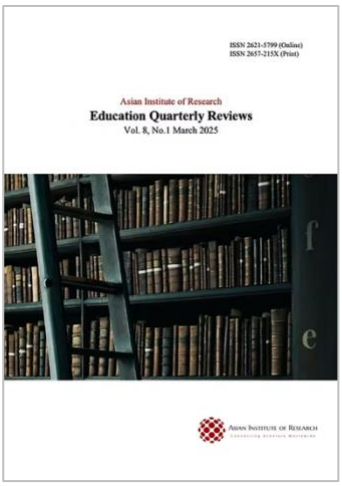

Education Quarterly Reviews

Donkor, S. K. (2025). Revolutionizing Fitness: The Intersection of Artificial Intelligence and Physical Activity. *Education Quarterly Reviews*, 8(1), 92-100.

ISSN 2621-5799

DOI: 10.31014/aior.1993.08.01.556

The online version of this article can be found at:
https://www.asianinstituteofresearch.org/

Published by:
The Asian Institute of Research

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The Asian Institute of Research
Education Quarterly Reviews
Vol.8, No.1, 2025: 92-100
ISSN 2621-5799

DOI: 10.31014/aior.1993.08.01.556

Revolutionizing Fitness: The Intersection of Artificial Intelligence and Physical Activity

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Abstract
The rapid advancement of artificial intelligence (AI) technology is significantly reshaping the fitness industry, creating opportunities for enhanced personalization and effectiveness in exercise routines. This study explored the transformative impact of AI-powered wearables and smart fitness devices on individual fitness outcomes and overall physical activity levels. Utilizing a quantitative approach, the research involved a cross-sectional survey of 90 pre-service physical education students from the University of Education, Winneba, who provided insights into their experiences with AI technologies in fitness. The study employed a five (5) point Likert-scale questionnaire to assess respondents' perceptions of AI's influence on their exercise regimens. Data was analyzed using means, standard deviation, independent samples t-test and Pearson's correlation. The findings revealed that AI technologies significantly enhance the personalization of fitness programmes, enabling users to achieve tailored workout structures and set personalized fitness goals. Participants reported increased physical activity levels and improved consistency in their fitness routines, highlighting the positive correlation between AI integration and individual fitness outcomes. Additionally, the study emphasizes the necessity of addressing ethical considerations, in terms of algorithmic partiality and data confidentiality, to ensure equitable access to AI-driven fitness solutions. It was recommended that fitness organizations and AI developers should focus on user education, engagement, and continuous improvement of user experience to maximize the benefits of AI technologies.

Keywords: Fitness, Artificial Intelligence (AI), Physical Activity, Pre-Service Teachers

1. Introduction

The rapid development of digital technology and an increasing focus on holistic health and wellness have dramatically shifted the global fitness sector (Global Wellness Institute, 2021). This transformation is underscored by the emerging relationship between artificial intelligence (AI) and physical activity, positioning AI as a pivotal force in reshaping fitness practices. Traditionally, exercise programmes and fitness regimens have relied on standardized, one-size-fits-all approaches that often overlook individuals' distinct physiological and behavioral traits (Petersen & Gebhardt, 2017). This lack of personalization has limited the effectiveness of fitness interventions, as they fail to accommodate the unique needs of diverse populations. However, the rise of AI-powered technologies is ushering in a new era characterized by tailored, flexible, and data-driven fitness solutions, fundamentally disrupting these outdated paradigms. The potential applications of this technology are extensive and varied, ranging from AI-powered virtual coaches that can dynamically adjust workout plans based on real-time biometric data and individual user preferences (Liao et al., 2020) to intelligent wearables that analyze a person's movement patterns and provide immediate feedback on exercise form and technique (Srivastava et al.,

2020). These innovations not only enhance individual exercise experiences but also facilitate more effective training regimens that adapt to the user's progress.

As wearable technology and other digital health tools provide access to more data, fitness professionals should endeavour to empower and educate their clients on how to properly analyze and use the data to promote improvements in important health behaviours, like physical activity, sleep, and recuperation (Newsome (2023). Exercise experts can assist their customers in making long-lasting, sustainable changes that improve general health and wellness by counselling them on the importance of the data and how to use it to make wise decisions. For instance, personalized exercises, real-time performance analytics, and advice from qualified trainers are all provided by Apple Fitness+, a subscription-based fitness service that pairs with the Apple Watch (McAvoy, 2023). Moreover, the application of AI within the broader ecology of physical activity holds transformative potential beyond personal fitness. AI algorithms can be employed to enhance sports performance analysis, identify athletic talent, optimize urban infrastructure to support active transportation, and guide public health initiatives aimed at increasing physical activity levels in communities. Despite these promising advancements, the integration of AI in fitness raises significant ethical concerns that must be critically examined. Issues related to algorithmic bias, data privacy, and the potential for technology to exacerbate existing disparities in access to health and wellness services are paramount (Morley et al., 2019). For example, if AI systems are trained on biased datasets, they may perpetuate inequalities in health recommendations and access to personalized fitness solutions, thereby widening the gap between different socioeconomic groups. Additionally, the collection and analysis of personal health data pose risks to individual privacy, necessitating stringent safeguards to protect user information. In light of these complexities, the purpose of this study is to investigate the intricate relationship between artificial intelligence and physical exercise.

1.1. Statement of the Problem

The swift penetration and progression of artificial intelligence (AI) technologies has begun to reshape the landscape of the fitness industry, presenting both opportunities and challenges that warrant thorough investigation. Despite the promising potential of AI to personalize fitness solutions, enhance individual performance, and promote overall health, there remains a significant gap in understanding the extent of its transformative impact on exercise behaviors and fitness outcomes. Many existing fitness programmes continue to rely on traditional, standardized approaches that fail to accommodate individual differences in physiology, motivation, and lifestyle, leading to suboptimal results and disengagement among users (Petersen & Gebhardt, 2017).

The AI-powered algorithms analyze user data to recommend tailored workout routines. Furthermore, while AI technologies, such as wearable devices and virtual coaching platforms, offer innovative tools for personalized training, there is limited empirical research that systematically assesses their effectiveness in improving user engagement, adherence to fitness regimens, and overall physical activity levels. The lack of comprehensive studies in this area hinders our understanding of how these technologies can be best integrated into existing fitness paradigms to maximize their benefits and ensure equitable access for diverse populations. Additionally, the ethical implications of deploying AI in fitness contexts raise critical concerns that must be addressed. Issues of algorithmic bias, data privacy, and the potential for exacerbating health disparities pose significant risks to users. For instance, if AI systems are designed without considering diverse user demographics, they may inadvertently perpetuate inequalities in health outcomes and access to personalized fitness solutions. As such, there is a pressing need to explore not only the technological advancements but also the broader societal implications of AI integration in fitness.

Given these gaps in knowledge and the importance of addressing ethical considerations, this study aims to investigate the multifaceted relationship between artificial intelligence and physical fitness. By examining how AI-powered technologies transform individual fitness experiences and their implications for public health and social equity, this research seeks to contribute to an in-depth understanding of the challenges and opportunities presented by the intersection of AI and fitness. Ultimately, this investigation will inform stakeholders, including fitness professionals, health policymakers, and technology developers, about best practices for leveraging AI in ways that promote inclusivity, engagement, and positive health outcomes for all users.

1.2. Purpose of the Study

The study interrogated the transformative impact of the integration of artificial intelligence (AI) technology across fitness and physical activity.

1.3. Research Objectives

Specifically, the study sought to:

1. Ascertain ways AI-powered wearables and smart fitness devices transforming the personalization and effectiveness of individual exercise routines?
2. Assess how AI technologies improve individual fitness outcomes and overall physical activity levels among users.

1.4. Research Questions

1. What ways are AI-powered wearables and smart fitness devices transforming the personalization and effectiveness of individual exercise routines?
2. In what ways do AI technologies improve individual fitness outcomes and overall physical activity levels among users?

1.5. Hypotheses

Ho1: There are no statistically significant differences in perceptions of the effectiveness of AI technologies in fitness between male and female users.
Ho2: There is no statistically significant relationship between the perceived effectiveness of AI technologies and reported fitness outcomes and activity levels among users.

2. Theoretical Framework

This study utilizes the Diffusion of Innovations Theory proposed by Everett Rogers in 1957, which offers a robust framework for understanding how new technologies, such as artificial intelligence (AI) in fitness and physical activity, are adopted and spread within a social system. The theory outlines the process through which innovations are communicated and accepted, focusing on the key factors that influence their diffusion over time. By applying this framework, the study aims to illuminate the dynamics surrounding the integration of AI-powered fitness solutions and their impact on individual exercise routines and overall fitness outcomes. According to Rogers (2003), the diffusion process is shaped by several critical elements: the perceived characteristics of the innovation (such as relative advantage, compatibility, complexity, trialability, and observability), the communication channels used to disseminate information, the nature of the social system in which the innovation is introduced, and the role of change agents who facilitate the adoption process (Greenhalgh et al., 2004). In the context of AI in fitness technology, these factors are instrumental in determining how effectively users can personalize and enhance their exercise routines through AI-powered wearables and smart devices.

The application of the Diffusion of Innovations Theory is evidenced in prior research on health and wellness technologies. For instance, Gagnon et al. (2012) explored the adoption of telehealth technologies using this framework, identifying key drivers of acceptance in healthcare settings. Similarly, Payne et al. (2015) investigated the diffusion of wearable activity trackers among fitness enthusiasts, illustrating the theory's relevance in examining user characteristics and the broader social context influencing technology adoption. These studies affirm the theory's utility in dissecting the intricate interplay between technological advancements and the social environments that foster or impede their acceptance.

In this study, the Diffusion of Innovations Theory serves as a lens to investigate the transformative effects of AI technology on fitness and physical activity. It allows for an exploration of the multifaceted nature of AI integration, considering its implications across various domains, including individual exercise practices, sports science, urban

planning, and public health initiatives. The emphasis on communication channels and social networks within the theory provides insights into how AI-driven fitness solutions can be effectively disseminated and embraced by diverse stakeholders, including fitness enthusiasts, health professionals, technology developers, and policymakers.

3. Methodology

This study employed a quantitative research approach to investigate the transformative impact of artificial intelligence (AI) technology on fitness and physical activity. The focus of this approach was to quantitatively assess how AI-powered wearables and smart fitness devices influence the personalization and effectiveness of individual exercise routines, as well as their overall effect on fitness outcomes and physical activity levels among users. A cross-sectional survey design was utilized to gather data from a diverse group of participants. Census sampling technique was used to ensure adequate representation. The target population is made up of 101 pre-service physical education students. Although the study's target population was 101 respondents, the researcher was only able to contact and get information from 90 of them, leaving 11-person discrepancy. This indicates that 89.11% of the target population has been reached, while the remaining 10.89% has not. This sample size was deemed sufficient to analyze potential differences and relationships among variables.

Data collection was conducted using closed-ended questionnaire designed to assess respondents' perceptions and experiences with AI-powered fitness technologies. The survey included several components, beginning with demographic information where participants provided basic details such as age, gender, level of education, and fitness experience (e.g., novice, intermediate, advanced). Following this, a series of Likert-scale items (ranging from 1 = Strongly Disagree to 5 = Strongly Agree) were included to evaluate participants' perceptions of how AI technologies have impacted their exercise routines. Sample items included statements such as, "AI-powered devices have personalized my workout plans," and "I feel more motivated to exercise because of the feedback from my wearable." Additionally, further Likert-scale items assessed changes in fitness outcomes and overall physical activity levels due to AI integration, with items such as, "Since using AI technology, I have noticed an improvement in my fitness levels," and "My overall activity level has increased since I began using AI-powered devices." The survey was disseminated via online platforms, including social media channels and fitness forums, and participants were informed about the purpose of the study while giving consent to participate. Ethical considerations included ensuring confidentiality and the right to withdraw from the study at any time.

Data were analyzed using statistical software such as SPSS version 26. The analysis began with means and standard deviation to answer the research questions. The benchmark for interpreting the results of the five-point Likert scale as Boone and Boone (2012) stated; Strongly Disagree (1.00 - 1.80) represents a strong negative response or disagreement with the statement; Disagree (1.81 - 2.60) indicates a general negative response or disagreement, but with less intensity than "Strongly Disagree"; Neutral (2.61 - 3.40) reflects a neutral or undecided position, with neither strong agreement nor disagreement; Agree (3.41 - 4.20) shows a positive response or agreement with the statement; and Strongly Agree (4.21 - 5.00) denotes a strong positive response or high level of agreement. A standard deviation of less than (< 1.0 = homogeneousness; ≥ 1.0 = Heterogeneousness) of responses. T-tests, were employed to examine differences in perceptions and fitness outcomes across gender. Additionally, correlation analysis was performed to assess the relationships between perceived effectiveness of AI technologies and reported fitness outcomes and activity levels. The study received ethical approval prior to data collection. Informed consent was obtained from the participants, ensuring they understood their rights, the purpose of the study, and the measures taken to protect their data. Data privacy was strictly maintained, with all responses anonymized and securely stored. This quantitative methodology provided a structured approach to exploring the integration of AI in fitness and its impact on individual exercise routines and overall physical activity levels.

4. Results

Research question 1: What ways are AI-powered wearables and smart fitness devices transforming the personalization and effectiveness of individual exercise routines?

This analysis aims to provide insights into how participants perceive the role of AI technology in customizing and enhancing their workout experiences**.** Data from the survey were analyzed using means and standard deviations.

Table 1: Personalization and effectiveness of individual exercise routines through AI-powered wearables

Item	**N**	**M**	**S.D**
AI-powered devices provide workout recommendations that are tailored to my fitness level and goals.	90	3.32	0.31
My exercise routines have become more structured and effective since I started using AI-powered fitness devices.	90	4.51	0.21
AI technology helps me set realistic and personalized fitness goals.	90	4.37	0.33
I receive valuable feedback from AI-powered devices that help improve my exercise form and technique.	90	4.41	0.27
I rely on AI-powered devices to track and adjust my workout intensity based on my progress.	90	4.43	0.23
My workouts feel more enjoyable and engaging with AI-powered wearable guidance.	90	3.42	0.26
AI-powered devices have helped me diversify my exercise routines.	90	3.32	0.31
The personalized insights provided by AI technology have improved the overall quality of my workouts.	90	3.51	0.21
AI-powered devices adapt to my changing fitness needs over time, making them more relevant.	90	3.37	0.33
Mean of means/Standard deviation	**90**	**3.85**	**0.27**

Source: Field Data, 2024

The item with the highest mean score was “My exercise routines have become more structured and effective since I started using AI-powered fitness devices” (M = 4.51, S.D. = 0.21), suggesting strong agreement among participants that these devices significantly contribute to more organized and effective workouts. This high mean score, coupled with a low standard deviation, reflects a consensus that AI has a positive impact on the structuring of exercise routines. Moreover, participants expressed strong perceptions regarding AI's ability to assist in setting realistic fitness goals (M = 4.37, S.D. = 0.33) and providing valuable feedback on exercise form (M = 4.41, S.D. = 0.27). These results indicate that respondents feel that AI technologies enhance their ability to achieve personalized fitness objectives and improve their exercise technique, which is essential for injury prevention and maximizing performance. In contrast, the items measuring the personalization of workout recommendations and the diversification of exercise routines received lower mean scores (M = 3.32, S.D. = 0.31), suggesting that while participants acknowledge the usefulness of AI, there is still room for improvement in how these devices recommend new activities and adapt to users' evolving preferences. The overall mean of 3.85 indicates a generally positive perception of AI-powered wearables, reflecting that respondents recognize their value in personalizing fitness experiences. The standard deviation of 0.27 signifies a degree of homogeneity in responses, particularly for the higher-rated items, indicating that participants share similar views on the effectiveness of AI technologies in enhancing their exercise routines. This analysis highlights the transformative potential of AI in personalizing fitness, while also identifying areas where further development could enhance user experiences and engagement. This finding corroborates with Patton et al. (2016) which indicated that personalization in fitness routines is crucial for improving user engagement and adherence. AI technologies offer tailored recommendations based on individual fitness levels, preferences, and progress, allowing for more structured workouts. According to the Diffusion of Innovation Theory, the perceived advantages of AI technologies can lead to increased adoption and usage among users (Rogers, 2003). As individuals experience the benefits of personalized fitness experiences, they are more likely to incorporate these technologies into their routines, facilitating a positive feedback loop of engagement and effectiveness.

Research question 2: In what ways do AI technologies improve individual fitness outcomes and overall physical activity levels among users?

This analysis seeks to identify specific ways in which participants believe AI technology impacts their fitness progress and physical activity habits. The data analysis for this research question involved descriptive statistics.

Table 2: Effectiveness of AI technologies in improving individual fitness outcomes and overall physical activity

Item	N	M	S.D
AI technologies have increased my physical activity levels.	90	4.54	0.54
I am more consistent in my fitness routine due to the reminders and guidance from AI-powered devices.	90	4.34	0.67
AI-powered devices have helped me track and achieve my fitness goals effectively.	90	4.54	0.54
The feedback from AI devices has contributed to improvements in my physical performance.	90	4.51	0.38
My awareness of my physical health and fitness levels has increased through the use of AI technology.	90	4.32	0.35
AI technologies make it easier for me to monitor my progress and make adjustments as needed.	90	3.94	0.41
AI-powered devices provide me with useful information about my recovery needs and activity balance.	90	3.84	0.46
My health and wellness have improved as a direct result of using AI-powered fitness tools.	90	3.78	0.37
Mean of means/ standard deviation	**90**	**4.23**	**0.47**

Source: Field Data, 2024

The item "AI technologies have increased my physical activity levels" received a mean score of 4.54 (S.D. = 0.54), indicating a strong agreement among respondents about the positive impact of AI on their activity levels. This suggests that users feel empowered by AI to engage more frequently in physical activities. Similarly, the statement "AI-powered devices have helped me track and achieve my fitness goals effectively" matched this high mean score of 4.54 (S.D. = 0.54), reinforcing the notion that AI tools are instrumental in helping users attain their fitness objectives. Moreover, the feedback provided by AI devices appears to have a significant role in enhancing physical performance, as indicated by a mean score of 4.51 (S.D. = 0.38). This suggests that users find the real-time data and insights from these devices beneficial for improving their exercise routines. The item regarding consistency in fitness routines, "I am more consistent in my fitness routine due to the reminders and guidance from AI-powered devices," also received a favorable mean of 4.34 (S.D. = 0.67), highlighting that the reminders and support from AI contribute to regular exercise habits. Further analysis of the data shows that participants reported an increased awareness of their health and fitness levels through AI technology, with a mean score of 4.32 (S.D. = 0.35). However, some items yielded lower mean scores, indicating areas that may need improvement. For instance, the item "AI-powered devices provide me with useful information about my recovery needs and activity balance" scored a mean of 3.84 (S.D. = 0.46), and "My health and wellness have improved as a direct result of using AI-powered fitness tools" had a mean of 3.78 (S.D. = 0.37). These results suggest that while participants acknowledge the benefits of AI, they perceive that there is room for enhancement in the information regarding recovery and overall wellness. The overall mean score of 4.23 (S.D. = 0.47) across the assessed items reflects a generally positive perception of AI technologies among participants, with low standard deviations indicating a strong consensus in their responses. This analysis emphasizes the positive role that AI technologies play in enhancing users' fitness journeys and encourages further developments to maximize the effectiveness and comprehensiveness of AI-driven fitness tools. The findings suggest that users feel more motivated and accountable due to the continuous feedback and reminders provided by AI devices. This supports research by Jago et al. (2016), which highlighted that technology-mediated feedback enhances physical activity levels by fostering motivation and reinforcing behavior change. The Diffusion of Innovation Theory emphasizes that innovations perceived as beneficial in improving fitness outcomes are more likely to be adopted, as users recognize their value in achieving personal fitness goals (Rogers, 2003). Thus, the effective integration of AI in fitness technology may lead to sustained increases in physical activity levels, promoting healthier lifestyles.

Ho1: There are no statistically significant differences in perceptions of the effectiveness of AI technologies in fitness between male and female users.

To test this hypothesis independent samples t-tests were conducted to compare the mean scores of male and female participants regarding their perceptions of AI technologies in fitness. The result is presented in Table 3.

Table 3: Gender Differences in perceptions of the effectiveness of AI technologies in fitness

Sex	N	Mean	Std. Dev.	T	df	Sig-Value
Male	67	3.43	0.39	1.180	216	0.239
Female	23	3.41	0.42			

Source: Field Data, 2024

The analysis of gender differences in perceptions of the effectiveness of AI technologies in fitness, as illustrated in Table 3, reveals that male participants (N = 67) had a mean score of 3.43 (SD = 0.39), while female participants (N = 23) had a slightly lower mean score of 3.41 (SD = 0.42). The t-test conducted to compare these means resulted in a t-value of 1.180 with 216 degrees of freedom and a significance value (p-value) of 0.239. Given that the p-value exceeds the level of 0.05, the researcher fails to reject the null hypothesis (Ho1). This indicates that there are no statistically significant differences in perceptions of the effectiveness of AI technologies in fitness between male and female users. Thus, both genders appear to have a similar level of agreement regarding the effectiveness of AI technologies in enhancing their fitness experiences. This finding is noteworthy as it suggests a universal acceptance of AI technologies across genders, which is not always evident in technology adoption studies. Previous research has indicated varying attitudes towards technology based on gender, often highlighting that women may feel less comfortable using fitness technologies (Coffey et al., 2021). However, the absence of significant differences in this study suggests that AI technologies may be designed in a way that is inclusive and appealing to all users, regardless of gender. This could be linked to the Diffusion of Innovation Theory, which posits that the compatibility of innovations with existing values and experiences influences their adoption (Rogers, 2003). The neutrality in perceptions may suggest that AI-powered wearables are effectively addressing the needs of a diverse user base.

Ho2: There is no statistically significant relationship between the effectiveness of AI technologies and reported fitness outcomes and activity levels among users.

Peason's correlation analysis was conducted to examine the relationship between participants' perceived effectiveness of AI technologies and their reported fitness outcomes and activity levels. This analysis provides insights into whether users who perceive AI technologies as effective also report better fitness outcomes and higher levels of physical activity. The result of the relationship between effectiveness of AI technologies and fitness outcomes is presented in Table 5.

Table 5: Relationship between effectiveness of AI technologies and fitness outcomes

Variable	Mean	*Sd*	*R*	R^2	*P*
Effectiveness	4.23	.47	.784	.615	0.000
Fitness outcome	3.85	.27			

Source: Field Data, 2024

The mean score for the perceived effectiveness of AI technologies was 4.23 (SD = 0.47), indicating a generally high perception of effectiveness among participants. Conversely, the mean score for fitness outcomes was 3.85 (SD = 0.27), suggesting a favorable but slightly lower perception of actual fitness results. The correlation

coefficient (R) was found to be 0.784, indicating a strong positive relationship between the perceived effectiveness of AI technologies and reported fitness outcomes. The coefficient of determination (R^2) of 0.615 suggests that approximately 61.5% of the variance in fitness outcomes can be explained by the perceived effectiveness of AI technologies. This strong relationship implies that users who perceive AI technologies as effective are likely to report better fitness outcomes. The p-value for this correlation was 0.000, which is below the threshold of 0.05. This statistically significant result suggests the rejection of the null hypothesis (Ho2). This confirms that there is indeed a statistically significant relationship between the perceived effectiveness of AI technologies and reported fitness outcomes and activity levels among users. Users who viewed these technologies as effective reported better fitness results, supporting the notion that the perceived utility of an innovation directly influences its adoption and resulting outcomes (Rogers, 2003). This finding aligns with the work of Kwan et al. (2020), which demonstrated that user perceptions of technology's effectiveness are crucial predictors of its impact on behavior change and fitness achievements. In the context of the Diffusion of Innovation Theory, this relationship underscores the importance of enhancing user perceptions through effective marketing and user education, thereby increasing the likelihood of sustained use and positive health outcomes.

5. Findings

The analysis of the data reveals the following findings:

1. AI-powered wearables significantly enhance the personalization and effectiveness of individual exercise routines. Participants reported positive perceptions of how AI improves workout structure, aids in setting personalized fitness goals, and contributes to overall workout enhancement.
2. AI technologies are perceived to improve fitness outcomes and physical activity levels. Respondents indicated a strong belief that these technologies increase their physical activity and help maintain consistency in their fitness routines.
3. There is no statistically significant difference in perceptions of the effectiveness of AI technologies between male and female users. The analysis revealed no significant differences in perceptions between genders.
4. There is a statistically significant relationship between the perceived effectiveness of AI technologies and reported fitness outcomes. The analysis confirmed a strong positive relationship, indicating that higher perceptions of AI effectiveness are associated with better fitness outcomes.

6. Conclusion and Recommendations

The study highlights the significant role of AI-powered wearables and smart fitness devices in enhancing the personalization and effectiveness of exercise routines. Participants expressed strong positive perceptions regarding the impact of AI technologies on their workout experiences, goal-setting, and overall fitness outcomes. Additionally, the findings confirmed a strong positive relationship between users' perceptions of AI effectiveness and their reported fitness outcomes, emphasizing the potential of AI technologies to elevate physical activity levels. Notably, the analysis indicated that gender does not significantly influence perceptions of AI effectiveness, suggesting a universal appreciation for these technologies among users. The following recommendations are made:

1. Fitness organizations and AI technology developers should provide educational resources to help users understand the full capabilities and benefits of AI-powered devices. This could include workshops, tutorials, and user manuals that highlight personalized features and their impact on fitness goals.
2. To maximize the benefits of AI technologies, users should be encouraged to engage with their devices consistently. This includes utilizing features such as goal setting, feedback mechanisms, and tracking capabilities to enhance their fitness journey.
3. Fitness developers should prioritize user-friendly interfaces and ensure that AI technologies are easily accessible and intuitive for all users, regardless of their technical expertise. Continuous improvement of the user experience will facilitate greater adoption and satisfaction.

4. Combining AI technologies with personalized coaching or fitness programmes could enhance motivation and accountability. This could involve the integration of AI insights with professional guidance to tailor fitness plans to individual needs.

Funding: Not applicable.

Conflict of Interest: The authors declare no conflict of interest.

Informed Consent Statement/Ethics Approval: Not applicable.

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