Health & Place 94 (2025) 103498

Contents lists available at ScienceDirect

Health and Place

journal homepage: www.elsevier.com/locate/healthplace

Walking in nature decreases state anxiety through pleasure

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ARTICLE INFO

Keywords:
Walking
Nature
Forest
Urban
State-anxiety
Pleasure
Mediation analyses

ABSTRACT

Walking in nature has shown to be a medication-free and cost-effective way to reduce state anxiety. Nature-based walks may also afford a more enjoyable experience than walking in urban environments. Nevertheless, it is currently unclear if walking in nature decreases state anxiety through pleasure. Here, we examine this question by comparing the impact of a forest walk to an urban one (independent variable) on the pleasure experienced by participants during the walk (mediator) and on the pre-and post-walk state anxiety change (dependent variable). Using three sequential steps of mediation analyses, we observed that walking pleasure mediates the effect of the type of walking environment (forest vs. urban) on the pre- and post-walk decrease of state anxiety. This study provides the first empirical evidence for the mediating role of pleasure in the restorative effect of a nature walk on state-anxiety. We further discuss how future studies should examine how pleasure experienced while walking impacts state anxiety change.

1. Introduction

Walking constitutes an accessible and convenient way to reduce transitory feelings of apprehension and nervousness, e.g., state anxiety (Kelly et al., 2018). These effects are particularly robust for walking sessions undertaken in nature-based environments (as compared to urban-based environments), such as forest settings (e.g., Grassini, 2022; Ma et al., 2024).

This affective change might be driven by humans' innate affinity toward nature (i.e., Stress Reduction Theory; Ulrich et al., 1991), independently of the robust attention restoration effect of nature walks (as those environments are cognitively less demanding than urban environments; i.e., Attention Restoration Theory; Kaplan, 1995; Kaplan and Kaplan, 1989). Specifically, studies showed that cognitive capacity and positive affect improve to a greater extent after a nature walk (relative to an urban walk), but that those effects are not correlated, suggesting separable mechanisms (Berman et al., 2008, 2012). In addition, studies have shown that forest walks generate more pleasure-related responses than walks undertaken in urban environments (Fraser et al., 2019; Song et al., 2022).

It follows that the increased effect of forest walks on state anxiety can be explained by higher levels of pleasure experienced during this activity (compared to an urban walk). Preliminary evidence for this hypothesis comes from studies showing that exposure to nature-related images leads to larger affect change than urban-related images, and that this effect was mediated by the hedonic tone of the image (i.e., level of preference/attractiveness; Beute and de Kort, 2014; van den Berg et al., 2003; see also Browning et al., 2020; Karmanov and Hamel, 2008; Meidenbauer et al., 2020; White et al., 2010). It remains unclear, however, whether comparable mediation effects occur during an actual walk. The present study aimed to address this research question by employing a two-level within-subjects design, where all participants completed a walking session in a forest and a walking session in an urban setting. Through this approach, we tested whether walking pleasure mediates the effect of the type of walking environment (forest vs. urban) on the pre-and post-walk decrease in state anxiety.

2. Methods

2.1. Ethics

The protocol of the study was approved by the Ethics Committee of

This article is part of a special issue entitled: Urban Health Research published in Health and Place.

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https://doi.org/10.1016/j.healthplace.2025.103498
Received 9 August 2024; Received in revised form 5 June 2025; Accepted 5 June 2025
Available online 9 June 2025

the UCLouvain Institute of Psychological Sciences (#2022–68) and by the Ethics Review Panel of the University of Luxembourg (ERP 22–077 WTW).

2.2. Sample size estimation

This study is part of a larger project involving a series of studies investigating the impact of "real" versus "virtual" (i.e., exposure to first-person perspective walking videos) nature and urban walks on markers of affective responses. The sample size of the present study ($N = 45$) was based on an a-priori sample size estimation from this larger project. A sensitivity analysis (using G*Power version 3.1.9.7) showed that with $N = 45$, an effect size (Cohen's d) of .42 is necessary to detect an effect of the type of walking environment (forest versus urban) on state anxiety change with a power of 0.80 on a paired sample t-test with an alpha level of .05 (i.e., the first step of the mediation analyses; see section "data analyses" below).

2.3. Participants

Forty-five French-speaking individuals completed the study. Fifty participants were initially recruited, but 5 did not complete the two walking sessions and were thus excluded from data analyses. Participants were recruited through flyers displayed on social networks ($age_{mean} = 22.5$, $SD = .53$; 30 females). To be included in the study, participants needed to be at least >18 years old, hold a university student status at UCLouvain (Louvain-la-Neuve campus), and report being able to walk for at least 40 min without difficulty. Participants received compensation in the form of a 40€ gift voucher.

2.4. Walking trails

The maps and illustrations of the urban and the nature trails are detailed in Fig. 1.

2.5. Walking pleasure

We used a (French) single-item measure (Brevers et al., 2024a, 2024b) for estimating the level of pleasure experienced during the overall walking session ("What intensity of pleasure did you feel during this session?"; 7-point Likert scale ranging from $0_{none\_at\_all}$ to $6_{extreme}$).

2.6. State anxiety change

The difference in pre- and post-walking session state anxiety was assessed before and after each walking session using the aggregated score on the 20 items (10 items reverse-scored; higher scores mean higher state anxiety; Cronbach's α range for this study .82 to .92) of the French version of the Spielberger State Anxiety Inventory (STAI-S; Gauthier and Bouchard, 1993; Spielberger et al., 1983). Items were preceded by the main instruction: "Indicate *how you feel now, that is, at this moment*". State $anxiety_{change}$ was operationalized as pre-session STAI-S minus post-session STAI-S.

2.7. Control measures

The following complementary measurements were included in the study protocol: (i) level of daily-life physical activity was assessed with the French version of the International Physical Activity Questionnaire (IPAQ; Craig et al., 2003; category: low, moderate, and high); (ii) the average heart rate (HR; beats per minute, bpm) of the walking session was recorded by Polar H10 heart rate sensor synchronized on a free-access smartphone app (Formyfit, https://www.formyfit.com; due to technical issues, HR data was only available for 39 participants), (iii) the duration of the walking session (also recorded on Formyfit), (iv) a French single-item measure of perceived exertion ("What intensity of exertion did you feel during this session?"; Likert scale ranging from 0_{null} to $10_{maximal}$; Haddad et al., 2013), (v) and the weather condition of each walking session (coded: "sunny", "cloudy", or "light_rain"; no walking

Fig. 1. Maps, illustrations, elevation, and distance of **(A)** the forest and **(B)** the urban walking routes. The forest walking trail was mainly located at the "Bois de Lauzelle" (Forest of Lauzelle); the first and last 200 m of the trail were located in the urban areas of the "Blocry" sports centre. The urban trail was located in the heart of the UCLouvain campus of Louvain-la-Neuve, which is essentially pedestrian with the exception of a few crossroads with slow urban car traffic. The urban trail was essentially constituted of university-based buildings and student housing. It featured a few spaces with natural vegetation.

sessions was undertaken under heavy rain weather condition).

2.8. Procedure

The study was carried out in winter (from November 2023 to January 2024). Sessions were conducted between 10AM and 3:30PM on weekdays to ensure daylight. Participants were allowed to schedule their sessions at their convenience within two weeks (online booking system). Participants were asked to wear clothes adapted to the weather conditions and to have installed the Formyfit app on a fully charged smartphone. Five sessions had to be rescheduled due to heavy rain. The same meeting/starting points were set for the urban and the forest session (within a quiet office at the Sports Hall Center "Blocry", Louvain-la-Neuve; see Fig. 1). Participants arrived at the meeting point using their own means of transportation.

Experimental conditions were randomized and counterbalanced using an online randomizer tool (www.randomizer.org). In the informed consent form stated that participants would take part in one nature-based and one urban-based walking session (see also Fig. 2 for details on the study procedure). During each walking session, participants were instructed to walk at their preferred pace. This procedure was chosen as research suggests that when individuals select their own exercise intensity, rather than having it imposed, they may experience a greater sense of autonomy and higher levels of enjoyment while exercising (e.g., Ekkekakis et al., 2011; Oliveira et al., 2015). Participants were requested to walk with their smartphones in silent mode and to not use their phones while walking. Participants were provided with a researcher's telephone number for emergencies, though none contacted them during the walking sessions. After the session, participants were asked whether they had used their phones or had been disturbed by their phones during the walk (yes/no questions). All participants answered "no" to these two questions.

On the day of the session participants **(i)** read and signed an informed consent form (*first walking session only), then **(ii)** filled out the STAI-S (i.e., pre-session anxiety), **(iii)** received instruction on the walking session (oral instructions about the self-selected intensity mode and written instructions on the route and duration of the trail), **(iv)** let the experimenter place the HR sensor on their right arm and synchronize it on the walking app (Formyfit), **(v)** started the walking session (pressed "start session" on the Formyfit app), **(vi)** directly after the walking session, filled-out the single-item of walking pleasure, then the single-item of physical exertion, the STAI-S (i.e., post-session state-anxiety), and finally the IPAQ. Participants received the gift voucher directly after the completion of the second walking session.

2.9. Data analyses

Before conducting the mediation analyses, we first performed preliminary checks to assess the potential confounding effects of control variables on the primary measures (walking pleasure and state anxiety change). Additionally, we ensured that the experimental conditions did not differ in baseline state anxiety and that they produced the expected primary effects necessary for testing mediation (differences in pleasure between experimental conditions and a reduction in state anxiety between the beginning and the end of the walking session).

To examine the mediation of $walking_{pleasure}$ on the type of walking environment (urban vs. forest) on state $anxiety_{change}$, we used the three-step method of Judd et al. (2001), which allows for testing mediation with a two-level within-subjects design. Fig. 3 depicts the raw data points and distribution shapes of the scores of $walking_{pleasure}$ and of state $anxiety_{change}$. All analyses were run on JASP.0.18.3. (JASP Team, 2024).

Step 1. The main effect of the independent variable (IV; the type of walking environment: urban vs. forest) on the dependent variable (DV; state $anxiety_{change}$) must first be shown. A paired Sample *t*-test was used to examine this effect.

Step 2. For step 2, regression analyses were carried out separately for each level of the within-subject factor (forest vs urban conditions), with the mediator (M; walking pleasure) as the IV and state $anxiety_{change}$ as the DV. The data on the single item of walking pleasure were not normally distributed (see Fig. 3 for raw data points and distribution shapes). Simple linear regression analyses with bootstrapped confidence intervals (based on 5000 replicates and coefficient estimate based on the median of the bootstrap distribution) were thus used.

Step 3. Finally, regression analyses were conducted (with bootstrapped confidence intervals), including the difference between the two levels of state $anxiety_{change}$ (forest minus urban) as the DV and the difference between the two M levels ($walking_{pleasure\_forest}$ minus $walking_{pleasure\_urban}$) as the IV.

As a complementary analyses, we also tested mediation using a path-analytic framework applied to within-subject design (Montoya and Hayes, 2017), as the Judd et al. (2001) approach does not allow to estimate *indirect effects* (i.e., the conjunction of the effect of the independent variable on the mediator and the effect of the mediator on the dependent variable). Specifically, we conducted a two-level within-subject mediation analysis to examine whether $walking_{pleasure}$ mediates the effect of the type of walking environment (urban vs. forest) on state $anxiety_{change}$. Given the repeated-measures nature of the data, MEMORE was used to account for within-subject dependencies and estimate the indirect effect. The analyses were run on SPSS.29.0.2.0 (IBM Corp, 2022). using the MEMORE macro (Montoya and Hayes, 2017), with 5000 bootstrap samples for bootstrap confidence intervals.

3. Results

3.1. Preliminary analyses

Control measures. The weather conditions for each session were as follows: forest: sunny = 11, cloudy = 24, light rain = 11; urban: sunny = 8, cloudy = 16, light rain = 21. The number of participants in each IPAQ category was low = 5, moderate = 12, high = 19.

Wilcoxon tests showed a higher duration (forest: $Mdn = 42.20_{min}$, minimum = 25.2, maximum = 64.2; urban: $Mdn = 37.80_{min}$, minimum = 28.0, maximum = 51.2; $W = 778$, $p < .001$, Rank biserial correlation = .72) and level of physical exertion (forest: $Mdn = 3.20$, minimum = 1, maximum = 8; urban: $Mdn = 2.78$, minimum = 1, maximum = 6; $W = 778$, $p < .001$) in the forest condition, as compared to the urban condition. No significant difference was observed on the average heart rate between the forest condition ($Mdn = 118_{bpm,}$ minimum = 92, maximum = 155) and the urban condition ($Mdn = 113_{bpm}$, minimum = 76, maximum = 142; $W = 477$, $p = .12$).

Exploratory correlation analyses revealed only non-significant (all $p > .07$) and weak coefficient sizes (Spearman's rank correlation coefficient, all $r_s < |.26|$) between primary ($walking_{pleasure}$, state $anxiety_{change}$) and control measures (level of physical exertion, average heart rate, walking session duration), for both the forest and the urban conditions. There was no main effect of weather conditions or IPAQ categories on state $anxiety_{change}$ (one-way ANOVAs, all $p > .14$) and

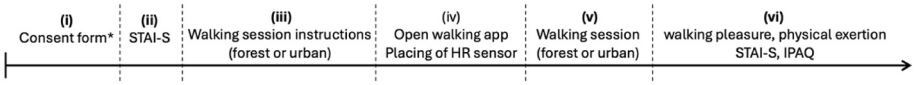

Fig. 2. Design and procedure of the experiment.

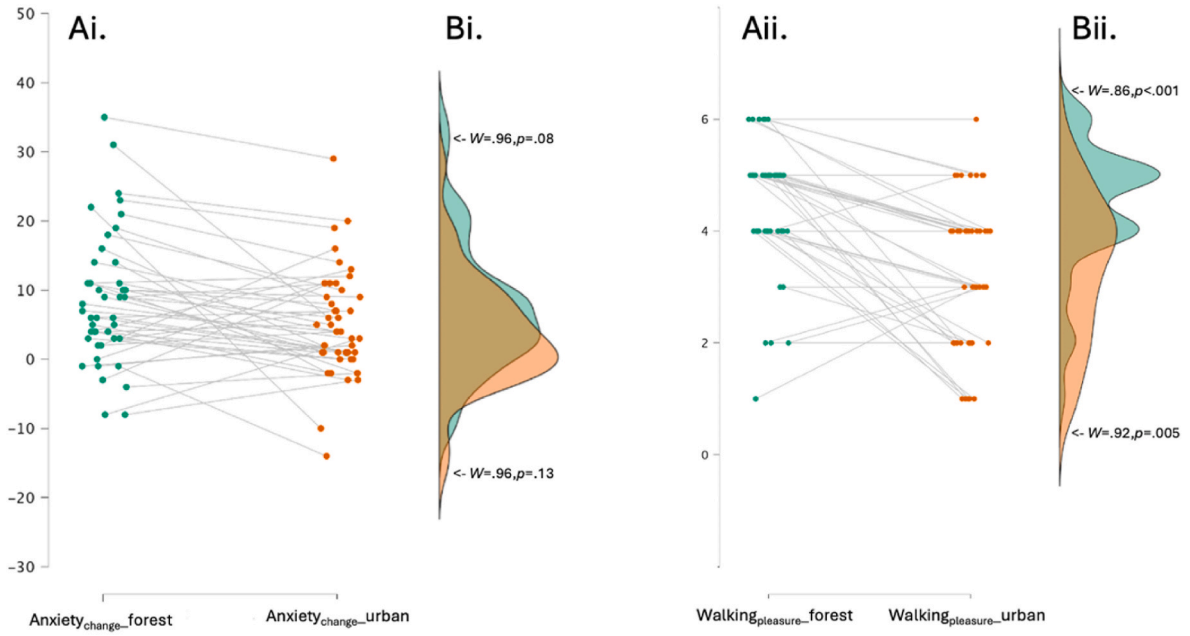

Fig. 3. **(A)** Raw data points and **(B)** distribution shapes for the scores of **(i)** $anxiety_{change}$ and of **(ii)** $walking_{pleasure}$ in the forest (in green) and the urban (in orange) walking conditions. W = Shapiro-Wilk statistics for each distribution shape.

$walking_{pleasure}$ (Kruskal-Wallis tests, all $p > .17$).

Baseline level of state anxiety. A paired-t test revealed no significant difference between pre walking session score of state anxiety between the forest ($M = 38.40$, $SD = 10.55$, minimum = 20, maximum = 64) and the urban condition ($M = 36.60$, $SD = 9.70$, minimum = 20, maximum = 54); $t[44] = 1.73$, $p = .09$, $d = 0.25$).

Level of state-anxiety change. One-sample t-tests showed that scores of state $anxiety_{change}$ were greater than 0 (test value) for both the forest condition, $t(44) = 6.14$, $p < .001$, $d = 0.92$, and the urban condition, $t(44) = 4.35$, $p < .001$, $d = 0.65$. These results indicate that both conditions decreased state anxiety between the start and the completion of the walking session.

Difference in pleasure between urban and forest sessions. A Wilcoxon test revealed a significantly higher level of pleasure in the forest ($Mdn = 5.00$), as compared to the urban condition ($Mdn = 4.00$; $W = 544$, $p < .001$, Rank biserial correlation = .83).

3.2. Mediation analyses

Step 1. We observed that the level of state $anxiety_{change}$ was higher in the forest ($M = 8.53$, $SD = 9.32$) than in the urban condition ($M = 5.00$, $SD = 7.70$; $t[44] = 2.65$, $p = 0.01$, $d = .40$; see Fig. 4A.).

Step 2. $Walking_{pleasure}$ predicted state-$anxiety_{change}$ in the forest condition, $\beta = 3.33$, $SE = 1.13$, $p = .005$, $95\%CI = 1.29–5.76$, see Fig. 4Bi, and the urban condition, $\beta = 2.69$, $SE = 0.80$, $p = .002$, $95\% CI = 1.33–4.53$; see Fig. 4.Bii.

Step 3. The state $anxiety_{change}$ level difference was predicted by the $walking_{pleasure}$ difference, $\beta = 2.77$, $SE = 1.03$, $p = .006$, $95\%CI = 0.88–4.86$, see Fig. 4C.

3.3. Complementary analyses

By undertaking a mediation analysis using a path-analytic framework applied to within-subject design (Montoya and Hayes, 2017), we observed a significant indirect effect of walking environment *on* $walking_{pleasure}$, $b = .25$, $SE = .14$, $95\%CI$ [.03, .55]. Since the confidence interval does not include zero, this suggests a statistically significant mediation effect. The direct effect of walking environment on state $anxiety_{change}$ was $b = .86$, $SE = .19$, $t(43) = 4.40$, $p < .001$, suggesting partial mediation. The mediation effect accounted for 30% of the total effect. These findings further support the hypothesis that $walking_{pleasure}$ plays a mediating role in the effect of walking environment relationship on state $anxiety_{change}$.

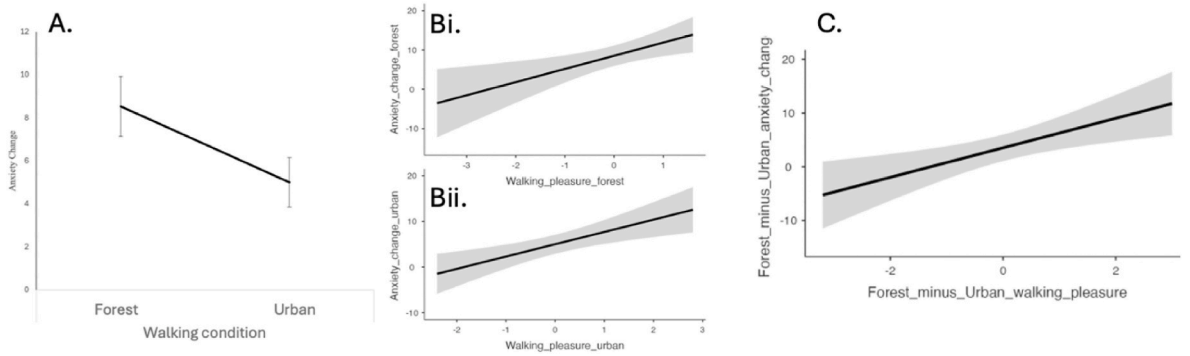

Fig. 4. **(A)** Impact of walking condition on level of state-$anxiety_{change}$, **(B)** impact of $walking_{pleasure}$ on state-$anxiety_{change}$ **(i)** in the forest condition and **(ii)** in the urban condition, **(C)** impact of $walking_{pleasure}$ difference (forest minus urban) on the state-$anxiety_{change}$ level difference (forest minus urban).

4. Discussion

In the present study, we observed that walking pleasure mediates the effect of the type of walking environment (forest vs. urban) on the decrease of state anxiety after the walk. The urban walk also decreased state anxiety through pleasure, but this effect was significantly stronger for the forest walk.

This pattern aligns with Stress Reduction Theory (Ulrish et al., 1991), which posits that an (immediate) positive affect shift from nature exposure plays a role in reducing stress and negative emotional arousal. Moreover, our findings, derived from actual walking sessions, align also well with results from studies showing comparable mediation effects using image-based exposure procedures (Beute and de Kort, 2014; van den Berg et al., 2003). Besides, present results were observed by asking university students to walk through urban and forest trails that are part of their campus environment. Accordingly, this study not only advances fundamental knowledge on the benefits of nature walks but also maps and quantifies the restorative potential of local urban and forest walks. Hence, local university mental health centres could use the present findings to further promote nature-based walks to regulate anxiety states in the university community. Nevertheless, one limitation of our study is that participants did not report high levels of pre-session state anxiety (forest: low, $n = 26$, moderate, n = 18; high = 1; urban: low, $n = 28$, moderate, n = 17; high = 0). It is, therefore, important to examine whether the present findings can be generalised to individuals experiencing high levels of state anxiety, such as students during exam sessions. Indeed, studies have shown that those who experience high levels of anxiety have a more blunted hedonic response capacity, meaning they have a diminished response to pleasurable activities (Pizzagalli et al., 2007; Yalçın et al., 2023). A second limitation concerns the lack of a non-walking control group. Although it is unlikely that the observed reductions in state anxiety would have occurred spontaneously (i.e. without the intervention), a simple time-effect (further fueled by the mere participation in the experiment or by participants' expectations toward anxiety decreases) cannot be completely ruled out.

In the present study, pleasure was assessed using a single-item measure capturing the overall experience of walking pleasure, which revealed a partial mediation effect. Future studies are needed to determine whether walking in nature decreases state anxiety through multiple hedonic-based mechanisms simultaneously (e.g., by testing models with multiple mediators in within-subject designs; Montoya and Hayes, 2017). For instance, the affective-reflective theory of physical activity (ART; Brand and Ekkekakis, 2018; Ekkekakis & Brand, 2019; 2021) advances that pleasure is a core part of the affective experience of physical activity, and can be conceptualized in three distinct yet related ways. These variants assessed through the Affective Exercise Experiences (AFFEXX) questionnaire (Ekkekakis et al., 2021), include: (1) pleasure vs. displeasure, (2) high-activation pleasure vs. low-activation displeasure (e.g., energizing-fatiguing, invigorating-tiring), and (3) high-activation displeasure vs. low-activation pleasure (e.g., stressful-relaxing). Studies adopting this approach could provide a more fine-grained understanding of the mediation effect of walking pleasure from a dimensional perspective.

Future studies are also needed to better understand under which specific walking conditions the effect of pleasure on state anxiety is the strongest. Specifically, in the present study, participants were asked to provide retrospective pleasure ratings of the overall walking session. It is possible, however, that the level of pleasure may not be stable throughout the walk. For instance, during certain parts of the walking trail or at various points throughout the walk, individuals may experience heightened pleasure (e.g., achieving an optimal state of experience while walking (Antonelli et al., 2021). This research question could be examined by requesting participants to (verbally) report pleasure ratings at specific stages of the session (e.g., beginning, middle, end), and not only after the session.

Future studies should also adopt experimental designs to further examine the effect of pleasure on state anxiety decreases. One option is manipulating the ability to predict how participants will feel during a future event, i.e., affective forecasting (Gilbert and Wilson, 2007; Wilson and Gilbert, 2003, 2005). For instance, the expected enjoyment of physical exercise increases when participants consider beginning their routine with their favourite type of exercise and ending with their least favourite exercise (Ruby et al., 2011). A comparable approach could be adapted to our design by using a framing procedure informing participants that they will either walk through a "beautiful" route or an "unattractive" route (forest or urban) while not being aware that a similar route is used in both conditions. This framing technique could experimentally modulate the level of pleasure experienced during the walk. Alternatively, participants could be instructed to adjust their walking speed, either increasing or decreasing it throughout the session. Recent studies have found that reducing effort intensity over the course of a physical exercise session is associated with greater retrospective pleasure (Fessler et al., 2024; Hutchinson et al., 2020, 2023). The present study asked participants to walk at a self-selected intensity. Introducing this experimental manipulation, however, would allow for an examination of whether the effect of walking pleasure on state anxiety varies according to changes in effort intensity.

To conclude, we found that the increased restorative effect of forest walks on state anxiety is affected by the degree of pleasure experienced during the walk. This finding should initiate new lines of research to offer fine-grained insight into the hedonic component of (nature-based) walking.

CRediT authorship contribution statement

James Madog Harris: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Claus Vögele:** Writing – review & editing, Supervision, Resources, Project administration, Funding acquisition. **İrem Tuğçe Öz:** Writing – review & editing, Methodology, Investigation, Formal analysis, Data curation. **Damien Brevers:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Acknowledgment

This study has received funding from the European Union's Horizon 2020 research and innovation program-project "SURREAL-Systems approach of urban environments and health" under grant agreement No 956780.

Data availability

Data will be made available on request.

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