep 21

ABSTRACT

Purpose: The education sector is undergoing a profound transformation, driven by rapid advances in artificial intelligence (AI). Campus physical activities not only serve to enhance students' physical health but increasingly recognized for their potential value in disseminating health risk awareness. Fluoride (F), a chemical element ubiquitous in daily life and natural environment, may cause health issues, such as skeletal and dental problems when overexposed. However, public risk awareness remains insufficient.

Methods: This study investigates how AI-enabled campus physical activities enhance fluoride risk awareness, focusing on their mediating role. Furthermore, it analyzes the interactive mechanisms between educational investment and regional economic alignment. AI applications in physical education and health management, highlighting the unique advantage of campus physical activities in integrating health risk awareness with physical exercise.

Results: An interactive pathway linking education, economy, and health are constructed through three dimensions, i.e., optimizing educational investment, fostering regional economic linkage, and achieving regionally tailored risk awareness. Proposing AI-based practical strategies and policy recommendations, including cross-departmental collaborative governance, regionally differentiated interventions, and precise allocation of educational resources.

Conclusions: The study finds that AI-driven campus sports initiatives successfully promote fluoride risk awareness, reveal a synergistic relationship between educational investment and regional economic development, and provide novel practical frameworks and theoretical insights for advancing public health education and coordinated regional development.

Keywords: *Artificial Intelligence; Campus sports activities; Fluoride risk awareness; Educational investment; Regional economic adaptation*

INTRODUCTION

With the rapid advancement of artificial intelligence (AI) technology, the education system is undergoing profound transformation.[1] AI demonstrates broad application prospects not only in classroom teaching and learning assessment but also increasingly permeates areas, such as campus sports activities and health management, injecting new momentum into traditional education.[2] Against this backdrop, leveraging AI to optimize educational resource allocation while embedding health risk awareness into students' daily activities has become a critical focus for both academia and practitioners.

Fluoride (F), a ubiquitous element in the natural environment and human life, offers positive effects like preventing dental caries at appropriate doses.[3] However, excessive intake can lead to severe health issues, such as dental and skeletal fluorosis. Due to widespread public ignorance about F risks, its potential hazards are often overlooked.[4] In recent years, as public health education has gained prominence, enhancing societal awareness,

particularly among adolescents about F risks through educational channels has become a critical focus in public policy and educational research.

School sports activities, as an integral part of adolescents' learning and development, possess characteristics, such as collectivity, interactivity, and practicality.[5] They enhance physical fitness and serve as an effective channel for conveying health knowledge and risk awareness. Integrating F risk education with sports activities through artificial intelligence technology could not only increase student engagement and acceptance but also subtly foster healthy lifestyles and self-protection awareness.[6]

The relationship between educational investment and regional economic development also warrants attention. The allocation of educational resources directly impacts the effectiveness of health education, while regional economic development determines the capacity for sustainable investment in education and public health. Therefore, exploring the interactive mechanisms among educational investment, campus physical activities, and regional economic alignment within an AI environment not only facilitates the development of more scientific educational models but also provides advance theoretical foundations and practical pathways for regional coordinated development and public health management. This paper aims to explore how campus physical activities can serve as a medium for disseminating F risk awareness within an AI environment, while further analyzing the interactive mechanisms between educational investment and regional economic alignment. Based on this, corresponding practical pathways and policy recommendations are proposed to provide reference for education departments, public health governance institutions, and regional economic development planning.

INTEGRATION OF ARTIFICIAL INTELLIGENCE AND CAMPUS PHYSICAL ACTIVITIES

The application of artificial intelligence in education is progressively extending into physical activities and health management.[7] Through wearable devices, motion sensors, and intelligent analysis platforms, data generated during students' physical exercises can be collected and analyzed in real time, providing teachers with scientific and personalized instructional references.[8] This data-driven model not only overcomes the limitations of traditional physical education relying on experience and observation but also enables training to be tailored more precisely to individual students' physical fitness and health needs.

Building on this foundation, the educational functions of campus sports activities are being further expanded.[9] While traditional physical education emphasizes physical conditioning and competitive performance, the introduction of AI allows sports activities to carry additional health education content.[10] By integrating health knowledge prompts into the exercise process through intelligent systems, students can receive education on diet, nutrition, risk prevention, and other topics while exercising, thereby enhancing the role of physical activities in improving overall health literacy. Student fitness score calculated as a weighted combination of physical activity (P), health metrics (H), and AI-collected data (D):

$$F_i = \alpha \cdot P_i + \beta \cdot H_i + \gamma \cdot D_i \quad (1)$$

AI-enhanced F risk awareness index calculated using weighted knowledge scores (K) across multiple dimensions.

$$R_i = \frac{\sum_{j=1}^{n} w_j \cdot K_{ij}}{\sum_{j=1}^{n} w_j} \quad (2)$$

Regarding the dissemination of F risk awareness, AI-enabled sports activities offer new possibilities. By analyzing students' drinking habits, living environments, and health conditions through AI systems, personalized risk alerts and educational content can be generated.[11] This information can be seamlessly integrated into physical education classes or activities. Through this implicit educational approach, students subtly develop awareness of the dangers of excessive F exposure during exercise and interaction, enhancing their ability for proactive protection and scientific response.[12] Relationship between student sports participation and F risk awareness (Figure 1).

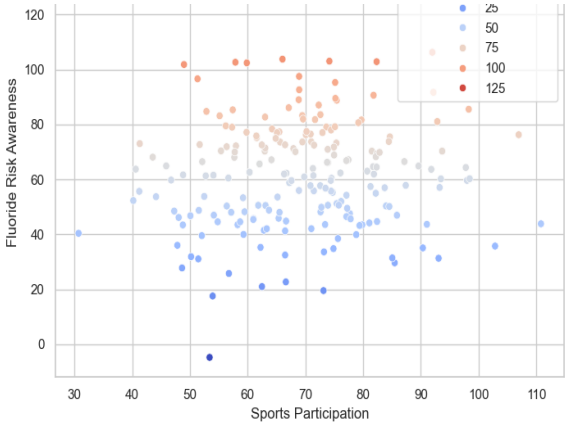

Figure 1. Student sports participation vs. fluoride risk awareness

The integration of AI with physical activities also creates opportunities for interdisciplinary education. Physical activities are not only processes for physical fitness training but also crucial areas for social interaction and value formation. When AI technology deeply integrates health education with physical activities, it enables multidimensional convergence among physical education, health sciences, and public

policy. This convergence not only enhances the social function of physical education but also opens new practical pathways for public health management and risk awareness cultivation. Sample data showing the relationship between student sports participation and fluoride risk awareness (Table 1).

Table 1. Student sports participation and fluoride risk awareness

Student ID	Sports participation (%)	F-risk awareness score
1	72	65
2	60	58
3	85	78
4	55	50
5	70	62

INTERACTIVE MECHANISM BETWEEN EDUCATIONAL INVESTMENT AND REGIONAL ECONOMIC ALIGNMENT

A close interactive relationship exists between educational investment and regional economic development. This relationship manifests not only in the role of educational funding in enhancing talent cultivation and societal health levels but also in the constraints regional economies impose on the supply capacity and distribution patterns of educational resources. In the AI environment, campus physical activities serve as a vital vehicle for disseminating F risk awareness, with their effectiveness largely dependent on the rational allocation of educational resources and the support of regional economic development. How can the optimization of educational investment structures provide safeguards for risk awareness cultivation? How can the linkage between regional economic development and educational health investments form a virtuous cycle? How can F risk awareness education achieve differentiated and adaptive development across diverse regional characteristics?

Structural optimization of educational investment and risk awareness cultivation

The rationality of educational investment lies not only in the total funding volume but more critically in structural optimization. Historically, educational funding has often been concentrated on infrastructure development and routine teaching, with relatively insufficient investment in health and risk prevention education. This imbalance has led to progress in students' knowledge and skill development, but significant shortcomings in their understanding of health risks. Against the backdrop of AI technology gradually permeating the education sector, optimizing the structure of educational investment and increasing support for campus physical activities and health education resources can provide foundational safeguards for cultivating F risk awareness. Regional education investment efficiency (E) computed by investment per student (I/N) weighted by regional health education score relative to the average, as stated:

$$E_r = \frac{I_r}{N_r} \cdot \frac{H_r}{\overline{H}} \tag{3}$$

Increment in regional F risk awareness (Delta R) as a function of education investment (E) and regional economic level (G):

$$\Delta R_r = \lambda \cdot E_r + \mu \cdot G_r \tag{4}$$

Structural optimization of educational investment facilitates cross-disciplinary resource integration. Fluoride risk education inherently involves knowledge from chemistry, medicine, public health, and social education. By directing funding to establish interdisciplinary health education curricula in universities and K-12 schools, risk awareness can be naturally integrated into physical education. Integrating AI health monitoring devices into physical education classes can enhance athletic performance while providing data feedback that alerts students to F risks associated with water quality and diet, achieving dual outcomes of knowledge education and behavioral intervention. Regional differences in education investment affecting health education scores (Figure 2).

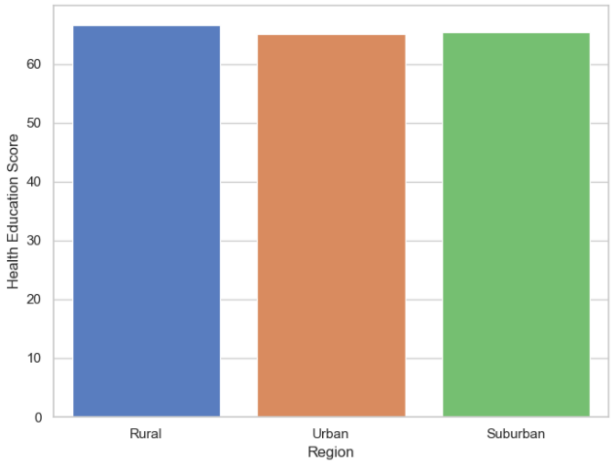

Figure 2. Education investment vs. health education score

Optimizing educational investment structures also promotes the professional development of teaching staff. Currently, different physical education teachers possess limited expertise in health education, making it challenging for them to effectively disseminate F risk awareness. Reallocating educational resources toward teacher training and professional development can enhance educators' competence in health education

and risk communication. With AI-assisted tools like data platforms, smart teaching materials, and virtual learning scenarios, teachers can deliver health risk education more efficiently.

Adjusting educational investment structures extends beyond school-based education to encompass external social support systems. Collaborations with local public health departments, community organizations, and regional economic development agencies can facilitate resource sharing and coordinated governance, expanding the reach of F risk awareness education. Particularly in regions with uneven economic development, optimizing educational investments can bridge regional gaps. This ensures risk awareness education balances universality with targeted approaches, fostering a cohesive force for health education across society.

THE SYNERGISTIC EFFECTS OF REGIONAL ECONOMIC DEVELOPMENT AND INVESTMENTS IN EDUCATION AND HEALTH

The level of regional economic development directly determines the capacity for investment in education and health sectors. In economically developed regions, governments and social capital often provide more substantial financial support, thereby promoting the implementation of health curricula within education systems and the construction of smart sports facilities. These investments enhance conditions for campus physical activities, creating a more favorable environment for raising awareness about F risks. In contrast, economically underdeveloped regions face significant gaps in educational and health investments due to limited resources, resulting in substantial deficiencies in students' risk awareness and protective consciousness.

A mutually reinforcing relationship exists between regional economic prosperity and investments in education and health. Health education and physical activities enhance adolescents' physical fitness and health awareness, thereby improving overall workforce quality and social productivity, providing long-term support for regional economies. When educational investment prioritizes health, students acquire knowledge, develop healthy habits, and cultivate risk prevention concepts during their school years. This enhanced quality translates into competitive advantages for regional economies in the future. Educational health investment is not only a product of economic development but also a vital driver of sustained economic prosperity. Influence of different sports activities on F knowledge showed in Figure 3.

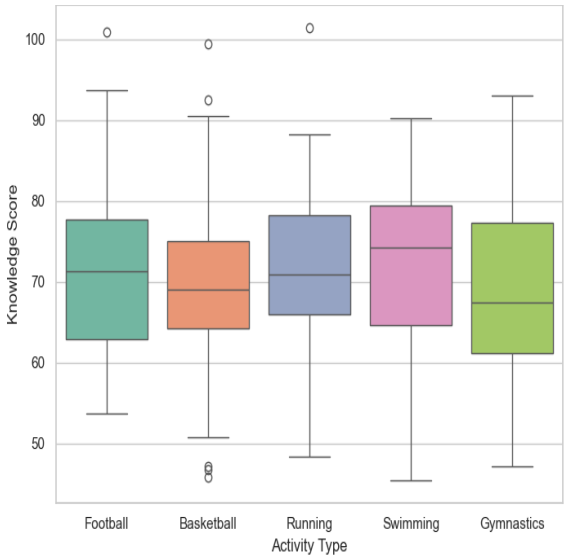

Figure 3. Distribution of F-knowledge scores by different types of sport activities

Regional economic development creates institutional and mechanistic innovation space for education and health investments. In the era of AI, economically advanced regions often pioneer intelligent education and public health management models, using AI data platforms for student fitness records, F monitoring in drinking water, and early warning systems. If these innovations are scaled through educational funding, they can form distinctive regional health education models, providing replicable experiences and pathways for other areas. Comparative data on regional education investment and corresponding health education scores (Table 2).

Table 2. Regional education investment and health education score

Region	Education investment (USD)	Health education score
Urban	55	72
Suburban	48	65
Rural	35	58
Urban	60	74
Suburban	50	66

The issue of balanced educational and health investment demands urgent attention. Significant disparities in regional economic development lead to uneven distribution of educational resources, exacerbating differences in health risk awareness across areas. This not only raises concerns about educational equity but may also impact overall public health standards across society. At national and regional policy levels, efforts should promote rational of educational investment, establish interregional

cooperation and resource-sharing mechanisms, and ensure economically underdeveloped areas also benefit from campus physical education and health education. This fosters a virtuous cycle among education, health, and economic development.

Regional adaptation pathways for F-risk awareness

Communication of F risk awareness requires customized design based on regional environmental differences. Significant variations in water resources, industrial structures, and local lifestyles across regions result in uneven levels of F exposure risk. In areas with high groundwater F concentrations, students and residents face greater health threats, necessitating enhanced F education within physical education and health curricula. Conversely, regions with lower F exposure risks should adopt a science-literacy-focused approach, avoiding resource waste and excessive education.

Regional adaptation pathways should emphasize flexible educational formats. In urban areas, AI and digital platforms can integrate F risk knowledge into smart physical education curricula, using wearable devices and virtual training platforms to enhance student engagement and interactivity. In rural and remote regions, greater reliance on offline collaboration between schools, communities, and public health institutions are needed. This can be achieved through group physical activities, health lectures, and lifestyle guidance to promote risk awareness. This locally tailored educational model better aligns with regional development conditions. Analysis of economic level, education investment, and student sports participation rate are shown in Figure 4.

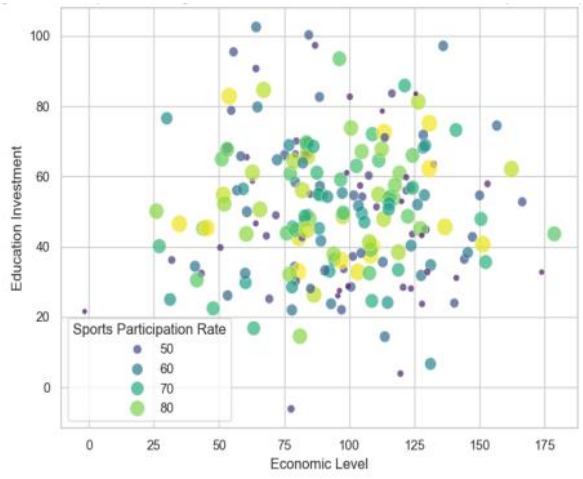

Figure 4. Relationship between regional economic level, education investment and sports participation rate

Regional adaptation must also account for cultural and social structural differences. In some areas, traditional dietary habits, drinking water practices, or societal perceptions may influence understanding and acceptance of F risks. Educational content that fails to integrate local cultural contexts and social psychology may create cognitive barriers, undermining effectiveness. Therefore, regional adaptation pathways require incorporating localized case studies and promotional language into physical activities and health education, making scientific knowledge about F risk prevention more accessible and acceptable to students. Average F knowledge scores by type of campus sport activities (Table 3).

Table 3. Fluoride knowledge scores by sports activity type

Type of activity	Mean knowledge score	Standard Deviation (SD)
Running	68	8
Basketball	72	10
Swimming	70	9
Gymnastics	66	7
Football	71	9

Effective implementation of regionally tailored approaches requires multi-sectoral governance collaboration. Local governments, education departments, public health agencies, and regional economic development organizations should establish cooperative mechanisms to integrate F risk education into overall regional development strategies. Financial support, policy guidance, and social mobilization are essential to ensure the sustainability and effectiveness of educational activities. Particularly in an AI-enabled environment, cross-regional data sharing and risk monitoring provide scientific foundations for educational adaptation. This enables dynamic adjustments to educational priorities based on local conditions, achieving precise dissemination and long-term consolidation of F risk awareness across diverse regions.

PRACTICAL PATHWAYS AND POLICY RECOMMENDATIONS

An AI-based model for campus physical education and health education should be established. By integrating wearable devices, exercise monitoring platforms, and intelligent teaching systems into physical education classes, F risk alerts and health knowledge dissemination can be embedded within the process of exercise data collection and analysis. During student exercise load assessments, the system can generate personalized hydration and nutritional guidance by incorporating regional water quality data. This transforms physical activities not only into channels for physical exercise but also into critical settings for health awareness education. Effectiveness

of AI-assisted sports training (T) calculated using baseline health metrics (H) and AI training intensity (A), as stated below:

$$T_i = \theta \cdot H_i + \phi \cdot A_i \quad (5)$$

Overall regional F risk awareness (R_total) as the weighted sum of individual regional awareness indices (R_r):

$$R_{total} = \sum_{r=1}^{m} \omega_r \cdot R_r \quad (6)$$

Establish a cross-departmental collaborative governance mechanism. Fluoride risk education spans multiple sectors including education, health, environmental protection, and local government, making systemic outcomes difficult for any single department to achieve alone. Promote cooperation between education authorities and public health institutions to integrate risk education into the institutional framework of campus physical activities. Local governments should enact policies ensuring sustained funding and resource allocation. Simultaneously, encourage social organizations and enterprises to participate in health education initiatives, jointly advancing campus-community collaboration. AI-assisted sports training impact on health risk awareness showed in Figure 5.

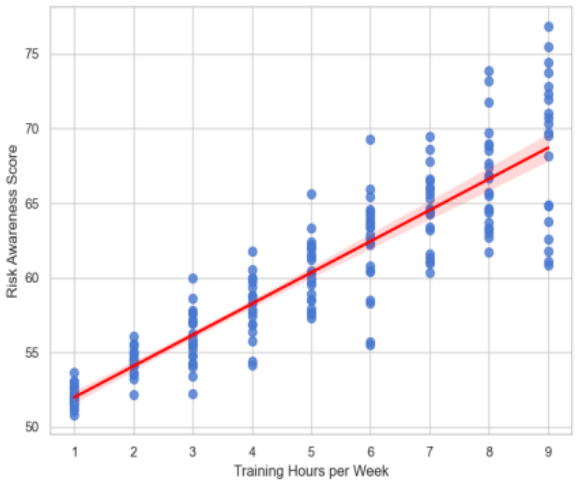

Figure 5. Effect of AI-assisted sports training on health risk awareness

Regional differentiation in educational approaches should be promoted. In high-risk F contaminated areas, strengthen relevant education in physical education classes and extracurricular activities, integrating AI platforms for dynamic risk monitoring and early warning. In lower-risk regions, prioritize disseminating foundational scientific knowledge and fostering healthy lifestyles to avoid inefficient resource allocation. This tiered, categorized strategy will develop regionally distinctive education systems, enhancing overall educational efficiency and health awareness levels. Data illustrating the linkage between regional economic level, education investment, and sports participation rate (Table 4).

Table 4. Regional economic level, education investment and sports participation rate

Region	Economic level index	Education investment (USD)	Sports participation rate (%)
Urban	120	55	80
Suburban	95	50	70
Rural	75	35	55
Urban	130	60	85
Suburban	100	52	72

Strengthen the synergistic development of educational investment and regional economies. At the policy level, integrate funding for health education and physical activities into long-term regional economic development plans to develop a virtuous cycle of "education-health-economy." Specifically, ensure economically underdeveloped regions access essential educational resources through fiscal subsidies, dedicated funds, and regional cooperation mechanisms, thereby narrowing regional disparities. Leverage AI to achieve precise allocation of educational resources and evaluate outcomes, continuously optimizing investment structures while enhancing transparency and efficiency in fund utilization.

CONCLUSION AND FUTURE RESEARCH

This paper examines the mediating role of campus physical activities in enhancing F risk awareness within an AI-enabled environment, while analyzing the interactive mechanisms between educational investment and regional economic alignment. Research indicates that AI technology can effectively integrate health risk education into campus physical activities through data collection, intelligent analysis, and personalized feedback, enabling students to enhance their F risk awareness and self-protection capabilities while exercising. Structural optimization of educational investment and regional economic support provide essential safeguards for this educational model, forming a mutually reinforcing virtuous cycle. The regional adaptation pathways and practical strategies proposed in this paper demonstrate that the health education programs tailored to local conditions and school-specific needs can effectively address regional disparities in F exposure risks, economic development levels, and

educational resource allocation. This approach achieves precision and sustainability in health education. Cross-departmental collaborative governance, regional economic support, and the application of AI technology provide actionable pathways for integrating physical education with risk awareness education.

Further advancements in AI technology will unlock greater potential for deep integration between campus physical education and health education. AI enables dynamic risk monitoring, personalized educational content delivery, and educational effectiveness evaluation, continuously optimizing educational programs to enhance the scientific rigor and efficiency of risk awareness education. The refinement of interdisciplinary educational models, regional coordination mechanisms, and policy support will foster positive interactions among educational investment, regional economies, and public health. This approach provides new theoretical foundations and practical paradigms for public health governance and the enhancement of youth health literacy.

FUNDING

Not applicable

DISCLOSURE OF FINANCIAL AND NON-FINANCIAL RELATIONSHIPS AND ACTIVITIES AND CONFLICTS OF INTEREST

None

REFERENCES

[1] Li W, Liu M, Liu J, Zhang B, Yu T, Guo Y, et al. A review of artificial intelligence for sports: Technologies and applications. Intelligent Sports Health 2025;1(3): 113-126. DOI: 10.1016/j.ish.2025.05.001

[2] Zhao R. Research on digital empowerment of public sports service system construction. J Edu Educat Res. 2024;9(1):1-4. DOI: 10.54097/bh9c9y65

[3] Zhang X, Ma C. Intelligent development of college physical education teaching mode based on “Internet+”. Int J Web-Based Learning Teaching Technol (IJWLTT) 2024;19(1):1-13. DOI: 10.4018/IJWLTT.340724

[4] Haffner L, Oshri I, Kotlarsky J. Directions for future IS research on sports digitalisation: A stakeholder perspective. The J Strategic Information Syst. 2025; 34(2):101905. DOI: 10.1016/j.jsis.2025.101905

[5] Mateus N, Abade E, Coutinho D, Gomez M, Penas CL, Sampaio J. Empowering the sports scientist with artificial intelligence in training, performance, and health management. Sensors 2024;25(1):139. DOI: 10.3390/s25010139

[6] Hu Z, Liu Z, Su Y. AI-driven smart transformation in physical education: Current trends and future research directions. Appl Sci. 2023;14(22):10616. DOI: 10.3390/app142210616

[7] Wang Y, Wang X. Artificial intelligence in physical education: Comprehensive review and future teacher training strategies. Front Public Health 2024;12:1484848. DOI: 10.3389/fpubh.2024.1484848

[8] Papalia Z, Wilson O, Bopp M, Duffey M. Technology-based physical activity self-monitoring among college students. Int J Exerc Sci. 2018;11(7):1096. DOI: 10.70252/FZTM4744

[9] Gong Y, Yang H, Bai X, Wang Y, An J. (2023). The relationship between physical exercise and smartphone addiction among Chinese college students: The mediating effect of core self-evaluation. Behavioral Sci. 2023;13(8): 647. DOI: 10.3390/bs13080647

[10] Huang Z, Wang W, Jia Z, Wang Z. Exploring the integration of artificial intelligence in sports coaching: Enhancing training efficiency, injury prevention, and overcoming implementation barriers. J Comp Communications 2024;12:201-217. DOI: 10.4236/jcc.2024.1212012.

[11] Naughton M, Salmon PM, Compton HR, McLean S. Challenges and opportunities of artificial intelligence implementation within sports science and sports medicine teams. Front Sports Active Living 2024;6:1332427. DOI: 10.3389/fspor.2024.1332427

[12] He Z, Niu X. Applying artificial intelligence to primary and secondary school physical education. *2nd Int Conf Information Sci Edu (ICISE-IE)*, Chongqing, China, 2021, pp. 1577-1581. DOI: 10.1109/ICISE-IE53922.2021.00349