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Sustainable Eating Mediates the Relationship Between Physical Activity and Love and Care for Nature

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Abstract

Background

Climate change directly and indirectly threatens human health, especially among young people, who will face its most severe consequences. Within the planetary health framework, behaviors such as physical activity and sustainable eating are protective lifestyle factors, while love and care for nature supports pro-environmental engagement and psychological resilience. Yet how these interrelate in youth remains unclear.

Methods

A sample of 1,230 students aged 9–16 completed validated measures of physical activity frequency (PACE+), sustainable eating (SHED Index subscale), and love and care for nature (Perkins scale). Using Hayes' PROCESS macro (Model 4), we tested a mediation model.

Results

Physical activity positively predicted sustainable eating, which in turn predicted love and care for nature, partially mediating the activity–nature association (significant indirect effect; 10,000 bias-corrected bootstraps).

Discussion

Sustainable eating thus appears a key pathway linking youth physical activity with care for nature, underscoring the value of integrated planetary health interventions targeting multiple behaviors to strengthen both health and pro-climate engagement.

Introduction

Climate change is widely recognized as the greatest public health challenge of the 21st century, threatening planetary systems and directly affecting children and adolescents [1]. Rising global temperatures, which cause extreme weather events, and disruptions to food and water security all undermine both physical and mental health outcomes [2]. Young people are physiologically sensitive to environmental changes, psychologically attuned to eco-anxiety, and positioned to inherit the long-term consequences of environmental degradation [3]. The planetary health framework emphasizes the deep interdependence between human health and the state of Earth's natural systems [4], calling for systemic changes in health behaviors and societal practices that reduce ecological footprints while promoting well-being. Among such practices, Physical Activity (PA) and Sustainable Eating (SE) stand out as healthy behaviors with dual benefits for both personal and planetary health [2,5]. Moreover, nurturing Love and Care for Nature (LCN) may strengthen children's resilience and engagement with pro-environmental actions [6]. Despite the theoretical links between these constructs, few empirical studies have examined how PA, SE, and LCN interrelate in young populations.

PA and Planetary Health

PA is universally recognized as essential for physical, psychological, and social well-being [7]. Regular PA reduces the risk of non-communicable diseases, supports healthy growth, enhances cognitive function and physiological health, and alleviates symptoms of depression and anxiety in young people [8]. Importantly, PA also intersects with planetary health in meaningful ways. Active transportation such as walking and cycling reduces carbon emissions, lowers air pollution, and mitigates climate change drivers, while promoting individual fitness [9]. A recent scoping review by Capdevila et al. [5] systematically mapped 62 studies on PA and planetary health and identified four primary investigation areas: individuals' attitudes toward the environment and nature, promotion of active lifestyles including active commuting, event organization, and the direct consequences of PA and sports on the natural world. These findings underscore the urgency for more experimental designs to establish causal relationships between PA and its ecological consequences.

Recently, Comoutos et al. [10] suggested that PA may serve not only as a health-enhancing behavior but also as a psychological buffer in the face of climate-related stressors. In school-aged populations, however, PA levels remain below the recommended guidelines in most countries [11], a trend compounded by sedentary lifestyles, urbanization, and digitalization. Understanding the broader co-benefits of PA including potential links to pro-environmental attitudes may strengthen policy arguments for integrating PA promotion into planetary health initiatives [12]. Yet, evidence connecting youth PA to pro-environmental orientations remains scarce.

SE in Youth Populations

Dietary choices are among the most powerful determinants of both human and planetary health [13]. High consumption of red and processed meat, ultra-processed foods, and foods transported over long distances contribute not only to chronic non-communicable diseases but also to greenhouse gas emissions, deforestation, and biodiversity loss [14]. Conversely, SE patterns characterized by higher intake of plant-based foods, local and seasonal products, and reduced food waste are protective for health while lowering environmental impacts [15].

Adolescence is a critical developmental stage for establishing dietary habits that continue to adopt into adulthood [16]. Interventions promoting sustainable diets in young populations are therefore, central to planetary health goals. A recent scoping review by Lanham and van der Pols [17] examined the effectiveness of interventions targeting sustainable diets in adolescents. The study found that programs that help young people understand and adopt sustainable food choices tend to improve attitudes, whereas interventions that increase the availability of sustainable foods improve the environmental sustainability of adolescents' actual dietary intake. Lanham and van der Pols [17] also highlighted that multicomponent, tailored, and community-based interventions were most effective, though long-term effects remain unclear. Integrating SE education into school curricula and linking SE with other lifestyle practices may turn a particularly effective strategy in reinforcing behavioral change.

Nature Connectedness and Climate Resilience

Nature connectedness reflects individuals' affective, cognitive, and experiential bond with the natural environment [18]. A specific dimension of this construct, LCN, captures the emotional empathy and intrinsic valuing of nature [19]. Higher nature connectedness is linked with greater psychological well-being, lower levels of stress, and stronger pro-environmental behaviors [20,21]. Moreover, in children, frequent interaction with natural environments fosters ecological literacy, empathy for non-human life, and a sense of responsibility toward the planet [22].

Recent systematic reviews provide further the existing evidence. Madera et al. [23] synthesized 63 studies on nature connectedness in individuals aged 11–26 years and identified four key themes: nature connection's role in improving mental well-being, its influence in promoting pro-environmental behavior and sustainability, the interaction between technology use and nature connection, and nature's contribution to social connectedness. Similarly, Guazzini et al. [24] in their systematic review examined the grid between connectedness to nature and pro-environmental behaviors, and consistently found a significant and positive association, although a considerable variability was recorded across the reviewed studies. In line, the systematic review by Harris et al. [25] further demonstrated that nature connectedness and behaviors for learning could be deliberately developed in children, adolescents, and young adults through structured interventions.

Although PA, SE, and LCN are, each, independently associated with health and environmental outcomes, pathways revealing their interplay remain underexplored. Available research has largely examined these behaviors in isolation. Particularly, studies show that youth engaging in higher PA frequency are often reporting healthier diets [26], while pro-environmental attitudes are correlating with sustainable dietary practices [27]. Emerging evidence also suggests that PA, especially when practiced outdoors, may also enhance nature connectedness [28]. In a recent study, Theodorakis et al. [29] revealed that PA was a significant positive predictor of a child's LCN, which in turn predicted higher attitudes, subjective norms, and perceived behavioral control regarding the environment. The study by Theodorakis et al. [29] concluded that fostering active lifestyles in nature is a pivotal way to develop environmentally responsible citizens. Further, the systematic review by Blyth et al. [30] on behavioral clustering in childhood and adolescence, showed that health behaviors including PA, diet, sedentary behavior, and sleep tend to cluster together and track over time, with participants commonly transitioning to similarly characterized clusters between developmental stages. Moreover, children who had healthy habits largely continued (60–100%) to maintain them as they grew older. Unfortunately, the same applies to bad habits. Children who remained in 'unhealthy clusters' of habits had increased levels of body fat (obesity) as they grew up. Yet, empirical models testing how PA may indirectly foster LCN through SE remain untested.

The Present Study

From a theoretical standpoint, behavioral clustering frameworks propose that health behaviors co-occur and reinforce one another [30,31]. Engaging in PA may heighten awareness of bodily health, which could generalize to food choices aligned with sustainable diets. In turn, SE may strengthen values and practices consistent with caring for the environment, thereby enhancing LCN.

To address this gap, the present cross-sectional study examined whether SE mediates the relationship between frequency of PA and LCN. We hypothesized that: (1) Frequency of PA would positively predict LCN; (2) Frequency of PA would positively predict SE; (3) SE would positively predict LCN; and (4) SE would partially mediate the relationship between frequency of PA and LCN.

Method

Participants and Procedure

In this cross-sectional population-based study, participants were recruited via school administrators from January to March 2024. In particular, young people aged 9–16 years enrolled in school in central Greece were invited to participate. The final sample consisted of 1,230 students (*M*age = 12.31, *SD* = 1.39), from 30 school units across central Greece. The sample included 550 boys and 665 girls (15 missing) from 672 primary school students and 552 secondary school students (6 missing).

The research followed international ethical guidelines consistent with those of the American Psychological Association and the Declaration of Helsinki, and was approved by the University Ethics Committee (Ref. No. 09/17.1.2024). Informed consent was obtained from pupils and their parents or caregivers before data collection began.

Participation was voluntary. Students completed a multi-section paper-based questionnaire assessing the variables of interest during a physical education class, with a researcher present throughout. Beforehand, they were informed of the purpose of the study, the anonymity and confidentiality of their responses, and their right to withdraw at any point. To reduce socially desirable responding, they were further told that there were no right or wrong answers and asked to answer as honestly as possible.

Measures

Participants completed a demographic form and validated questionnaires measuring their frequency of moderate-to-vigorous PA, SE, and LCN.

Demographic Form. Participants reported their gender (male, female, other), age, school class (5th primary, 6th primary, etc.), region, and ethnicity.

PA Frequency. The brief two-item questionnaire (PACE+) was employed to record the frequency of adolescents' engagement in moderate-to-vigorous PA [32]. Participants responded to the stem, "*Over the past 7 days, or a typical or usual week, on how many days were you physically active for a total of at least 60 minutes per day?*" on an 8-point Likert scale from 0 (*0 days*) to 7 (*7 days*). A composite score was created by taking the mean of the responses.

SE. To assess students' SE, the 7-item SE subscale from the Sustainable-HEalthy-Diet (SHED) Index [33] was administered. Example items include: "*Limit red meat*," "*Consume organic products*," and "*Buy local products*." Respondents answered on a 4-point Likert-type scale ranging from 1 (*Almost never true*) to 4 (*Almost always true*). A composite score was created by taking the mean of the responses.

LCN. The 15-item LCN scale [19] was administered to assess students' emotional affinity for nature. Example items include: "*I feel joy just being in nature*" and "*I feel a deep love for nature.*" Respondents answered on a 7-point Likert-type scale ranging from 1 (*Strongly disagree*) to 7 (*Strongly agree*). The back-to-back translation process [34] was used to translate the scale items into Greek.

Data Analyses

All statistical analyses were conducted with IBM SPSS Statistics v29, with significance set at $p \leq .05$. Descriptive statistics, internal consistency coefficients (Cronbach's alphas), and Pearson's correlations were calculated. To examine the hypothesized simple mediation model, we used the PROCESS macro for SPSS (version 4.2), Model 4 [35]. We used bias-corrected bootstrapping with 10,000 resamples to calculate 95% Confidence Intervals (CIs). A significant indirect effect is indicated if the 95% CI does not include zero (see Fig. 1).

Results

Descriptive Statistics and Correlations

Descriptive statistics, internal reliability scores, and correlations are presented in Table 1. Mean scores for frequency of PA, SE, and LCN were all above the respective scales' midpoints. All scales showed acceptable internal reliability (Cronbach's *α*). Correlation analyses revealed that all variables were significantly and positively correlated to each other, with low to moderate coefficients.

Table 1
Descriptive Statistics, Cronbach's Alpha, and Correlations for All Study Variables

Variables	***M***	***SD***	***a***	**1**	**2**	**3**
1. Frequency of physical activity (days per week)	3.92	1.73	.84	-		
2. Sustainable eating	2.49	.52	.64	.14***	-	
3. Love and care for nature	5.36	.91	.92	.10 ***	.37 ***	-

Note: Frequency of physical activity (days per week) scores (possible range 0–7); Sustainable eating scores (possible range 1–4); Love and care for nature scores (possible range 1–7). ***$p < .001$.

Mediation Analysis

In the total effect model (*c* path), frequency of PA significantly explained 1% of the variance in LCN ($p < .001$). In the simple mediation model, after the inclusion of SE, frequency of PA significantly explained 2% of the variance in SE (*a* path), while frequency of PA and SE conjointly explained 14% of the variance in LCN ($p < .001$).

The total effect of frequency of PA on LCN (*c* path) was significant and positive ($\beta = .11$, $p < .001$), as was the direct effect (*c'* path) adjusted for SE ($\beta = .06$, $p = .032$). Frequency of PA significantly and positively predicted SE (*a* path; $\beta = .13$, $p < .001$), which in turn significantly and positively predicted LCN (*b* path; $\beta = .36$, $p < .001$).

The indirect effect (*ab*) of frequency of PA on LCN through SE was significant and positive (*b* = .03, *SE* = .01), as indicated by the 95% bias-corrected bootstrap CI, which ranged from .01 to .04. The completely standardized indirect effect was β = .05, *SE* = .01, 95% CI [.03, .07]. Therefore, SE partially mediated the relationship between frequency of PA and LCN (see Table 2).

Table 2
Summary of the Results for the Simple Mediation Analysis

	Simple Mediation Model							**Total Effect Model**			
	Outcome							**Outcome**			
Predictor	**Sustainable eating (M)**				**Love and care for nature (Y)**			**Love and care for nature (Y)**			
		b	**SE**	**β**		**b**	**SE**	**β**		**b**	**SE**	**β**
Frequency of physical activity (days per week) (X)	*a* path	.04***	.01	.13	*c′* path	.03*	.01	.06	*c* path	.06***	.02	.11
Sustainable eating (M)		-	-	-	*b* path	.62***	.05	.36	-	-	-	-
Constant		2.33***	.04			3.69***	.13			5.14***	.07	
		R^2 = .02 *F* (1, 1140) = 21.01, *p* < .001				R^2 = .14 *F* (2, 1139) = 90.79, *p* < .001				R^2 = .01 *F* (1, 1140) = 13.44, *p* < .001		

Note. b = Unstandardized coefficients; *β* = Standardized coefficients; *SE* = Standard error. **p* < .05. *** p < .001.

Discussion

The present study investigated whether SE mediates the relationship between frequency of PA and LCN in a large sample of youth aged 9–16 years. Consistent with our first hypothesis, frequency of PA was positively, albeit modestly, associated with LCN. This finding aligns with previous research showing that physically active youth tend to spend more time outdoors and in natural settings, which in turn fosters a stronger emotional bond with the natural world [6,28]. The relatively small direct effect is not surprising, given the multidimensional nature of LCN and the increased number of factors shape LCN. Nonetheless, this association was statistically significant in a large and diverse sample underscoring the relevance of PA as one element within a broader constellation of behaviors that support nature connectedness. Recent work by Theodorakis et al. [29] similarly demonstrated that PA was a significant positive predictor of children's LCN, which in turn, predicted more favorable attitudes, subjective norms, and perceived behavioral control regarding the environment. Moreover, Theodorakis et al. [36] successfully integrated Self-Determination Theory and the Theory of Planned Behavior, demonstrating that a strong sense of perceived competence is the primary driver of adolescents' attitudes, subjective norms, and perceived behavioral control toward eco-friendly behaviors.

Our second and third hypotheses that PA and SE would predict, respectively, SE and LCN were both supported. The positive association between PA and SE is consistent with behavioral clustering frameworks, which posit that health-promoting behaviors tend to co-occur [31]. Regularly active young people may develop a heightened awareness of their bodily health, which could extend to the food choices they make. A recent systematic review by Blyth et al. [30] provided compelling evidence that PA, diet, sedentary behavior, and sleep cluster together throughout childhood and adolescence, with participants commonly transitioning to similarly characterized clusters across developmental stages. This finding suggests that the co-occurrence of PA and SE observed in the current study reflects a broader behavioral tendency rather than an isolated association.

Confirming our last hypothesis, the results showed that SE partially mediated this relationship. These findings suggest that the link between an active lifestyle and a deeper emotional connection with nature is, at least in part, channeled through dietary practices that are aligned with environmental sustainability. These findings offer an important contribution to the growing body of research on planetary health by demonstrating that health behaviors do not operate in isolation but rather through interconnected pathways that shape young people's environmental orientations.

The strong relationship between SE and LCN is particularly noteworthy. Choosing to eat sustainably by reducing red meat, favoring local and seasonal products, and minimizing food waste reflects a set of values and daily practices that are inherently connected to caring for the environment. This finding resonates with recent reviews showing that individuals who feel a stronger sense of connectedness with nature tend to engage more consistently in pro-environmental behaviors, including sustainable dietary choices [24]. Madera et al. [23] systematically reviewed 63 studies on nature connectedness in adolescents and young adults, and identified sustainability promotion as one of the four primary themes through which nature connectedness exerts its influence. In practical terms, the act of choosing food that is better for the planet may itself reinforce a child's emotional appreciation for the natural world.

The key finding of the current study that SE partially mediates the PA–LCN relationship offers a nuanced picture of how these behaviors interact. Previous studies have highlighted individual links between PA, diet, and environmental attitudes, but they rarely examined the combined pathways across the links. Our simple mediation model integrates these strands by showing that SE partly explains how PA translates into stronger LCN. This is consistent with the hypothesis, which suggests engaging in one pro-environmental behavior can facilitate the adoption of other environmentally friendly practices [37]. In this case, PA may serve as an entry point into a broader lifestyle that includes SE, which then deepens a young person's emotional connection to nature.

These findings also speak to a growing recognition in the literature, that planetary health interventions should target multiple behaviors concurrently rather than in isolation. Recent evidence from a scoping review on 62 studies on PA and planetary health [5] highlights the multifaceted ways in which active lifestyles interact with environmental outcomes through attitudes, active commuting, and direct ecological impacts. The present study adds to this evidence by demonstrating that the psychological and behavioral pathways linking PA to environmental connectedness in youth are themselves mediated by another key health behavior, which is SE. Accordingly, PA promotion among young people may be more effective in cultivating pro-environmental dispositions if it simultaneously addresses dietary practices.

From a developmental perspective, our findings are particularly meaningful. Our study participants had an age range varying from middle childhood to early adolescence, a youth period during which dietary habits, PA patterns, and environmental attitudes are being established and are still amenable to change [16,17]. The systematic review by Harris et al. [25] showed that nature connectedness can be deliberately developed in children and young adults through structured interventions, suggesting that this is a window of opportunity for shaping lifelong environmental engagement. Our findings bridge existing literature by showing that even at this early stage, lifestyle behaviors cluster in ways that may shape future pro-environmental orientations.

Our findings also resonate with the broader literature on eco-anxiety and youth resilience. Comoutos et al. [10] found that PA may buffer the negative psychological impacts of eco-anxiety in youth, who had experienced climate-related events such as floods. The present study complements this work by suggesting that SE representing another behavior within the planetary health domain, may similarly contribute to positive environmental orientations. Together, these findings point to a holistic model in which PA, SE, and nature connectedness form a mutually reinforcing system that supports both the well-being of young people and the health of the planet.

Limitations and Future Directions

Several limitations must be acknowledged. First, the cross-sectional design precludes causal inference; longitudinal studies are needed to determine the directionality of these relationships and to establish whether changes in PA may lead to subsequent changes in SE and LCN over time. Second, PA was assessed through self-report, which may introduce measurement errors; future research should combine self-reported and device-based measures of PA to enhance accuracy. Third, the cultural context of Greece with its Mediterranean dietary traditions and proximity to natural environments may have influenced the results, making replication in diverse cultural and geographical settings essential. Fourth, the effect sizes recorded in this study were modest. While this finding is consistent with previous research in the area, it suggests that other variables not included in our model may also play important roles. Future research could employ structural equation modeling to test more complex pathways, such as moderated mediation models examining if the mediating role of SE varies by age, gender, or level of nature exposure.

Practical Implications

The present findings carry several practical implications. First, school-based interventions that promote both PA and SE may yield synergistic benefits, strengthening physical health, environmental concern, and LCN simultaneously. Physical education classes, for instance, could be complemented with nutrition education that emphasizes the environmental dimensions of food choices. Second, from a policy perspective, planetary health approaches should frame PA and SE as interconnected practices with co-benefits rather than as isolated targets. Third, nature-based PA programs such as outdoor physical education, school gardens, and active commuting initiatives may offer opportunities for cultivating both SE awareness and nature connectedness in young people. Finally, encouraging children towards sustainable food choices and regular PA may reinforce environmental stewardship, cultivating a generation that is committed to both personal well-being and climate action.

Conclusions

Sustainable eating mediated the link between physical activity and love and care for nature, suggesting these behaviors reinforce one another. Interventions pairing physical activity with the environmental dimensions of food choice may therefore build health and nature connectedness together. Longitudinal work is needed to confirm the direction of these pathways.

Declarations

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Data Availability

The datasets generated and/or analyzed during the current study are not publicly available because this research is part of an ongoing funded project, but they are available from the corresponding author on reasonable request.

Declaration of generative AI and AI-assisted technologies in the manuscript preparation process

During the preparation of this work, the authors used ChatGPT Pro to assist with English-language editing and the development of the graphical abstract. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

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Declaration of interests

 The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

 The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Ethics Approval and Consent to Participate

The research followed international ethical guidelines consistent with those of the American Psychological Association and the Declaration of Helsinki, and was approved by the University Ethics Committee (Ref. No. 09/17.1.2024). Informed consent was obtained from pupils and their parents or caregivers before data collection began.

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Figures

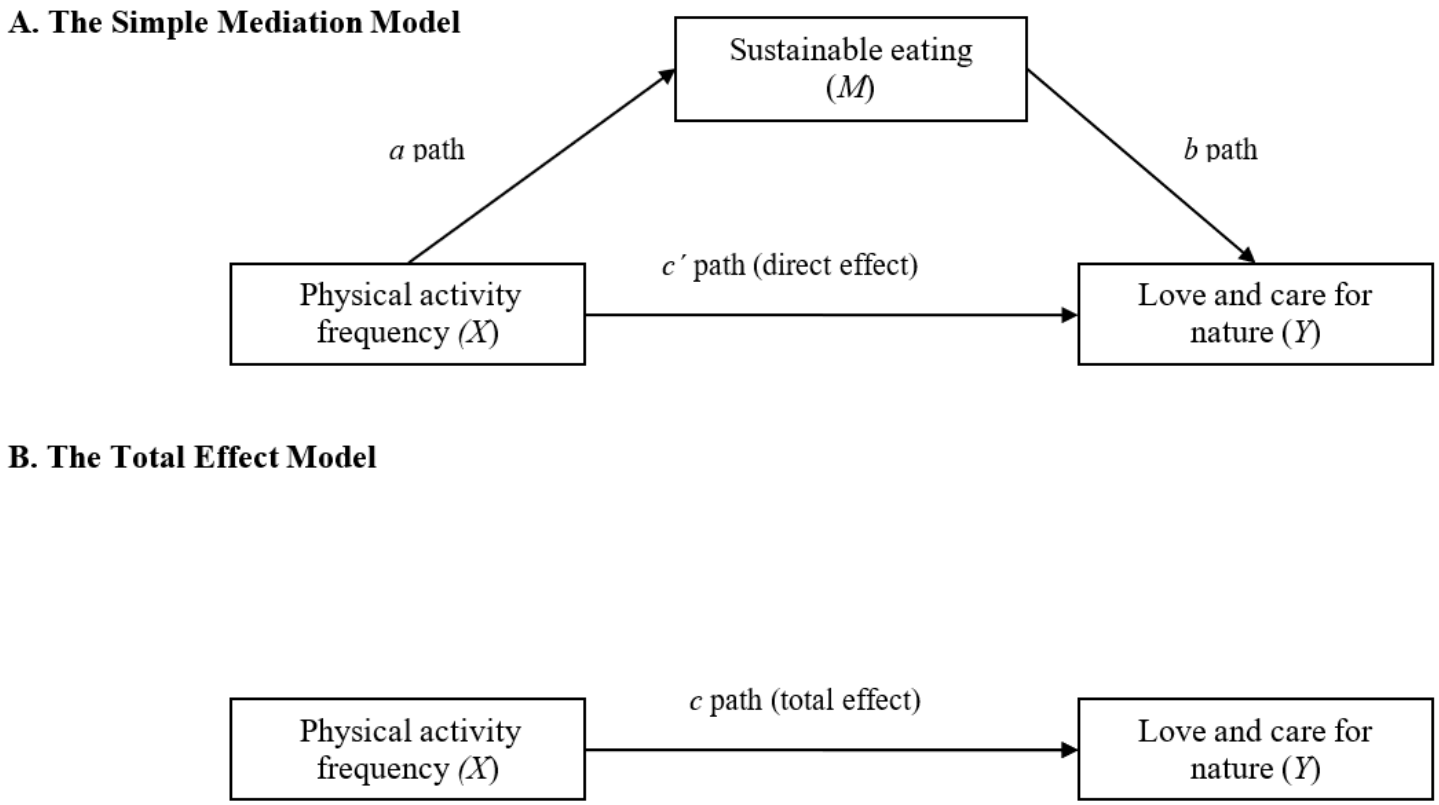


Figure 1

The Statistical Diagram of the Hypothesized Simple Mediation Model Linking Students' Physical Activity Frequency (Days/Week) to Love And Care For Nature Via the Sustainable Eating

Note. Panel A: The simple mediation model linking students' frequency of physical activity (days/week) to love and care for nature via the sustainable eating (mediator). Panel B: The total effect model linking students' frequencyof physical activity (days/week) to love and care for nature ignoring the mediator (sustainable eating). The simple mediation model decomposes the total effect (*c* path), into the indirect effect, *ab* (product of the indirect paths *a* and *b*) and the direct effect (c′ path, controlling for the effect of the mediator).