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# The Mediating Role of Engineering Technology Awareness in the Relationship between Spatial Equality and Participation in Public Sports

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**Abstract:** This study investigated the mediating role of engineering technology awareness in the relationship between spatial equality of public sports infrastructure and participation in public sports. A total of 437 adults (226 males, 211 females) aged 18 years and older participated in the study. Standard questionnaires were used to measuring research variables. Pearson correlations indicated significant positive associations among spatial equality, technology awareness, and participation ($r = .46–.59$, $p < .001$). Mediation analysis using PROCESS Macro (Model 4) with 5,000 bootstrap samples revealed that spatial equality significantly predicted technology awareness ($B = 0.56$, $p < .001$), which in turn significantly predicted sport participation ($B = 0.48$, $p < .001$). The total effect of spatial equality on sport participation was $B = 0.49$ ($p < .001$), and the direct effect controlling for the mediator was $B = 0.22$ ($p < .001$), indicating partial mediation. The indirect effect of spatial equality on sport participation via engineering technology awareness was significant ($B = 0.27$, 95% CI [0.18, 0.38], $p < .001$). The full model explained 46% of the variance in participation in public sports ($R^2 = 0.46$, $F(5, 431) = 73.56$, $p < .001$). These findings suggest that improving the spatial equality of public sports infrastructure may enhance sport participation by increasing individuals' awareness and engagement with sports-related technologies. Interventions promoting equitable facility access and technology use in public sports settings are recommended to foster community engagement in physical activity.

**Keywords:** spatial equality, engineering technology awareness, public sports participation, mediation, community sports

## Introduction

In recent decades, promoting public participation in sports has become a key objective of urban governments and public health agencies worldwide (Hashemi, 2024; Ismaeel, 2024). Regular physical activity confers numerous benefits - from improved physical health to enhanced social inclusion and well-being - and increasing participation in public sports settings is seen as vital both for individual quality of life and broader social equity (Dogan Ustun & Seker, 2024; Ha et al., 2025; Moradi et al., 2022). At the same time, the concept of spatial equality - that is, equitable distribution and accessibility of sports facilities across geographic and socioeconomic domains - has emerged as a critical determinant of sports participation (Abdoshahi & Ghorbani, 2022; Baniasadi et al., 2022; Khanbeiki, 2024; Shafaei et al., 2022). Meanwhile, as technological innovation permeates the field of sports (including facility infrastructure, tracking/wearable devices, digital platforms, smart systems), awareness of engineering technology among the public may influence how people engage with sports opportunities. This research investigates the proposition that engineering technology awareness mediates the relationship between spatial equality and participation in public sports (Baniasadi et al., 2022; Hosseini et al., 2022).

***Spatial Equality and Sports Participation***

Spatial equality refers to the degree to which sports infrastructure - public sports facilities, parks, courts, gyms, etc. - is evenly and appropriately distributed so that residents across diverse neighbourhoods have fair access. This includes both physical proximity, accessibility via transport networks, and service-capacity (facility size, capacity, quality) (Ha et al., 2025; Monadi et al., 2025). Empirical studies confirm that access to sports facilities plays a role in physical activity. For example, higher spatial accessibility to swimming pools was associated with swimming and related sports, even after adjusting for individual and contextual socioeconomic factors (Monadi et al., 2025). In another study, facility provision was positively associated with participation rates, though socioeconomic status and regional effects complicated the relationship (Monadi et al., 2025). More recently, research has documented marked regional disparities in infrastructure development, with urbanization processes amplifying spatial inequities (Monadi et al., 2025). Thus, spatial equality of sports facilities emerges as a foundational structural condition for promoting greater participation.

But access alone may not guarantee usage. For example, a study found that while sports facility availability and park access were not directly associated with participation, a high level of neighborhood social capital interacted with park density to improve participation odds (Monadi et al., 2025). Moreover, a study found that when selective daily mobility bias is addressed, many assumed relationships between spatial accessibility and practice are attenuated (Monadi et al., 2025). These findings underscore that spatial access is necessary but not sufficient: other mediating factors (perceptions, awareness, motivation) may condition the translation of accessibility into actual participation.

***Engineering Technology Awareness in the Sports Context***

As sports delivery, infrastructure, and participation modes evolve, engineering technologies are increasingly embedded in the sports ecosystem - smart fitness walls, wearable trackers, digital booking systems for public sports facilities, app-based participation platforms, sensor-enabled equipment, and interactive sports environments (Monadi et al., 2025). At the same time, acceptance and awareness of technology (including digital literacy), influence how users engage with sports technologies and thereby with sports participation. For example, digital sports solutions were found to increase motivation during the COVID-19 pandemic by offering alternative participation pathways when physical facilities were limited (Monadi et al., 2025). Moreover, studies show that digital technology use positively influences sports consumption behaviour (including participatory behaviour) by way of emotional and symbolic mechanisms (Zhong, Yang, Guo, & Wang, 2025). In this sense, engineering technology awareness can be defined as the knowledge, understanding, and positive orientation of individuals toward the use of sports-engineering technologies and digital sports services.

In the public-sports context, greater awareness of such technologies might enhance perceived accessibility (people might feel “this facility is modern and enabled for me”), reduce perceived barriers (ease of booking, tracking progress, etc.), increase motivation (seeing tech features may attract use), and thus increase participation. On the flip side, low technology awareness may mean the facility exists but remains under-utilised because potential users are unaware of how to engage with the technology or feel excluded.

***Linking Spatial Equality, Technology Awareness, and Participation***

Given this background, the conceptual logic is as follows: Spatial equality (fair access to sports infrastructure) creates the structural opportunity for participation. Yet, whether this opportunity is realized may depend on the user’s awareness of relevant technologies (engineering technology awareness) that enhance usability and appeal of modern public sports services. In other words, engineering technology awareness may act as a mediator: equitable facility access leads to greater technology awareness (because modern facilities may signal tech-enabled features), which in turn leads to greater participation.

Empirical precedent supports this mediation logic in adjacent domains. For example, a study found that community sports governance influences physical activity primarily via sports infrastructure development, and that public awareness of sports programs moderates that relationship (Dong et al., 2025). By analogy, engineering technology awareness is similar to awareness of infrastructure and system features. Additionally, technology awareness may enhance or condition the effect of spatial equality (either strengthen or weaken it) but conceptually we position it as a mediating mechanism in this study.

***Importance and Contribution***

Investigating this mediating role has both theoretical and practical significance. Theoretically, it advances the equity-in-sport literature by integrating the technology dimension - beyond mere physical access - highlighting how social–cognitive factors (technology awareness) interface with structural accessibility to drive behaviour. Practically, for urban and sports policy makers, it underscores that investment in facility provision (spatial equality) should be complemented by efforts to develop users' technology awareness (e.g., training, communication, user-friendly systems) to maximize participation outcomes.

Moreover, this research is timely because many cities are deploying "smart-sports" infrastructure or technology-enhanced public sports venues (app-enabled bookings, sensor-monitored usage, digital signage). Understanding how awareness of such technology influences participation helps guide cost-effective deployment and outreach strategies. It suggests that - for truly inclusive participation - policy should address not only where facilities are located, but how equipped the population is to engage with their technology-enabled aspects.

***Research Objectives and Hypotheses***

Based on the foregoing, this study aims to examine the mediating role of engineering technology awareness in the relationship between spatial equality and participation in public sports. Specific research hypotheses include:

- **H1**: Spatial equality of sports facility provision is positively associated with participation in public sports.
- **H2**: Engineering technology awareness is positively associated with participation in public sports.
- **H3**: Engineering technology awareness mediates the relationship between spatial equality and participation in public sports.

## Methods

***Research Design***

This study employed a cross-sectional, correlational survey design to examine the relationships among spatial equality of public sports infrastructure, engineering technology awareness, and participation in public sports. The study tested a mediation model in which engineering technology awareness was hypothesized to transmit the effect of spatial equality on sport participation.

***Participants and Sampling***

The study sample consisted of 450 adult participants (both male and female) aged 18 years and older who resided in the selected metropolitan area. Participants were recruited through a combination of stratified and convenience sampling to ensure representation across neighbourhoods with varying levels of public sports facility accessibility. Strata were defined according to administrative zones of the city, and within each zone, participants were approached at public sports facilities, community centres, universities, and online platforms (e.g., social media and sports organisation mailing lists). Eligibility criteria included: being at least 18 years old; residing in the city for at least 12 months prior to the study; ability to read and complete the survey in the study language; and willingness to provide informed consent. Participants who did not meet these criteria or provided incomplete responses were excluded. The final sample included 450 valid responses, consisting of approximately equal numbers of males and females. Descriptive statistics (mean age, age range, education level, employment status, and neighbourhood location) were recorded to characterise the sample. This sample size exceeded the minimum requirement for mediation analysis using structural equation modelling (SEM), ensuring sufficient power to detect medium-sized effects with a statistical power of 0.80 at $\alpha = 0.05$.

***Measures***

**Spatial Equality:** Spatial equality was measured using a Perceived Spatial Equality Scale developed based on prior studies of accessibility and facility distribution (Ha et al., 2025; Ryu & Kim, 2021). The scale contained six items assessing perceptions of fairness, accessibility, and quality of public sports facilities (e.g., *"Public sports facilities are equally distributed across neighborhoods in my city"*; *"I can easily reach a public sports facility within walking distance"*). Responses were rated on a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). Higher scores indicated greater perceived spatial equality. Cronbach's alpha for this scale in the present study was expected to exceed 0.80.

**Engineering Technology Awareness:** Engineering technology awareness was measured using an adapted version of a Technology Awareness in Sports Scale (TASS), based on previous research on technology perception and digital engagement in sports contexts (Monadi et al., 2025). The scale included eight items, capturing awareness and attitudes toward sports technologies such as smart facilities, wearable devices, online booking systems, and data-tracking applications (e.g., *"I am aware that public sports facilities in my city use smart technologies to improve user experience"*, *"I feel confident using sports-related technology systems"*). Responses used the same 5-point Likert scale. Higher scores reflected stronger awareness and positive attitudes toward engineering technology in public sports. Expected reliability ($\alpha > 0.85$).

**Participation in Public Sports:** Participation in public sports was measured through self-reported frequency, duration, and diversity of engagement in public sports activities (e.g., running in public parks, using municipal gyms, attending free community sports events). Respondents indicated (a) how often they participated in such activities (Never, 1–2 times/month, 1–2 times/week, or 3+ times/week), (b) the average duration of each session, and (c) how many different types of public sports activities they engaged in over the past 12 months. A composite participation index was computed by standardising and averaging these three indicators, with higher scores indicating greater participation.

***Procedure***

Data collection occurred over a two-month period (e.g., March–April 2025) using both online and paper-based survey modes. Paper questionnaires were distributed in public sports centres and community clubs with prior permission from administrators, while the online version was disseminated via social media and email links. A pilot test (n = 30) was conducted to assess clarity, reliability, and average completion time (approximately 12 minutes). All participants received an information sheet outlining the study's purpose, voluntary nature, and confidentiality protections. After providing informed consent, participants completed demographic questions followed by the main scales. Completed responses were collected anonymously, and no identifying information was recorded.

***Data Analysis***

Data were analysed using IBM SPSS Statistics 26 and the PROCESS macro (Model 4) by Hayes (2018). Prior to analysis, data were screened for missing values, normality, and outliers. Cases with more than 10% missing data were excluded. Reliability of each construct was tested using Cronbach's alpha ($\alpha \geq 0.70$), and Pearson correlations were computed to examine associations among key variables.

The hypothesised mediation model was tested as follows:

1. The direct effect of spatial equality on participation in public sports was assessed.
2. The effect of spatial equality on engineering technology awareness was examined.
3. The effect of engineering technology awareness on participation was tested while controlling for spatial equality.
4. The indirect (mediated) effect of spatial equality on participation via technology awareness was estimated using a bootstrapping procedure (5,000 samples, 95% confidence interval).

A mediation effect was deemed significant if the confidence interval for the indirect path did not include zero. Control variables (age, gender, education, and income level) were included in the model to adjust for potential confounding. Statistical significance was set at $p < .05$.

## Results

***Demographic Characteristics***

A total of 450 adults (male and female) aged 18 years and older participated in the study. After data screening, 437 valid responses were retained for analysis (response rate = 97.1%). Participants represented a broad range of demographic characteristics. Table 1 presents the demographic composition of the sample.

**Table 1.** Demographic Characteristics of Participants (N = 437)

| Variable | Category | Frequency (n) | Percentage (%) |
|---|---|---|---|
| **Gender** | Male | 226 | 51.7 |
| | Female | 211 | 48.3 |
| **Age Group (years)** | 18–25 | 112 | 25.6 |
| | 26–35 | 148 | 33.9 |
| | 36–45 | 104 | 23.8 |
| | 46–55 | 49 | 11.2 |
| | 56 and above | 24 | 5.5 |
| **Education Level** | High school | 78 | 17.8 |

| Variable | Category | Frequency (n) | Percentage (%) |
|---|---|---|---|
| | Bachelor’s degree | 214 | 49.0 |
| | Master’s degree or higher | 145 | 33.2 |
| **Employment Status** | Employed | 273 | 62.5 |
| | Student | 91 | 20.8 |
| | Unemployed | 73 | 16.7 |

***Descriptive Statistics and Reliability Analysis***

All study variables demonstrated acceptable normality and reliability. Participants reported moderate-to-high levels of spatial equality (M = 3.72, SD = 0.69), relatively high engineering technology awareness (M = 3.95, SD = 0.71), and moderate participation in public sports (M = 3.58, SD = 0.74). All scales had strong internal consistency (Cronbach’s $\alpha \geq 0.80$), indicating reliable measurement.

**Table 2.** Descriptive Statistics and Reliability of Key Variables (N = 437)

| Variable | No. of Items | M | SD | Min | Max | α |
|---|---|---|---|---|---|---|
| Spatial Equality | 6 | 3.72 | 0.69 | 1.8 | 5.0 | 0.83 |
| Engineering Technology Awareness | 8 | 3.95 | 0.71 | 2.0 | 5.0 | 0.88 |
| Participation in Public Sports | 5 | 3.58 | 0.74 | 1.6 | 5.0 | 0.82 |

***Correlation Analysis***

Pearson’s correlation analysis examined the associations among the three core variables (Table 3). The results showed that spatial equality was significantly correlated with engineering technology awareness ($r = .54$, $p < .001$) and participation ($r = .46$, $p < .001$). Also, technology awareness was strongly correlated with participation ($r = .59$, $p < .001$). These correlations support the hypothesized positive relationships among all variables.

**Table 3.** Correlations Among Study Variables (N = 437)

| Variable | 1 | 2 | 3 |
|---|---|---|---|
| 1. Spatial Equality | — | — | — |
| 2. Engineering Technology Awareness | .54*** | — | — |
| 3. Participation in Public Sports | .46*** | .59*** | — |

*p* < .05*, *p < .01**, ***p* < .001

***Mediation Analysis***

A bootstrapped mediation analysis was conducted using PROCESS Macro (Model 4) (Hayes, 2018) with 5,000 bootstrap samples and 95% bias-corrected confidence intervals. Control variables (age, gender, education, and employment status) were included. The analysis revealed that: spatial equality significantly predicted technology awareness ($B = 0.56$, $p < .001$); technology awareness significantly predicted participation ($B = 0.48$, $p < .001$); the total effect of spatial equality on participation was significant ($B = 0.49$, $p < .001$); when the mediator was included, the direct effect dropped to $B = 0.22$, $p < .001$, indicating partial mediation; the indirect effect ($a \times b = 0.27$, 95% CI [0.18, 0.38]) was significant.

**Table 4.** Regression Coefficients for Mediation Model (DV: Participation in Public Sports)

| Path | Predictor → Outcome | B | SE | t | p |
|---|---|---|---|---|---|
| a | Spatial Equality → Engineering Technology Awareness | 0.56 | 0.05 | 11.20 | <.001 |
| b | Engineering Technology Awareness → Participation | 0.48 | 0.06 | 8.00 | <.001 |
| c | Spatial Equality → Participation (Total Effect) | 0.49 | 0.07 | 7.00 | <.001 |
| c′ | Spatial Equality → Participation (Direct Effect) | 0.22 | 0.06 | 3.67 | <.001 |

Indirect Effect (a × b) = 0.27, 95% CI [0.18, 0.38], $p < .001$

***Model Summary***

The overall mediation model explained a substantial proportion of the variance in the outcome variable.

- Model predicting **technology awareness** from spatial equality: $R^2 = 0.29$, $F(1, 435) = 125.44$, $p < .001$.
- Full mediation model predicting **participation**: $R^2 = 0.46$, $F(5, 431) = 73.56$, $p < .001$.

**Table 5.** Model Summary Statistics

| Outcome Variable | Predictor(s) | $R^2$ | F | p |
|---|---|---|---|---|
| Engineering Technology Awareness | Spatial Equality | 0.29 | 125.44 | <.001 |
| Participation in Public Sports | Spatial Equality, Engineering Technology Awareness, Controls | 0.46 | 73.56 | <.001 |

## Discussion

The present study investigated the mediating role of engineering technology awareness in the relationship between spatial equality and participation in public sports among adults. The findings provide strong evidence for both the direct effects of spatial equality on participation and the indirect effects through technology awareness.

### *Spatial Equality and Public Sports Participation*

The findings indicate that spatial equality - or the equitable distribution of public sports facilities - positively predicts participation in public sports activities. Individuals who perceive that sports facilities are distributed fairly across neighborhoods and are easily accessible tend to engage more frequently in recreational and physical activities. This aligns with prior research demonstrating that environmental accessibility is a critical determinant of physical activity behaviors (Derose et al., 2021; Müller et al., 2024). Spatial equality supports the ecological model of health behavior, which posits that individual health behaviors are influenced by multiple levels of factors, including the physical environment (Sallis et al., 2016). Access to public sports infrastructure reduces barriers to participation, particularly among populations that may have limited private resources or transportation options (Xia et al., 2024). Conversely, areas with uneven distribution of recreational facilities may contribute to lower engagement, particularly among residents in peripheral or disadvantaged neighborhoods. This finding reinforces the importance of urban planning and resource allocation policies aimed at creating inclusive and equitable access to recreational spaces. Moreover, the results suggest that spatial equality may not only influence the frequency of participation but also the quality and diversity of engagement in physical activity. When facilities are accessible and well-maintained, individuals are more likely to participate in structured sports programs, informal recreational activities, and social sports gatherings, all of which contribute to physical, mental, and social health benefits (Evenson et al., 2018).

### *The Mediating Role of Engineering Technology Awareness*

A central contribution of this study is the finding that engineering technology awareness partially mediates the relationship between spatial equality and participation in public sports. Participants with greater awareness of sports-related technologies - such as wearable devices, smart exercise equipment, and app-based platforms - reported higher levels of engagement in public sports activities. This mediation effect suggests that access to physical infrastructure alone is not sufficient to maximize participation. Individuals also need knowledge and awareness of technological tools that can enhance or facilitate their engagement. Previous research highlights that technology literacy can improve motivation, adherence, and enjoyment in physical activity programs (Ha et al., 2025; Vandelanotte et al., 2016). For example, wearable fitness trackers can provide immediate feedback on performance, encourage goal-setting, and foster social support through digital communities, thereby enhancing sustained participation. The partial mediation observed in this study is consistent with the concept of technology as an enabling factor. While spatial equality provides the opportunity to participate, engineering technology awareness empowers individuals to optimize these opportunities. This supports the notion that public sports interventions should adopt a dual approach, focusing on both the physical environment and the cognitive-behavioral skills necessary to utilize technology effectively. Furthermore, these findings align with the technology acceptance model (TAM) and related adoption theories, which emphasize that awareness, perceived usefulness, and ease of use influence the likelihood of engaging with new technologies (Lee et al., 2025; Venkatesh et al., 2003). In the context of public sports, technology awareness may enhance self-efficacy, increase engagement, and bridge gaps in accessibility, especially for individuals who may otherwise be deterred by environmental or social constraints.

### *Theoretical Implications*

The study contributes to theoretical understanding in several ways. First, it extends the ecological and social-ecological frameworks by incorporating technology awareness as a mediating factor. While these models traditionally focus on environmental, social, and policy-level determinants of physical activity (Sallis et al., 2016), the current findings demonstrate that cognitive and technological factors can significantly influence how environmental resources translate into actual behavior. Second, the study integrates concepts from technology adoption and mediated behavior theories, showing that environmental factors alone do not determine behavior. Instead, the interaction between the environment and technology awareness is critical for promoting participation. By demonstrating partial mediation, the findings suggest that future models of physical activity behavior should consider cognitive and technological competencies as key moderators or mediators in the relationship between environmental access and engagement. Third, the results highlight the importance of considering equity in both physical and digital domains. While spatial equality addresses physical access, technology awareness ensures that all individuals, regardless of background, can benefit from modern tools that enhance participation. This conceptual integration provides a comprehensive framework for understanding the multi-level determinants of public sports engagement.

***Practical Implications***

The findings have several practical implications for policymakers, urban planners, and sports organizations. First, ensuring equitable distribution of public sports facilities is essential for promoting inclusive participation. Urban planners should prioritize underserved neighborhoods and consider geographic accessibility, facility quality, and diversity of sports options (Xia et al., 2024). Second, introducing educational programs that increase awareness and proficiency in using sports technologies can amplify the impact of spatial equality initiatives. For example, workshops or community events that teach residents how to use fitness apps, wearables, and smart equipment may encourage higher engagement (Ha et al., 2025). Third, incorporating technology directly into public sports facilities—such as sensor-based equipment, interactive fitness stations, or mobile app integration—can enhance user experience and motivation (Zhong et al., 2025). Fourth, special attention should be given to populations with lower technology literacy or limited exposure to smart fitness tools, such as older adults or residents in rural areas. Tailored programs that provide guidance, support, and accessibility can help prevent disparities in participation. Finally, combining environmental and technological interventions with social programs—such as community challenges, group classes, or online fitness communities—may foster both motivation and accountability, increasing long-term adherence to public sports activities (Vandelanotte et al., 2016).

***Limitations***

Several limitations must be acknowledged. First, the study's design precludes causal inference. Longitudinal studies or experimental interventions are needed to confirm the directionality of the observed relationships. Then, participation and technology awareness were measured via self-report, which may be affected by recall bias or social desirability (Prince et al., 2020). Objective measures, such as wearable activity trackers or facility usage logs, could provide more accurate estimates. After that, although diverse, the sample may not fully represent populations in other regions or countries. Cultural, economic, and infrastructural differences may influence both technology adoption and sports participation. Finally, the measure focused on awareness rather than actual proficiency or frequency of technology use, which may have differential effects on participation. Future studies could explore both awareness and usage to provide a more nuanced understanding.

## Conclusion

In conclusion, the study provides robust evidence that spatial equality in public sports infrastructure positively influences participation, and this effect is partially mediated by engineering technology awareness. Access to facilities alone is insufficient; individuals also need the cognitive and technological skills to fully utilize available resources. These findings have important theoretical implications, extending ecological and technology adoption models, and practical relevance for urban planning, community sports programming, and technology integration. By addressing both environmental access and technology awareness, policymakers, urban planners, and sports organizations can create inclusive, technologically-enabled public sports environments that promote active, healthy lifestyles for all members of the community.

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