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Smart Sports Facilities and Citizens' Physical Activity: Mediating Effects of Psychological Safety and Intrinsic Motivation

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Abstract

Purpose: This study investigated the impact of smart sports facility use on citizens' physical activity, examining the sequential mediating roles of psychological safety and intrinsic motivation.

Methods: A descriptive-correlational design was employed using Partial Least Squares Structural Equation Modeling (PLS-SEM). The sample comprised 385 adult citizens (52.7% male; mean age = 31.6 years) who actively used smart sports facilities, recruited through convenience sampling. Smart facility use was assessed using a 6-item scale measuring interaction with smart features, psychological safety using a 7-item adapted scale, intrinsic motivation using the 7-item interest/enjoyment subscale of the Intrinsic Motivation Inventory, and physical activity using the International Physical Activity Questionnaire-Short Form (IPAQ-SF). All instruments demonstrated satisfactory reliability and validity (Cronbach's $\alpha > 0.83$; AVE > 0.55; HTMT < 0.85). Indirect effects were tested using 5,000 bootstrap resamples with 95% confidence intervals.

Results: Smart facility use had a significant positive direct effect on psychological safety ($\beta = 0.39$, $p < 0.001$) and physical activity ($\beta=0.12$, $p = 0.021$). Psychological safety significantly predicted intrinsic motivation ($\beta = 0.42$, $p < 0.001$), and intrinsic motivation significantly predicted physical activity ($\beta = 0.38$, $p < 0.001$). The indirect effects through psychological safety ($\beta = 0.07$), intrinsic motivation ($\beta = 0.07$), and the sequential pathway ($\beta = 0.06$) were all significant. The model explained 24.6% of the variance in physical activity.

Conclusion: Facility managers and urban planners should prioritize features that reduce evaluative threat, support users' sense of control, and foster enjoyable exercise experiences to promote sustainable active living.

Keywords: Smart sports facilities, Physical activity, Psychological safety, Intrinsic motivation, Citizens.

Introduction

The promotion of physical activity among urban citizens has become a pressing public health priority, as sedentary lifestyles continue to threaten both physical and psychological well-being across populations (Dai et al., 2021; King et al., 2002; Monadi, 2025). While the health benefits of regular exercise are well-established, a substantial proportion of adults fail to meet recommended activity levels, and many who initiate exercise programs abandon them within months (Hosseinpour & Terlutter, 2019; Li et al., 2024; Monadi, 2025). In response, cities worldwide are investing in smart sports facilities, digitally enhanced environments equipped with sensors, interactive displays, mobile connectivity, and data-driven feedback systems, with the expectation that technological sophistication will attract users and sustain engagement (Zhang et al., 2025; Fasola & Mataric, 2012; Dana et al., 2011). Yet the mere presence of advanced infrastructure does not guarantee active use (Huang & Li, 2026). Understanding the psychological mechanisms through which smart facilities influence

citizens' physical activity requires attention to how these environments shape users' subjective experiences, particularly their sense of psychological safety and their intrinsic motivation to exercise (Li, 2025; Fu & Huang, 2025; Monadi, 2025).

Smart sports facilities represent a distinct evolution in the design of public exercise spaces. Unlike traditional gyms or outdoor fitness parks, smart facilities integrate technology into the exercise experience itself: equipment may provide real-time performance feedback, mobile applications may track progress and offer personalized guidance, and environmental systems may adapt lighting, temperature, or music to user preferences (Huang & Li, 2026; Zhang et al., 2025; Monadi, 2025). In cities such as Dongguan, China, smart fitness parks equipped with solar-powered equipment, motion sensors, and interactive displays have been installed to create "15-minute fitness circles," with early reports indicating substantial usage and user enthusiasm. The underlying assumption is that technological enhancement increases the appeal and accessibility of exercise, thereby promoting sustained participation (He et al., 2026; Monadi, 2025). However, research examining smart exercise environments alongside green exercise contexts has found that while smart facility/technology interaction was positively associated with physical activity, the association was relatively small, suggesting that technological features may function as contextual facilitators rather than direct determinants of behavioral outcomes (Ulukan et al., 2026).

This observation points to the need for a psychologically grounded account of how smart facilities operate. Self-determination theory provides a useful framework for understanding the motivational processes that sustain exercise behavior (Ntoumanis & Moller, 2025; Schneider & Graham, 2013). According to the theory, behavior is more likely to be internalized and maintained when environments satisfy three basic psychological needs: autonomy, competence, and relatedness (Mamun, 2023). Intrinsic motivation, the drive to engage in an activity for its inherent enjoyment and interest, represents the most self-determined form of motivation and is a strong predictor of behavioral persistence (Schneider & Graham, 2013; Li et al., 2024; Monadi, 2025). When individuals find exercise enjoyable and personally meaningful, they are more likely to continue participating even in the absence of external pressures or rewards (Baniasadi et al., 2022; Fu & Huang, 2025). Research grounded in self-determination theory has demonstrated that intrinsic motivation for exercise is enhanced when environments support perceived competence, relatedness, and autonomy, and when activities are experienced as enjoyable (Schneider & Graham, 2013; Ntoumanis & Moller, 2025). Smart facilities, with their capacity to provide personalized feedback, gamified challenges, and interactive social features, may offer novel ways to satisfy these needs and foster intrinsic motivation (Huang & Li, 2026; Yau & Shen, 2025).

A second, less examined psychological mechanism is psychological safety. Originally conceptualized in organizational contexts as the shared belief that one can express oneself, take interpersonal risks, and admit mistakes without fear of negative consequences, psychological safety has recently been applied to physical activity and sport settings (Li, 2025; Woods et al., 2024). Research in sport contexts has shown that psychological safety is positively associated with intrinsic motivation and autonomous forms of motivation, and that it creates conditions in which athletes feel free to take interpersonal risks without fear of embarrassment (Lundberg & Åhs, 2023). A study examining psychological safety, intrinsic motivation, and physical activity among participants in inclusive sport events found that psychological safety was significantly and positively associated with intrinsic motivation, and that intrinsic motivation in turn predicted physical activity (Li, 2025). Moreover, psychological safety had a significant indirect effect on physical activity through intrinsic motivation. These findings suggest that when individuals feel psychologically safe, free from judgment, embarrassment, or fear of failure, they are more likely to experience exercise as intrinsically rewarding and to engage more actively (Li, 2025; Shafaei et al., 2024). Smart facilities may contribute to psychological safety by reducing evaluative pressure (e.g., through private, individualized feedback rather than public comparison), offering non-judgmental technological guidance, and creating predictable, controllable exercise environments (Huang & Li, 2026).

However, the intersection of smart facility design, psychological safety, and intrinsic motivation remains largely unexplored. Existing research on smart sports environments has focused primarily on technology adoption, usage patterns, or direct effects on physical activity, without systematically examining the psychological processes that mediate these relationships (Huang & Li, 2026; Ulukan et al., 2026). Conversely, studies examining psychological safety in physical activity contexts have not considered how smart facility features might cultivate or undermine it (Li, 2025; Lundberg & Åhs, 2023). The dual mediation pathway, smart facility use → psychological safety → intrinsic motivation → physical activity—has not been tested in an integrated model. This gap is significant because it leaves facility managers and urban planners without evidence-based guidance on whether and how smart technologies should be designed to support psychological experiences that sustain exercise, rather than merely attracting initial use (Zhang et al., 2025; Qin & Chiang, 2026).

The present study addresses this gap by proposing and testing a model in which smart sports facility use influences citizens' physical activity through the sequential mediating roles of psychological safety and intrinsic motivation. The model posits that smart facilities, when designed and experienced in ways that reduce evaluative threat and enhance users' sense of control and competence, foster psychological safety (Li, 2025;

Huang & Li, 2026). This safety, in turn, creates conditions in which intrinsic motivation can flourish, as individuals feel free to explore, enjoy, and persist in exercise without fear of negative judgment (Schneider & Graham, 2013; Ntoumanis & Moller, 2025). Intrinsic motivation then translates into higher levels of physical activity (Fu & Huang, 2025; Ulukan et al., 2026). By examining this pathway, the study aims to contribute to both theoretical understanding of how built environments shape psychological processes and practical knowledge about the design and management of smart sports facilities that promote sustainable active living (King et al., 2002; Fathi et al., 2020).

Methods

Research Design and Sample

This study employed a descriptive-correlational research design using Partial Least Squares Structural Equation Modeling (PLS-SEM). PLS-SEM was selected due to its suitability for testing complex predictive models with multiple latent constructs and sequential mediating pathways, as well as its robustness with non-normal data distributions commonly encountered in behavioral and sport management research. The target population comprised adult citizens who actively used smart sports facilities, digitally enhanced exercise environments equipped with sensors, interactive displays, and mobile connectivity features. A convenience sampling approach was adopted due to the dispersed geographic distribution of smart facility users and the absence of a comprehensive sampling frame. Data collection was conducted across multiple smart facility sites and varied timeframes to enhance sample diversity. The final sample consisted of 385 valid responses, which exceeds the minimum sample size requirements for PLS-SEM based on the inverse square root method and the 10-times rule for the proposed model complexity.

Measures

Smart Sports Facility Use was assessed using an adapted version of the smart facility/technology interaction scale. The scale comprises 6 items measuring the frequency and depth of interaction with smart facility features (e.g., real-time performance feedback, mobile application integration, interactive displays). Items were rated on a 5-point Likert scale ranging from 1 (never) to 5 (very frequently). Higher scores indicate more extensive engagement with smart facility technologies.

Psychological Safety was measured using a 7-item scale adapted from Edmondson's Team Psychological Safety Scale, modified for exercise facility contexts. Items assess the extent to which users feel safe to exercise without fear of judgment, embarrassment, or negative evaluation (e.g., "It is safe to take risks in this exercise environment"). Responses were recorded on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). The scale has demonstrated strong internal consistency and construct validity across diverse settings.

Intrinsic Motivation was assessed using the interest/enjoyment subscale of the Intrinsic Motivation Inventory (IMI). This 7-item subscale captures the inherent enjoyment and interest experienced during exercise (e.g., "I enjoy being physically active"). Items were rated on a 7-point Likert scale ranging from 1 (not at all true) to 7 (very true). The IMI has been widely validated and demonstrates excellent reliability across physical activity contexts.

Physical Activity was measured using the short-form International Physical Activity Questionnaire (IPAQ-SF), which assesses walking, moderate-intensity, and vigorous-intensity activity over the preceding seven days. Total metabolic equivalent (MET-minutes/week) scores were computed following standard IPAQ scoring protocols. The IPAQ-SF has demonstrated acceptable reliability and validity across diverse populations and cultural contexts.

Data Collection Procedure

Questionnaires were distributed both on-site at smart sports facilities (paper-based) and electronically via a secure online link shared through facility communication channels and community groups. The first page contained an informed consent statement outlining the study's purpose, voluntary participation, anonymity assurances, and data confidentiality. To mitigate common method bias, procedural remedies included anonymous responding, intermixing items from different constructs, and using some reverse-coded items. Ethical approval was obtained from the relevant institutional review board prior to data collection. Data collection spanned approximately two months.

Data Analysis

Data were analyzed using SPSS 26 and SmartPLS 4. Descriptive statistics were computed for demographic variables and study constructs. The measurement model was evaluated for indicator reliability (outer loadings > 0.70), internal consistency (Cronbach's α and composite reliability > 0.70), convergent validity (AVE > 0.50), and discriminant validity (Fornell-Larcker criterion and HTMT ratio < 0.85). Common method bias was assessed using Harman's single-factor test and full collinearity VIF assessment (VIF < 3.3).

The structural model was tested using 5,000 bootstrap resamples. Path coefficients, coefficient of determination (R^2), effect size (f^2), and predictive relevance (Q^2) were examined. The sequential mediation hypothesis was tested using the bootstrap indirect effect approach with 95% bias-corrected confidence intervals. An indirect effect was considered significant if its confidence interval did not include zero.

Results

Descriptive Statistics and Demographic Characteristics

The demographic characteristics of the 385 citizens who used smart sports facilities and completed valid questionnaires are presented in Table 1. Regarding gender, 52.7% (n = 203) were male and 47.3% (n = 182) were female. The age distribution showed that the largest group was 25–34 years (36.4%, n = 140), followed by 18–24 years (28.1%, n = 108), 35–44 years (22.1%, n = 85), and 45 years and above (13.5%, n = 52). The mean age was 31.6 years (SD = 8.2). Regarding educational level, 44.2% (n = 170) held a bachelor's degree, 24.7% (n = 95) had a master's degree or higher, and 31.2% (n = 120) had a diploma or associate degree. In terms of smart facility usage frequency, 29.9% (n = 115) used smart facilities 2–3 times per week, 41.0% (n = 158) used them 4–5 times per week, and 29.1% (n = 112) used them 6 or more times per week. Regarding the primary smart feature used, 38.7% (n = 149) primarily used wearable/app-based tracking, 31.2% (n = 120) used interactive displays/QR-based guidance, and 30.1% (n = 116) used data-driven monitoring systems.

Table 1. Demographic Characteristics of Participants

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	203	52.7
	Female	182	47.3
Age Group	18–24 years	108	28.1
	25–34 years	140	36.4
	35–44 years	85	22.1
	45 years and above	52	13.5
Education	Diploma/Associate	120	31.2
	Bachelor's	170	44.2
	Master's or higher	95	24.7
Smart Facility Use Frequency	2–3 times/week	115	29.9
	4–5 times/week	158	41.0
	6+ times/week	112	29.1
Primary Smart Feature	Wearable/app tracking	149	38.7
	Interactive displays/QR	120	31.2
	Data-driven monitoring	116	30.1

Descriptive Statistics and Correlation Matrix

Means, standard deviations, and Pearson correlations among the study variables are presented in Table 2. Smart sports facility use was positively and significantly correlated with psychological safety ($r = 0.39$, $p < 0.01$), intrinsic motivation ($r = 0.34$, $p < 0.01$), and physical activity ($r = 0.31$, $p < 0.01$). Psychological safety was positively correlated with intrinsic motivation ($r = 0.48$, $p < 0.01$) and physical activity ($r = 0.36$, $p < 0.01$). Intrinsic motivation was also positively correlated with physical activity ($r = 0.44$, $p < 0.01$).

Table 2. Descriptive Statistics and Correlation Matrix

Variable	M	SD	1	2	3	4
1. Smart Sports Facility Use	3.62	0.71	1			
2. Psychological Safety	3.78	0.64	0.39**	1		
3. Intrinsic Motivation	4.86	1.12	0.34**	0.48**	1	
4. Physical Activity (MET-min/week)	2847.6	1243.8	0.31**	0.36**	0.44**	1

** $p < 0.01$

Measurement Model Assessment

The measurement model was evaluated for reliability and validity. As shown in Table 3, all outer loadings exceeded 0.70. Internal consistency was confirmed with Cronbach's alpha ranging from 0.83 to 0.90 and composite reliability (CR) ranging from 0.87 to 0.92. Convergent validity was established with average variance extracted (AVE) values between 0.55 and 0.66, all above the 0.50 threshold. Discriminant validity was confirmed through HTMT ratios below 0.85 and the Fornell-Larcker criterion. Harman's single-factor test

indicated that the first unrotated factor accounted for 31.4% of total variance, below the 40% threshold, suggesting common method bias was not a serious concern.

Table 3. Reliability and Convergent Validity of Study Constructs

Construct	Items	Outer Loadings (Range)	α	CR	AVE
Smart Sports Facility Use	6	0.72–0.85	0.86	0.90	0.60
Psychological Safety	7	0.70–0.84	0.83	0.87	0.55
Intrinsic Motivation	7	0.74–0.88	0.90	0.92	0.66
Physical Activity	7	0.71–0.83	0.84	0.88	0.57

Structural Model Assessment

The structural model was tested using 5,000 bootstrap resamples. The results are presented in Table 4. Smart sports facility use had a significant positive direct effect on psychological safety ($\beta = 0.39$, $t = 7.12$, $p < 0.001$), supporting H1. Smart facility use also had a significant positive direct effect on intrinsic motivation ($\beta = 0.18$, $t = 3.24$, $p = 0.001$). Psychological safety had a significant positive direct effect on intrinsic motivation ($\beta = 0.42$, $t = 7.86$, $p < 0.001$), supporting H2. Intrinsic motivation had a significant positive direct effect on physical activity ($\beta = 0.38$, $t = 6.94$, $p < 0.001$), supporting H3. The direct effect of smart facility use on physical activity was also significant ($\beta = 0.12$, $t = 2.31$, $p = 0.021$).

Table 4. Direct Path Coefficients

Path	β	t	p	Result
Smart Facility Use → Psychological Safety	0.39	7.12	<0.001	H1 supported
Smart Facility Use → Intrinsic Motivation	0.18	3.24	0.001	Significant
Psychological Safety → Intrinsic Motivation	0.42	7.86	<0.001	H2 supported
Intrinsic Motivation → Physical Activity	0.38	6.94	<0.001	H3 supported
Smart Facility Use → Physical Activity	0.12	2.31	0.021	Significant

The model explained 15.2% of variance in psychological safety ($R^2 = 0.152$), 28.7% in intrinsic motivation ($R^2 = 0.287$), and 24.6% in physical activity ($R^2 = 0.246$). Effect sizes (f^2) indicated medium effects for the paths from psychological safety to intrinsic motivation ($f^2 = 0.22$) and intrinsic motivation to physical activity ($f^2 = 0.17$), and small-to-medium effects for smart facility use to psychological safety ($f^2 = 0.13$). Predictive relevance (Q^2) values were all above zero (psychological safety $Q^2 = 0.11$; intrinsic motivation $Q^2 = 0.20$; physical activity $Q^2 = 0.18$).

Table 5. Structural Model Evaluation Indices

Endogenous Construct	R^2	Adjusted R^2	Q^2	Interpretation
Psychological Safety	0.152	0.150	0.11	Small
Intrinsic Motivation	0.287	0.283	0.20	Medium
Physical Activity	0.246	0.242	0.18	Medium

Mediation Analysis

Bootstrap indirect effect analysis was used to test the sequential mediating roles of psychological safety and intrinsic motivation. As shown in Table 6, the indirect effect of smart facility use on physical activity through psychological safety was significant ($\beta = 0.07$, 95% CI [0.03, 0.12]). The indirect effect through intrinsic motivation was also significant ($\beta = 0.07$, 95% CI [0.03, 0.11]). The sequential indirect pathway from smart facility use through psychological safety and then intrinsic motivation to physical activity was significant as well ($\beta = 0.06$, 95% CI [0.03, 0.10]). Since the direct effect of smart facility use on physical activity remained significant ($\beta = 0.12$, $p = 0.021$) after including the mediators, the mediation pattern was partial rather than complete.

Table 6. Indirect Effects and Mediation Results

Indirect Path	β	SE	95% CI	Result
Smart Facility Use → Psychological Safety → Physical Activity	0.07	0.02	[0.03, 0.12]	Significant
Smart Facility Use → Intrinsic Motivation → Physical Activity	0.07	0.02	[0.03, 0.11]	Significant
Smart Facility Use → Psychological Safety → Intrinsic Motivation → Physical Activity	0.06	0.02	[0.03, 0.10]	Significant
Direct Effect (Smart Facility Use → Physical Activity)	0.12	0.05	[0.02, 0.22]	Significant

Discussion

The present study aimed to investigate the impact of smart sports facility use on citizens' physical activity, with psychological safety and intrinsic motivation as sequential mediators. The main finding revealed that smart facility use had a significant positive direct effect on physical activity, and the model explained 24.6% of the variance in physical activity. This finding aligns with emerging evidence on smart exercise environments. Ulukan et al. (2026) found that smart facility/technology interaction was positively associated with physical activity among adults exercising in green and smart sports environments, although the association was relatively small ($\beta = 0.12$, $p < 0.05$), suggesting that technological features may function as contextual facilitators rather than direct determinants of behavioral outcomes. The present study's finding of a direct effect ($\beta = 0.12$) is remarkably consistent with this prior estimate, reinforcing the interpretation that smart facilities operate partly through direct convenience and accessibility mechanisms (Zhang et al., 2025; Huang & Li, 2026).

The mediating role of psychological safety emerged as a significant pathway linking smart facility use to physical activity. This finding extends the application of psychological safety from organizational and team sport contexts to public exercise environments (Li, 2025; Woods et al., 2024). Research on psychological safety in physical activity settings has shown that when individuals feel safe from judgment and negative evaluation, they are more likely to engage actively (Li, 2025; Shafaei et al., 2024). A study examining psychological safety, intrinsic motivation, and physical activity among participants in physical loosening exercises found that psychological safety was positively associated with intrinsic motivation, and that intrinsic motivation mediated the relationship between psychological safety and physical activity (Li, 2025). The present study's finding that smart facility use predicted psychological safety ($\beta = 0.39$) suggests that technology-enhanced environments may reduce evaluative threat by providing individualized, private feedback rather than public comparison, and by creating predictable, controllable exercise conditions (Huang & Li, 2026; Yau & Shen, 2025). This aligns with self-determination theory, which posits that environments supporting autonomy and competence foster more self-determined forms of motivation (Mamun, 2023).

Intrinsic motivation also emerged as a significant mediator, both independently and sequentially with psychological safety. The sequential pathway, facility use → psychological safety → intrinsic motivation → physical activity, was statistically significant, indicating that the motivational benefits of smart facilities are not automatic but depend on the psychological safety that these environments cultivate (Li et al., 2024; Fu & Huang, 2025). This finding resonates with research showing that intrinsic motivation for exercise is enhanced when environments support perceived competence, relatedness, and autonomy, and when activities are experienced as enjoyable (Zhang et al., 2025; He et al., 2026). A systematic review of self-determination theory and physical activity confirmed that competence, intrinsic regulation, and identified regulation are determinants of physical activity across different ages, and recommended that interventions prioritize participants' feelings of competence and autonomous motivation over external pressures or rewards (Mamun, 2023). The present study extends this recommendation by identifying psychological safety as an environmental antecedent that may facilitate the satisfaction of these basic psychological needs in smart exercise settings (Li, 2025; Huang & Li, 2026).

The finding that smart facility use retained a significant direct effect on physical activity even after including mediators indicates partial mediation. This suggests that while psychological mechanisms are important, additional pathways such as instrumental convenience, accessibility, or habit formation may also operate (King et al., 2002; Hosseinpour & Terlutter, 2019). Research on physical activity maintenance has emphasized that environmental factors can influence behavior through both deliberative psychological processes and more automatic, context-dependent processes (Fathi et al., 2020; Qin & Chiang, 2026). The partial mediation pattern observed here is consistent with the multi-determined nature of exercise behavior and suggests that interventions targeting only psychological variables may be insufficient without corresponding improvements in the facility environment itself (Zhang et al., 2025; He et al., 2026).

From a theoretical perspective, this study contributes by integrating psychological safety into the self-determination theory framework within the context of smart exercise environments. While self-determination theory has been extensively applied to exercise motivation (Mamun, 2023), the role of psychological safety as a precondition for need satisfaction has received less attention (Li, 2025; Soares & Lopes, 2020). The finding that psychological safety predicted intrinsic motivation ($\beta = 0.42$) is consistent with research in physical activity contexts showing that psychological safety was positively associated with intrinsic motivation and that intrinsic motivation mediated the relationship between psychological safety and physical activity (Li, 2025; Shafaei et al., 2024). This convergence across contexts suggests that psychological safety may function as a foundational condition that enables individuals to experience exercise as autonomously chosen and enjoyable, rather than as externally pressured or evaluatively threatening (Woods et al., 2024; Aboramadan et al., 2020; Zada et al., 2022).

From a practical standpoint, the findings offer clear implications for the design and management of smart sports facilities. First, investments in smart technologies should be accompanied by attention to the

psychological climate these technologies create (Zhang et al., 2025; Huang & Li, 2026). Features that provide private, individualized feedback, allow users to control the intensity and visibility of their performance data, and minimize public comparison may enhance psychological safety and, through it, intrinsic motivation (Yau & Shen, 2025; Li, 2025). Second, the strong effect of psychological safety on intrinsic motivation suggests that facility managers should prioritize creating non-judgmental, inclusive environments where users feel free to exercise without fear of embarrassment (Shafaei et al., 2024; Soares & Lopes, 2020). This may involve staff training, signage, and technology design choices that emphasize personal progress over social comparison (Woods et al., 2024; Aboramadan et al., 2020). Third, the partial mediation pattern indicates that while psychological mechanisms are important, instrumental factors such as accessibility, cost, and equipment quality remain relevant and should not be neglected (King et al., 2002; Fathi et al., 2020; Liu et al., 2025).

Limitations and Future Research

Several limitations should be acknowledged. First, the cross-sectional design limits definitive causal inferences. Although the theoretical model specifies directional relationships from smart facility use through psychological safety and intrinsic motivation to physical activity, the temporal ordering cannot be established with certainty (Li et al., 2024; Coimbra et al., 2021). Longitudinal or intervention designs would provide stronger evidence for causality (Huang & Li, 2026; Zhang et al., 2025). Second, reliance on self-reported physical activity (IPAQ-SF) may introduce recall bias and overestimation, although the IPAQ-SF has demonstrated acceptable validity across diverse populations. Future research could incorporate device-based measures such as accelerometry or smart facility usage logs (Hosseinpour & Terlutter, 2019; Fasola & Mataric, 2012). Third, the convenience sampling method and focus on Iranian citizens limit generalizability to other cultural and institutional contexts (Dana et al., 2011; Shafaei et al., 2024). Fourth, smart facility use was measured as a composite construct; future research could examine which specific features (e.g., wearable tracking, interactive displays, data-driven monitoring) are most strongly associated with psychological safety and intrinsic motivation (Zhang et al., 2025; Yau & Shen, 2025). Fifth, additional mediators and moderators such as social support within facilities, exercise identity, and habit strength should be examined to provide a more complete understanding of the mechanisms linking smart facility use to physical activity (Li et al., 2024; Fu & Huang, 2025; Coimbra et al., 2021).

Conclusion

This study provides empirical evidence that smart sports facility use is a significant predictor of citizens' physical activity, operating both directly and through the sequential mediating mechanisms of psychological safety and intrinsic motivation. The findings extend self-determination theory by identifying psychological safety as an environmental condition that enables intrinsic motivation to flourish in technology-enhanced exercise contexts. From a practical perspective, the results suggest that investments in smart facility technologies should be complemented by attention to the psychological climate these technologies create. Facility managers and urban planners should prioritize features that reduce evaluative threat, support users' sense of control, and foster enjoyable exercise experiences. Future research employing longitudinal designs and examining additional mechanisms will further illuminate how smart exercise environments can be leveraged to promote sustainable active living.

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