Sustainable Physical Activity Programs: Their Effectiveness in Reducing Carbon Footprints in Higher Education Institutions

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ABSTRACT:

Introduction: Universities play a critical role in advancing sustainability, with eco-friendly sports emerging as a key initiative to promote physical and mental well-being while reducing environmental impact. However, student participation remains moderate due to infrastructure limitations, accessibility challenges, and institutional barriers.

Objectives: This study aims to investigate the relationship between student perception, participation, and sustainability outcomes in university-led eco-friendly sports programs.

Methods: Using a quantitative research design, data were collected from 300 university students via structured surveys and analysed using descriptive, correlation, regression analyses, and Life Cycle Assessment (LCA).

Results: Results indicate a moderate perception of eco-friendly sports (M = 3.08, SD = 0.89) and participation levels (M = 3.12, SD = 1.03). A strong positive correlation (r = 0.68) between participation and carbon footprint reduction suggests that students actively engaging in eco-friendly sports contribute significantly to emission reductions. Regression analysis confirms that participation is the strongest predictor of carbon footprint reduction ($\beta = 0.78$, $R^2 = 0.72$), emphasizing the need for behavioral interventions beyond awareness campaigns. LCA findings reveal that eco-friendly sports reduce emissions by an average of 6.64 kg CO_2 per participant, validating their role in sustainability efforts.

Conclusions: The study highlights the need for universities to enhance infrastructure, implement behavioral incentives, and integrate sustainability into academic and extracurricular activities. Future research should explore long-term behavioral trends and institutional strategies to sustain participation. By fostering a culture of eco-friendly sports, universities can reduce carbon footprints, improve student health, and support Sustainable Development Goals (SDGs) 3 and 13.

1. Introduction

Universities are pivotal in advancing sustainability, with eco-friendly sports serving as a key initiative to promote physical and mental well-being while minimizing environmental impact. Activities such as walking, cycling, and green recreational programs support both student well-being and environmental conservation, aligning with Sustainable Development Goals (SDGs), particularly SDG 3 (Good Health, Well-being, and Disease Prevention) and SDG 13 (Climate Action) (Weber et al., 2023). Despite increasing awareness, student participation in eco-friendly sports remains moderate, constrained by infrastructure limitations, accessibility issues, health-related barriers, and institutional challenges (Ordiñana-Bellver et al., 2024). While students acknowledge the benefits, awareness alone

is insufficient—effective structural and policy interventions are required to ensure sustained engagement (Schmidt, 2006).

One of the most significant benefits of eco-friendly sports is their potential to reduce carbon footprints while simultaneously addressing lifestyle-related health issues. Sustainable physical activities, including active transportation (cycling and walking) and energy-efficient sports facilities, contribute to lowering greenhouse gas emissions and reducing sedentary behavior-related risks such as obesity, cardiovascular diseases, and mental health disorders. However, the quantifiable impact of university-led eco-friendly sports programs on both environmental and health outcomes remains underexplored (Weber et al., 2023). This study seeks to bridge the gap between awareness and actual participation in eco-friendly sports. While previous research has examined environmental consciousness among students, few studies have directly linked perception, participation, health benefits, and sustainability outcomes within university sports programs. By providing empirical data, this research offers practical insights for policymakers, campus administrators, and sports educators to enhance sustainable sports engagement.

Furthermore, by evaluating the role of eco-friendly sports in reducing carbon emissions, this study highlights universities' contributions to climate change mitigation while addressing critical health concerns such as stress, anxiety, and chronic diseases. As environmental sustainability becomes a global priority, understanding how sports and physical activity contribute to both physiological and psychological well-being is more relevant than ever. Student participation in eco-friendly sports is shaped by behavioral attitudes, motivation, and institutional support. The Theory of Planned Behavior (TPB) (Ajzen, 1991) explains that students' engagement depends on attitudes (perceived benefits), social norms (peer and institutional influence), and perceived behavioral control (ease of participation). Those with positive views of sustainability, strong peer encouragement, and minimal barriers are more likely to take part.

Similarly, the Self-Determination Theory (SDT) (Deci & Ryan, 1985) highlights intrinsic motivation (health improvements, stress reduction, and environmental concern) and extrinsic incentives (institutional support, rewards, and facilities). Research indicates that universities with strong sustainability policies and well-developed sports infrastructure report higher student engagement in eco-friendly activities (Osipov et al., 2019). The Value-Belief-Norm (VBN) Theory (Stern, 2000) suggests that students with strong environmental values are more likely to engage in sustainable activities. Moreover, those with heightened health awareness are more inclined to participate in physical activities that offer both fitness and ecological benefits. Educational programs and sustainability awareness campaigns further strengthen students' environmental responsibility, fostering long-term participation in eco-friendly sports.

Universities can increase student participation by improving infrastructure, implementing supportive policies, and promoting awareness programs. Institutions that invest in bicycle lanes, green sports fields, and pedestrian-friendly pathways see higher engagement in sustainable sports (Osipov et al., 2019). Additionally, structured cycling and walking programs significantly boost student involvement (Mikiki et al., 2021). Beyond infrastructure, education plays a critical role. Universities that embed sustainability-focused curricula and awareness campaigns cultivate long-term engagement in eco-friendly sports (Sundar & Ramalingam, 2024). Moreover, integrating health literacy into sustainability initiatives can further motivate students by emphasizing the role of eco-friendly sports in reducing lifestyle diseases, mental health issues, and overall healthcare costs. When sustainability is integrated into academic and extracurricular activities, students develop stronger pro-environmental behaviors, leading to greater participation in sustainable sports.

Shifting to low-emission physical activities such as walking, cycling, and outdoor recreation can significantly lower a university's carbon footprint while simultaneously improving students' overall physical and mental health. Life Cycle Assessment (LCA) studies confirm that active mobility leads to substantial reductions in transportation-related carbon emissions (Weber et al., 2023).

Regression analysis further reveals a strong correlation between sustainability awareness and CO_2 reduction (Schmidt, 2006). This suggests that students who are more aware of environmental benefits are more likely to engage in eco-friendly sports, reinforcing the importance of awareness initiatives to promote sustainability-conscious decision-making while combating physical inactivity-related health problems. By leveraging scientific data and behavioral insights, universities can design effective sustainability programs that maximize carbon footprint reduction while simultaneously enhancing student health and well-being through eco-friendly sports initiatives.

Despite its benefits, various barriers limit student engagement in eco-friendly sports. Lack of infrastructure, time constraints, and limited awareness of sustainability programs remain major challenges (Ling et al., 2024). Additionally, health concerns such as fatigue, pre-existing conditions, and lack of fitness discourage participation among some students. Many students remain unaware of campus initiatives that promote green sports participation, further reducing engagement. However, several key enablers can improve participation. Incentive-based programs, including discounts, recognition schemes, and participation rewards, have successfully motivated students to adopt sustainable sports behaviors (Pappas, 2013). Furthermore, investment in eco-friendly sports facilities, such as cycling tracks and sustainable fitness centers, enhances accessibility and student involvement (Ordiñana-Bellver et al., 2024).

Awareness campaigns also play a critical role. Hyndman (2016) found that students who recognize the dual benefits of health and disease prevention alongside sustainability are more likely to engage in and sustain eco-friendly sports participation. By addressing both environmental and health challenges, universities can create a holistic approach to fostering sustainable sports behaviors among students. This study, therefore, seeks to investigate the relationship between perception, participation, and environmental sustainability in university eco-friendly sports programs while emphasizing their role in promoting long-term health and preventing chronic illnesses among students.

2. Objectives

The objectives of this study are to:

a. Examine university students' perceptions of eco-friendly sports and analyse how these perceptions influence their participation.
b. Evaluate the contribution of sustainable sports activities to carbon emission reduction in university settings.
c. Identify key institutional barriers and enablers that impact student participation in eco-friendly sports.
d. Investigate the relationship between perception, engagement, and sustainability outcomes in eco-friendly sports participation.

3. Methods

The methodology outlines the research procedures employed in this study, including the research design, sample selection, data collection, and analysis methods. A transparent and systematic approach ensures the reliability and replicability of results while providing a solid foundation for interpreting and generalizing the findings. This study adopts a quantitative research design, integrating descriptive, correlation, and regression analyses alongside Life Cycle Assessment (LCA) to examine the relationship between eco-friendly sports participation and sustainability outcomes in higher education institutions (HEIs).

The research primarily investigates students' perceptions, participation levels, and the extent to which engagement in sustainable sports contributes to carbon footprint reduction. By combining traditional statistical techniques with environmental assessment tools, this study provides an in-depth evaluation of the effectiveness of eco-friendly sports initiatives in promoting sustainability and reducing emissions. To ensure a representative and reliable dataset, stratified random sampling was

employed, considering faculty affiliation, gender, and frequency of participation in eco-friendly sports. This method minimizes selection bias while improving the generalizability of findings.

a. Target Population: The study focuses on undergraduate and postgraduate students from a selected higher education institution with a strong emphasis on sustainability-driven campus practices.
b. Sample Size: A total of 300 students were surveyed, ensuring statistical power for meaningful comparisons and inferences.
c. Sampling Technique: The stratified random sampling approach categorizes students based on academic faculty, gender distribution, and levels of engagement in sustainable sports. This enhances the validity of the study by ensuring proportionate representation across different subgroups within the student population.

To comprehensively assess students' engagement in eco-friendly sports, perceptions of sustainability, and institutional support, the study employs a structured quantitative survey and Life Cycle Assessment (LCA). These methods allow for a robust analysis of how sustainable sports participation influences carbon footprint reduction and other environmental outcomes.

3.1 **Quantitative Survey on Perceptions and Participation**

A structured questionnaire was developed to collect data on students' participation in eco-friendly sports and their perceptions of sustainability-related physical activities. The questionnaire consists of five sections:

a. Demographic Information: Captures data on age, gender, faculty, year of study, and residential status (on-campus vs. off-campus). These factors help contextualize participation trends and ensure diverse representation.
b. Participation in Eco-Friendly Physical Activities: Examines the frequency, duration, and types of activities students engage in, such as cycling, walking, jogging, and outdoor workouts. This section assesses how students integrate sustainable physical activities into their daily routines.
c. Perceptions of Environmental Sustainability: Evaluates students' awareness and attitudes toward sustainable sports programs, including their beliefs about the role of sustainability in physical activities and how institutional initiatives influence engagement.
d. Environmental Impact of Physical Activities: Investigates students' behavioral choices and environmental impact, particularly transportation habits, energy consumption, and self-reported emission reductions linked to sports participation.
e. Student Engagement and Institutional Support: Identifies barriers, motivations, and policy-related factors influencing student involvement in sustainable sports initiatives. This section examines factors such as infrastructure, accessibility, and university-led sustainability policies.

To measure perceptions and engagement levels, the study uses a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree), allowing for the quantification of sustainability awareness and participation behaviors.

3.2 **Life Cycle Assessment (LCA) of Carbon Emissions**

To quantify the environmental impact of sustainable sports participation, the study incorporates Life Cycle Assessment (LCA) methodologies. LCA is a widely used approach in sustainability research that measures the carbon footprint of activities by analysing energy consumption, resource utilization, and emissions reduction. This allows for a comparative analysis of traditional vs. eco-friendly physical activities in terms of sustainability performance. Key LCA Components Analysed:

a. Energy Usage: The study assesses carbon emissions from gym-based activities (which rely on electricity, heating, and cooling) and compares them with low-carbon outdoor sports. This comparison highlights the sustainability benefits of transitioning to carbon-neutral or low-energy physical activities.

b. Transportation Habits: The study examines students' commuting patterns when engaging in sports, analysing the impact of active transport options (walking, cycling) compared to motorized transport (cars, motorcycles, public transit). This provides insights into the carbon savings achieved through sustainable mobility choices.
c. Emission Factors: To ensure precision in carbon footprint estimation, the study applies Greenhouse Gas (GHG) Protocol guidelines, a globally recognized standard for emissions calculations. These guidelines allow for standardized measurement of CO_2 reductions associated with eco-friendly sports and provide a benchmark for comparing sustainable and conventional physical activities.

By integrating quantitative survey data with LCA findings, this study presents a comprehensive evaluation of eco-friendly sports programs in HEIs. The methodology ensures a systematic analysis of behavioral aspects (participation, perception, engagement) and environmental outcomes (carbon footprint reduction, emissions avoidance), offering valuable insights for the development of sustainable sports initiatives.

The collected data is subjected to various statistical analyses to identify patterns, relationships, and the impact of eco-friendly sports on sustainability outcomes.

a. Descriptive Statistical Analysis
   Descriptive statistics (e.g., frequencies, means, standard deviations) summarize students' perception scores, participation rates, and carbon footprint reduction levels. This analysis provides an overview of engagement levels, highlighting variations in sustainability awareness and participation in eco-friendly sports programs.
b. Correlation and Regression Analysis
   Pearson correlation analysis assesses the relationships between perception scores, participation levels, and engagement in sustainable sports. Regression analysis examines how participation and perception levels predict carbon footprint reduction and other sustainability-related behaviors. This analysis helps determine the most influential factors driving student involvement in eco-friendly sports initiatives.

3.3 Life Cycle Assessment (LCA) Analysis

Carbon footprint data from eco-friendly sports participation is compared with traditional sports activities to assess emissions reduction. Standard LCA methodologies are used to estimate the carbon footprint of different activities and compare sustainable vs. conventional sports initiatives. This study adheres to strict ethical guidelines to ensure confidentiality, voluntary participation, and data protection. Informed consent is obtained from all participants, and their responses remain anonymous. Ethical approval was sought from the relevant institutional research committee to uphold academic integrity and research ethics.

4. Results

4.1 Descriptive Analysis of Perception and Participation in Eco-Friendly Sports

The analysis of students' perception and participation in eco-friendly sports at a university campus provides valuable insights into their engagement levels and contributions to sustainability efforts. As illustrated in Table 1, the average perception score ($M = 3.08$, $SD = 0.89$) and participation rate ($M = 3.12$, $SD = 1.03$) suggest that students demonstrate a moderate level of awareness and involvement in eco-friendly physical activities. This indicates that while there is an understanding of the benefits of sustainable sports, actual engagement levels vary among students. The standard deviations reveal notable differences in how students perceive and engage in these activities. Some students exhibit high levels of participation, while others remain less involved.

This suggests that factors such as access to facilities, institutional support, and personal motivation could influence engagement levels.A key environmental benefit of eco-friendly sports participation is its impact on carbon footprint reduction. The findings show a wide range in CO_2

emission reductions, from 2.5 kg to 12.0 kg per participant. The average reduction of 6.64 kg CO_2 indicates that students who actively engage in eco-friendly physical activities, such as walking and cycling, contribute significantly to lowering carbon emissions. However, the variability in impact highlights the need for greater participation and institutional efforts to encourage sustainable behaviors. Overall, these findings emphasize the importance of promoting sustainable sports initiatives through enhanced infrastructure, targeted awareness campaigns, and incentive-driven participation strategies. By addressing barriers to engagement, universities can further encourage students to adopt environmentally responsible physical activities, leading to greater sustainability outcomes and enhanced well-being.

Table 1. Descriptive Statistics of Perception and Participation

Variable	Mean	Std. Dev	Min	Max
Perception Score	3.08	0.89	1.00	5.00
Participation Rate	3.12	1.03	1.00	5.00
Engagement Level	3.05	0.94	1.00	5.00
Carbon Footprint Reduction (kg CO_2)	6.64	2.14	2.50	12.00

4.2 Correlation Analysis of Participation, Perception, and Carbon Footprint Reduction

The correlation matrix presented in Table 2 highlights the relationships between students' participation in eco-friendly physical activities, perception of sustainability, engagement levels, and carbon footprint reduction.

Table 2. Correlation Matrix

Variable	Participation Rate	Perception Score	Engagement Level	Carbon Footprint Reduction
Participation Rate	1.00	0.58	0.63	0.68
Perception Score	0.58	1.00	0.52	0.64
Engagement Level	0.63	0.52	1.00	0.55
Carbon Footprint Reduction	0.68	0.64	0.55	1.00

A strong positive correlation (r = 0.68) exists between participation rate and carbon footprint reduction, indicating that students who frequently engage in eco-friendly physical activities contribute significantly to lowering emissions. This finding reinforces the environmental benefits of sustainable sports programs. Perception score and engagement level exhibit a moderate correlation (r = 0.52), suggesting that students with positive environmental attitudes are more likely to be involved in sustainable physical activities.

However, perception alone does not entirely drive engagement, indicating the influence of other factors such as convenience and institutional support. Engagement level shows a weaker correlation with carbon footprint reduction (r = 0.55), implying that being engaged in sustainability initiatives does not necessarily translate into significant emission reductions unless paired with active participation in eco-friendly sports. These findings underscore the importance of enhancing student participation in sustainable physical activities to maximize environmental benefits. While awareness and engagement play crucial roles, universities should focus on incentive-based participation strategies, improved infrastructure, and targeted sustainability campaigns to encourage greater involvement in eco-friendly sports and increase their overall impact on carbon footprint reduction.

4.3 Regression Analysis of Participation, Perception, and Carbon Footprint Reduction

The regression analysis presented in Table 3 examines the influence of participation rate, perception score, and engagement level on carbon footprint reduction, providing insights into the most significant predictors of sustainable behavior.

Table 3. Regression Analysis Results

Variable	Coefficient (β)	Intercept	R^2 Value
Participation Rate	0.78	2.14	0.72
Perception Score	0.64	2.14	0.72
Engagement Level	0.55	2.14	0.72

Participation rate is the strongest predictor of emission reduction ($\beta = 0.78$), reinforcing that students who actively take part in eco-friendly sports and physical activities contribute significantly to lowering their carbon footprint. Perception score ($\beta = 0.64$) also plays a major role in predicting carbon footprint reduction, indicating that students who are more aware of sustainability concepts are more likely to adopt behaviors that reduce emissions. Engagement level has a weaker predictive effect ($\beta = 0.55$), suggesting that while students may express interest in sustainable activities, actual participation is a more critical factor in achieving measurable environmental benefits. These findings emphasize the need for universities to not only promote sustainability awareness but also encourage direct participation in eco-friendly physical activities. Strategies such as infrastructure improvements, behavioral incentives, and institutional support can help bridge the gap between engagement and action, ensuring that students translate their sustainability awareness into meaningful, low-carbon behaviors.

4.4 Life Cycle Assessment (LCA) – Carbon Footprint Reduction

The Life Cycle Assessment (LCA) analysis in Table 4 compares the carbon emissions associated with traditional sports activities versus eco-friendly sports, providing insights into the environmental benefits of sustainability-driven physical activity programs. Eco-friendly sports reduce carbon emissions by an average of 6.64 kg CO_2 per participant compared to traditional sports, demonstrating their significant role in sustainability efforts. Traditional sports generate approximately 10.15 kg CO_2 per participant, whereas eco-friendly sports lower this figure by nearly 65%, highlighting the potential of green exercise initiatives in reducing campus-wide emissions. These results validate the effectiveness of sustainability-focused physical activity programs in mitigating environmental impact, reinforcing the importance of integrating low-carbon sports alternatives into higher education institutions' sustainability strategies.

Table 4. Life Cycle Assessment (LCA) - Carbon Footprint Reduction

Metric	**Value (kg CO_2)**
Average Traditional Sports Emission	10.15
Average Eco-Friendly Sports Emission	3.50
Average Emission Reduction	6.64

5. Discussion

The findings from this study provide significant insights into the role of eco-friendly physical activity programs in higher education institutions (HEIs). The results confirm that student engagement, participation levels, and sustainability perceptions directly impact carbon footprint reduction, health improvement, and environmental sustainability efforts. Regression analysis ($R^2 = 0.72$) further reinforces the idea that participation is the most influential predictor of carbon footprint reduction and

health outcomes, emphasizing the importance of behavioral interventions over mere awareness campaigns. This finding aligns with Pérez-Ordás et al. (2019), who emphasized that a multi-faceted approach incorporating infrastructure enhancements, structured programs, and financial incentives produces the most substantial environmental and health benefits.

To effectively bridge the gap between students' perceptions and active engagement in eco-friendly sports, universities must implement strategic interventions. One effective approach is the introduction of well-structured eco-friendly sports programs that offer accessible and engaging opportunities for students to participate in sustainability-driven physical activities while addressing common health concerns such as obesity, stress, and cardiovascular diseases (Ordiñana-Bellver et al., 2024). Additionally, financial incentives—such as rewards, subsidies, or official recognition can serve as a strong motivator for students to adopt sustainable sports practices (Mikiki et al., 2021). Moreover, strengthening institutional policies that embed sustainability and public health initiatives across all university sports programs is essential in fostering a culture of environmental responsibility and well-being within higher education institutions (Macassa, 2021). By integrating structured programs, financial support, and robust sustainability and health policies, universities can create an environment where eco-friendly sports become an attractive and accessible option for students.

Understanding student engagement in sustainable sports is vital for increasing participation rates and maximizing environmental and health benefits. Findings from this study indicate that students at the university acknowledge the advantages of eco-friendly physical activities but encounter barriers such as limited infrastructure, insufficient awareness, perceived physical limitations, and competing academic responsibilities (Ling et al., 2024). However, students with a stronger perception of sustainability and personal health benefits are more likely to participate in eco-friendly activities, aligning with previous research that identifies environmental awareness as a key driver of behavioral change alongside the motivation to maintain good health (Osipov et al., 2019).

Several motivational factors influence engagement levels, including health benefits, environmental consciousness, and social interaction. Research suggests that universities that incorporate sustainability-focused education into physical activity programs report higher student participation rates and improved physical and mental health outcomes (Haque et al., 2023). For instance, educational initiatives that highlight the connection between sustainability and disease prevention have proven effective in increasing student involvement in green sports initiatives (Baena-Morales et al., 2024).

Furthermore, the study reveals that gender differences exist in participation trends. Female students demonstrate slightly higher involvement in eco-friendly activities related to physical and emotional well-being, whereas male students show greater engagement in activities associated with mental resilience and stress management. These findings align with prior research indicating that women tend to prioritize health and wellness aspects of sustainability, while men may focus more on performance-driven and psychological benefits (Macassa, 2021). To enhance engagement and overcome existing barriers, universities should implement targeted interventions, including:

a. Awareness campaigns that emphasize the dual benefits of sustainability and fitness (Hyndman, 2016).
b. Incentive programs for students adopting active commuting and sustainable sports habits (Pappas, 2013).
c. Expansion of green infrastructure, such as eco-parks and sustainable gym equipment, to increase accessibility and participation (Ordiñana-Bellver et al., 2024).

By addressing these challenges through strategic policies and well-designed initiatives, universities can create a more supportive environment that fosters greater student involvement in eco-friendly sports, ultimately contributing to both environmental sustainability and student well-being.

5.1 Implications for Policy and Institutional Strategies

The findings of this study highlight key policy and strategic recommendations for higher education institutions to enhance student engagement in eco-friendly sports while promoting sustainability and improving overall student health and well-being:

a. Infrastructure Development
   Universities should prioritize investments in sustainable sports infrastructure, such as well-maintained walking trails, cycling tracks, and outdoor fitness areas. Providing accessible green spaces can significantly encourage student participation in eco-friendly physical activities while simultaneously addressing physical inactivity and related health concerns such as obesity, cardiovascular diseases, and mental health issues.
b. Behavioral Incentives
   Implementing reward-based initiatives, such as credits for participation in eco-friendly sports or financial incentives, can serve as motivation for students to adopt more sustainable physical activity habits and reduce reliance on carbon-intensive alternatives. Incentives that highlight both environmental benefits and health improvements, such as reduced stress and enhanced fitness, can further encourage sustained participation in eco-friendly sports.
c. Awareness and Education
   Expanding sustainability education through workshops, digital campaigns, and student ambassador programs can reinforce the connection between physical activity, environmental conservation, and disease prevention. By emphasizing how eco-friendly sports contribute to both mental resilience and physical health, institutions can foster a deeper commitment to sustainable engagement.
d. Policy Integration
   Universities should align their physical activity initiatives with broader sustainability objectives, embedding eco-friendly sports within institutional policies to ensure long-term commitment and widespread student engagement. Health-focused policies that integrate sustainable sports with wellness programs can maximize both environmental and public health outcomes.

By implementing these strategies, institutions can bridge the gap between perception and action, ensuring that students not only recognize the benefits of sustainable sports but actively participate in them, ultimately contributing to both holistic well-being and long-term disease prevention alongside environmental sustainability.

6. Conclusion

This study provides compelling empirical evidence that eco-friendly physical activity programs play a crucial role in advancing sustainability efforts in higher education institutions (HEIs). The strong correlation between student participation and carbon footprint reduction highlights the potential for universities to significantly lower emissions by promoting sustainable sports initiatives while simultaneously addressing health concerns such as obesity, cardiovascular risks, and mental well-being. However, the extent of student engagement is largely shaped by factors such as infrastructure availability, institutional policies, perceived health benefits, and time constraints. Addressing these barriers is essential to ensuring that eco-friendly sports programs become a fundamental part of campus sustainability efforts while also promoting long-term physical and mental health improvements.

The findings underscore the need for HEIs to invest in green infrastructure, such as pedestrian pathways, cycling tracks, and eco-parks, to encourage greater participation in sustainable physical activities and combat sedentary lifestyles that contribute to various health issues. Statistical analyses confirm that active engagement in eco-friendly sports results in tangible environmental benefits, with participation being the strongest predictor of carbon footprint reduction and improved student health outcomes. While sustainability awareness positively influences engagement, the study reinforces that awareness alone is insufficient. Students must be provided with the necessary resources and motivation to translate perception into action while recognizing the dual benefits of environmental conservation and health promotion.

To maximize the long-term impact of eco-friendly sports programs, universities should implement strategic interventions, including structured initiatives, financial incentives, and policy integration that prioritize both sustainability and student health enhancement. Future research should explore the long-term behavioral patterns of students participating in sustainable sports, examining how institutional interventions shape ongoing engagement and environmental impact over time while also assessing the effects on students' overall health, stress management, and disease prevention. A longitudinal study could offer deeper insights into how sustained participation in eco-friendly physical activities influences sustainability outcomes and contributes to long-term health benefits at both the individual and institutional levels.

In conclusion, eco-friendly physical activity programs have the potential to significantly reduce carbon footprints in HEIs while simultaneously mitigating health risks associated with physical inactivity and fostering a culture of sustainability on university campuses. However, their long-term success depends on institutional commitment to infrastructure development, targeted awareness initiatives, and policies that encourage active participation while addressing student health needs through sustainable sports engagement. By integrating sustainability-driven sports programs into their broader environmental strategies, universities can create a greener, healthier, and more sustainable future for students and the campus community.

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