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Original Research

# Effectiveness of a mindful nature walking intervention on sleep quality and mood in university students during Covid-19: A randomised control study

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ABSTRACT

*Objective:* The aim of this project was to conduct a randomised control study to examine whether outdoor mindful walking in nature can effectively improve university students' sleep quality, mood, and mindfulness during the Covid-19 pandemic in the U.K.

*Methods:* Participants were measured at $T_0$ (pre-study baseline), $T_1$ (pre-intervention), $T_2$ (post-intervention), and $T_3$ (follow-up). A total of 104 participants (female = 94) who were experiencing sleep difficulties were randomly allocated to either an experimental (i.e., nature) or control (i.e., urban) walking environment. Participants in each walking condition independently undertook a daily 35-minute walk for a week (7 days). Subjective sleep quality, total mood disturbance, mindfulness, and degree of nature connectedness, and participants' perspectives on the intervention, were collected.

*Results:* Findings suggest that both groups resulted in significant improvements in participants' trait mindfulness, sleep quality and mood after the intervention. However, mindful walking in nature did not bring additional mental health benefits to participants relative to those who walked an urban environment. Participants provided their perspectives about the intervention, which will assist with future intervention development.

*Conclusions:* Findings contribute to the evidence-base on the effectiveness of outdoor mindful walking interventions for enhancing mental health. These findings contribute new knowledge on how mindful walking outdoors reduces university students' mood disturbances and improves sleep quality and mindfulness level.

## Introduction

Walking 'in nature' has repeatedly been shown to bring more benefits than walking in other outdoor settings, such as built urban environments with busy streets, heavy traffic, and little greenery[1–4] . Walking in green space exposes people to a range of environmental sensory inputs including natural soundscapes (e.g., birdsong), visual stimuli including landscapes and flora and fauna, olfactory stimuli (e.g., plants) and tactile stimuli (e.g., heat of the sun, breezes, ground underfoot), which may also result in a greater sense of connection to nature[5,6].

Nature connectedness has been found to improve one's mood and reduce 'negative thoughts'[7]. Even passive interactions with nature may enhance one's state of mindfulness[8], while also improving mood and nurturing self-esteem[9]. According to Attention Restoration Theory, walking 'in nature' may reduce concentration fatigue (ART[10]).

ART divides human attention into two components, namely: direct, and effortless. The former is controlled by cognitive functions, which are associated with the consumption of brain capacity[4]. ART proposes that connections with nature allow people to observe the environment around them with 'effortless attention'. Effortless attention is involuntary and refers to the brain's inherent tendency to capture stimuli. Overuse of direct attention may result in mental fatigue and stress[11]. Moreover, the human attraction to nature allows cognitive processes to be relaxed, an experimental studies indicate that natural scenery has a lower attentional requirement than urban scenery[12].

ART focuses on cognitive aspects of consciousness, and more precisely, explains how nature positively affects human cognitive function[5]. As people spend more time in natural environments, greater present-moment awareness is experienced[8]. Trait mindfulness is positively associated with positive mood, and 'mind-wandering' was found to be the mediator between mindfulness and negative mood[13]. ART

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suggests that effortful attention may contribute to mental fatigue and mind-wandering, which therefore are related to mood disturbances[14]. Furthermore, a recent systematic review (n = 13) indicated that sleep quality and quantity was improved by nature exposure[15]. This suggests that green exercise has potential to be developed into an effective intervention to improve sleep quality and mood[15].

### *The present study*

College and university students experience a high incidence of mental-health concerns and sleep problems, and these may negatively impact students' mood, stress, and well-being levels, and thus impair academic achievement[16]. Up to 60% of university students have experienced sleep difficulties and 20% of students may encounter sleep disorders[17]. A cross-sectional study of 26 countries found that poor sleep quality and other sleep disturbances were experienced by 10.4% of university students[18].

It has been reported that university students' lives and studies have been negatively impacted by the Covid-19 pandemic. Specifically, the mental well-being and sleep quality of many students have been harmed by the long-termed enforced quarantine and isolation[19–22] . For example, one study found 25% university students reported symptoms of anxiety and strong concerns about academic and financial pressures because of lockdown[23]. Nearly one-third of college students reported their feelings of loneliness, worry, grief, depression, and PTSD related symptoms as they experienced frequent relocations[24]. There is an urgent need to address students' mental health issues during the COVID-19[25], therefore this study focused on this population, aiming to investigate whether nature-based mindful walking is an effective intervention to improve university students' levels of nature connection, mindfulness, mood, and sleep quality. The research questions and hypotheses were as follows:

1) Will mindful walking improve sleep quality and mood, regardless of the walking environment? The hypothesis was: mindful walking in both nature and urban environments would improve participants' sleep quality, mood, nature connectedness and mindfulness.
2) Compared with walking in urban environments, will 'nature walking' bring additional benefits in terms of mindfulness, connection to nature, mood, and sleep quality? The hypothesis was: green walking would lead to significantly greater improvements in mood, sleep quality, mindfulness, and nature connectedness than urban walking.

## Materials and methods

### *Participants*

Using G*power software[26], a-priori power analyses assuming a small effect size ($f^2$ =0.25) and 5% α error probability[27], it was estimated that a sample of 32 participants would be sufficiently powered to carry out the planned analyses (see below for details). Leaflets were distributed across a university's campuses and student accommodation and promoted via social media to recruit potential participants. The researcher contacted various department administrators who helped to promote (i.e., retweet the Twitter, email the students) this study. Interested individuals were invited to contact the principal researcher to obtain an information sheet and consent form.

A total of 118 university students registered their interests in this project, and 104 (m = 23.6 years, 90.4% female) consented to participate in the intervention between March and June 2021. Each group was assigned 52 participants. Two participants in nature group and three participants in urban group withdrew and gave their reasons. After the intervention, 20 and 28 participants of nature and urban group respectively were tested at follow-up. For the online questionnaire, 38 and 47 participants completed the survey in nature and urban groups at T1, respectively, and each group lost one participant at T2. Additionally, only 61 sleep diaries were returned to the researcher (nature = 28; urban = 33). The Consort Flow Diagram[28] in Fig. 1 shows more details about the allocation to conditions.

### *Inclusion and exclusion criteria of participants*

Participants were eligible for inclusion if they were: 1) adult university or college students (aged 16 and above); 2) self-identified as experiencing some level of sleep difficulties; 3) not in receipt of treatments for sleep problems, formally or informally, within the preceding six months (e.g., using sleep medicines or accepting psychological training for sleep difficulties); 4) self-identified as having sufficient English-language proficiency to fill in the questionnaires. Individuals who perceived themselves to be in high-risk categories regarding Covid-19 were excluded. Individuals with disabilities that might impede their engagement in a daily walking intervention were advised that they would not be suitable for participation.

### *Ethical considerations*

Ethical approval was granted by the relevant Ethics Committee at the University of Edinburgh (reference number: CLIN813). As this study was conducted just after lockdown during the Covid-19 pandemic, participants in both walking groups were reminded to follow the latest government rules (two-metres social distancing). Participants chose their own times for walking, did not meet each other, were not accompanied by the researcher or other friends, and walked alone in either an urban or natural setting. The researcher also reminded participants to wash their hands carefully before and after the walking sessions. The risks that the activity entailed were minimised becasue it was conducted outdoors.

### *Intervention*

#### *Randomisation*

This study employed a randomised controlled trail design. Participants were randomly assigned into either the experimental (i.e., nature) or control (i.e., urban) mindful walking groups. Participants firstly completed the baseline measurements, and they were randomly assigned into groups afterwards. Randomisation strategy was employed to minimise the variability of evaluation, and to avoid confounding variables from other known and unknown factors[29]. Since the sample size was relatively small (n = 104), block randomisation was employed to prevent an imbalanced number for each group[30]. A randomised list was generated using Microsoft Excel.

#### *Nature versus urban mindful walking*

The natural setting was a public park (see Fig. 2.1), a large area of open grassland crossed by lines of trees, covering 58.4 acres. The urban route (see Fig. 2.2) included the city's busiest commercial street, comprising many shops, tall buildings, crowds people and heavy traffic. However, it does run next to large formal gardens and is overlooked by the historic Edinburgh castle. All aspects of the urban walking intervention were equivalent to those of the nature walking group except for the environment. Both routes were chosen with due consideration for safety, and 30-35 minutes to walk at a moderate pace.

A guide on mindful walking was developed based on previous published guidance for walking meditation[31–33] and sent to each participant before they started the walking intervention (see Appendix. A). The mindfulness instruction focused on teaching participants to observe their body movements, their breath, and to be in the moment. The researcher gave clear guidance in advance regarding how to be mindful during the walking to ensure the participants fully understood how to mindfully walk and be involved in the environment around them. Additionally, for participants' safety and for the consistency of the intervention, participants were asked to walk during the daytime.

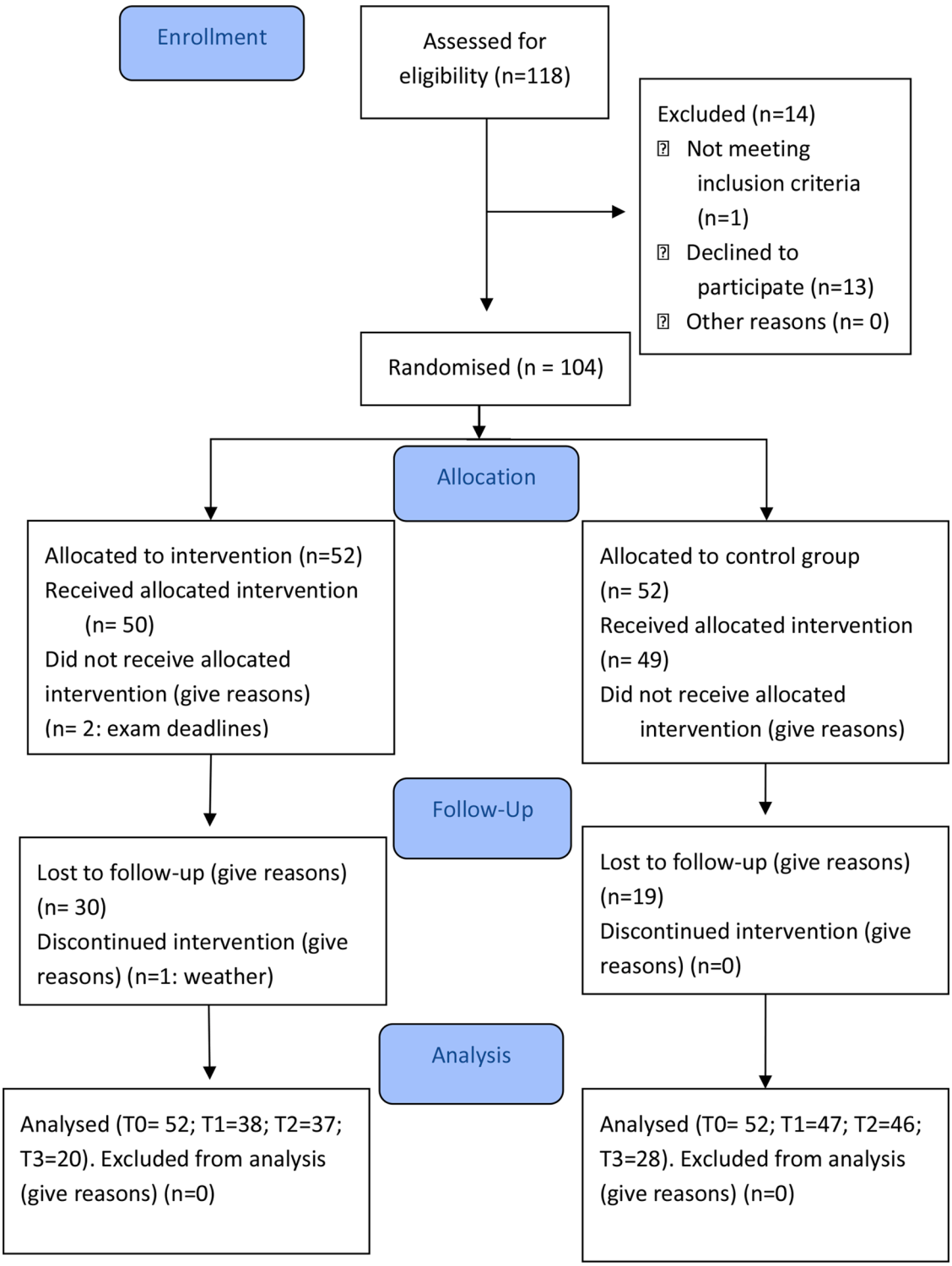


**Fig. 1.** CONSORT flow diagram. Randomised allocation to intervention environment (natural/urban) from enrolment to allocation time and to the follow-up test.

*Measures and procedures*

All the standardised questionnaires were completed digitally via Jisc online survey. The outcome measures included participants' subjective sleep quality, mood states, physical-activity (PA) levels, degrees of nature relatedness, and *state* and *trait* mindfulness.

**Demographics.** Questions regarding demographic variables included gender, age, educational level, and status regarding weekly physical activity. Participants' previous experience of walking in nature and exposure to nature, accessibility to green spaces (e.g., whether they lived near to or far away from green spaces), mental-health conditions, and treatment history regarding sleep difficulty (if any), were also asked.

**Sleep quality.** The Pittsburgh Sleep Quality Index (PSQI) was employed to measure changes of sleep quality. PSQI is a self-reported questionnaire that contains four open-ended questions regarding an individual's sleep habits. The remaining 'component scores' address a variety of factors, namely: subjective sleep quality, sleep latency, sleep

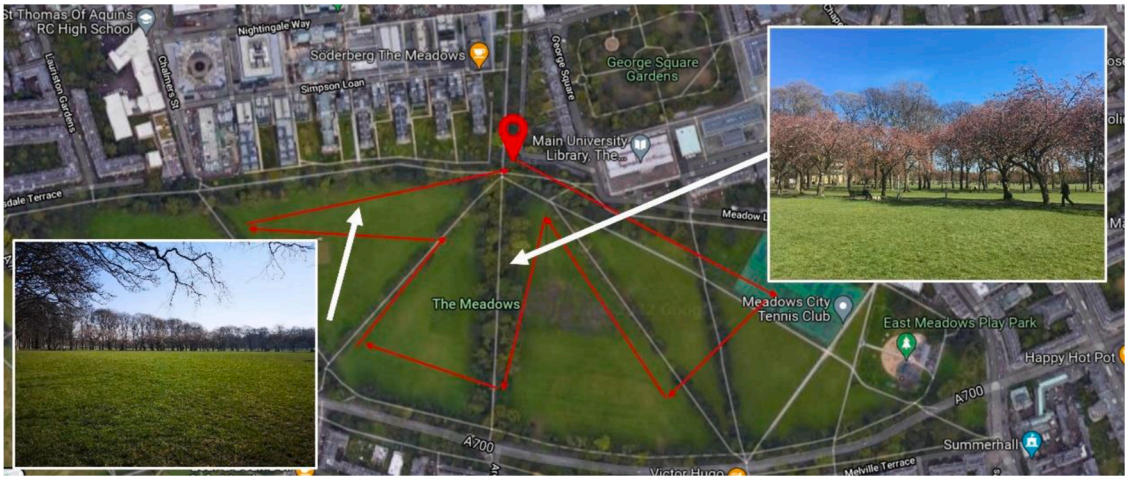


**Fig. 2.1.** Route map and inset photographs of the natural environment walk. The designed route displayed in red line. The photo in left hand and right hand were taken in February and May of 2021, respectively, by the researcher of this study. Copyright of these photos are reserved.


**Fig. 2.2.** Route map and inset photographs of the urban environment walk. The designed route displayed in red line. The photo in right hand and left hand were taken in February and May of 2021, respectively, by the researcher of this study. Copyright of these photos are reserved.

duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, daytime dysfunction, and overall rating of sleep quality in the last month[34]. A single global score is used to represent the entirety of the responses: the higher the global score, the poorer the sleep quality. The internal consistency ($\alpha > .70$) of PSQI has been found to be adequate[35]. It has also been widely reported that PSQI is a valid and reliable tool to assess sleep quality among different populations.[36–38].

**Mood.** The Short Form of Profile of Mood State (POMS-SF) was used to measure participants' daily mood states before and after their walking sessions. It is also highly flexible in capturing a participant's mood over the course of one week, as it captures his/her mood in the preceding week, 'today' and 'right now'[39]. The standard version includes 65 items with 5-point Likert response scales ranging from 'not at all' to 'extremely'. This study used the POMS short version of 37 items[40]. The internal consistency of the short-version POMS is comparable to that of the original version ($.75<\alpha<.92$) among both clinical and non-clinical samples[40,41].

**Physical activity (PA).** The short form of International Physical Activity Questionnaire (IPAQ) includes seven questions relating to the duration of vigorous/moderate physical activities, as well as the walking and sitting that participants had engaged in during the preceding week[42]. A robust level of stability is reflected in the test-retest reliability data ($\alpha < .80$)[42]. The internal reliability is also adequate ($.79<\alpha<.98$)[43].

**Nature Connection.** The degree of nature connection was measured by the Nature-Relatedness Scale, which includes six short questions with) five-point Likert scale (1 = strongly disagree, 5 = strongly agree) to assess the strength of one's connection to nature[7]. The NR-6 scale has proven robust in terms of both internal consistency and reliability ($\alpha = .83$)[7].

**Mindfulness.** Two measures were used to capture changes in mindfulness levels before and after walking. The Mindful Attention Awareness Scale (MAAS) and the Toronto Mindfulness Scale (TMS) were used to assess *trait* mindfulness and *state* mindfulness, respectively. MAAS was designed to measure changes of an individual's trait-mindfulness level overtime and has exhibited good psychometric properties ($\alpha = .83$). It has also been widely used across a range of different

samples[44,45]. Conversely, the TMS was designed to evaluate state mindfulness which reflect the instant changes of mindfulness levels before and after each walking session. It has also showed robust levels of internal consistency and validity (.84<α<.88)[46].

**Feedback form.** Two open ended questions were asked in the follow-up test: 1) what feedback for the intervention you would like to provide (both positive and negative aspects)? 2) do you have any suggestions on this intervention?

The study took 15 days in total, day 1 to day 3 were baseline period, and participants started one-week daily walking intervention from day 4 to day 10. The outcome variables were measured at four time points: pre-study baseline ($T_0$), pre-intervention ($T_1$), post intervention ($T_2$), and at follow-up ($T_3$) five days after the post-intervention. Notably, state mindfulness was tested before and after each daily walk.

During Phase 1 (day 1 - day 3), baseline data was collected ($T_0$) including demographic information, sleep quality, mood states, PA, and mood. In Phase 2 (day 4 - day 10), participants undertook their walking interventions every day for a week. Data were collected at $T_1$ (day 4) and $T_2$ (Day 10), and participants' POMS, PSQI, MAAS, and NR-6 were measured at these two time-points. TMS was completed before and after each walking session. In Phase 3 (day 11 - day 14), participants ceased walking and rested for three days. In this time participants could do as little physical activity as they liked, and the researcher did not monitor this. In Phase 4 (day 15), at the $T_3$ data collection point, the researcher sent the follow-up assessment (using POMS, MAAS, PSQI and a feedback form) to the participants.

### *Statistical analysis*

IBM's SPSS 25 statistics software was used. Descriptive statistics were explored, and Shapiro-Wilk test was adopted to test parametric assumptions and the violation of assumptions. As sample dropped down from $T_1$ to $T_3$, and to ensure the power of statistics analysis, two separate ANOVAs were conducted to compare the effects of the intervention from $T_1$ to $T_2$, and $T_2$ to $T_3$, respectively. A series of independent sample t-tests were employed to explore the difference of variations at baseline on measured dependent variables. For the open-ended questions regarding the feedback, content analysis was adopted to summarise the key information and generate themes[47]. The following steps were performed to analyse qualitative data with the current study: familiarise with contents, initial coding, structuring codes, generating themes, and defining the themes[48].

## Results

### *Sample characteristics*

The descriptive statistic shows the mean and standard deviation of the tested variables at baseline (see Table 1).

### *Exploratory data analysis*

Independent t-tests show that sleep quality (PSQI: $t = .45$, $p = .66$), total mood disturbance (TMD: $t = .81$, $p = .42$), trait mindfulness (MAAS: $t = .63$, $p = .53$), and nature relatedness (NR-6: $t = -.18$, $p = .86$) were not significantly different between the two walking groups at $T_1$, indicating that the two groups were matched at baseline, (Tables 2).

In addition, participants in both groups reported that their walking sessions took place most frequently from 16:00 to 17:00 pm (see Appendix C). An independent sample t-test showed that there was no statistically significant difference between two groups in walking duration in minutes: $t$ (57) = - 1.78, $p = .08$. Moreover, the Shapiro-Wilk test indicated that walking duration was not normally distributed ($p < .001$). Therefore, walking duration was not included as a co-variant in the following data analysis (section 3.3).

**Table 1**
Sample characteristics and outcome variables at pre-study baseline.

| Variables*N =104* | Descriptive StatisticsMean (SD)/Frequencies (%) | | 95%*CI* for mean [Lower Bound, Upper Bound] | Shapiro-Wilk test (*p*) |
|---|---|---|---|---|
| Age (mean, SD) | 23.6 (2.23) | | | |
| Gender (female/ male) | 94:10 | | | |
| Level of education N (%) | Undergraduate | 7 (6.7) | | |
| | Postgraduate (master student | 87 (83.7) | | |
| | Postgraduate (PhD student) | 10 (9.6) | | |
| Frequency of accessing natural environment N (%) | Never | 3 (2.9) | | |
| | Once a week | 51 (49) | | |
| | 2 ~3 times a week | 35 (33.7) | | |
| | Over 3 times a week | 15 (14.4) | | |
| Distance of living from natural green spaces N (%) | < 1 mile | 63 (60.6) | | |
| | 1 ~3 miles | 36 (34.6) | | |
| | 4 ~6 miles | 2 (1.9) | | |
| | 10 miles and above | 3 (2.9) | | |
| Treatment history of sleep difficulties N (%) | Pills | 7 (6.7) | | |
| | Psychotherapy | 2 (1.9) | | |
| | Non-medical supplements | 7 (6.7) | | |
| | Deep breathing/ relaxing/ meditation | 18 (17.3) | | |
| | All above | 1 (1) | | |
| | Never | 69 (66.3) | | |
| Physical activity level (mean/ SD) | Vigorous | 207 (186.27) | -24.28, 438.28 | <.001 |
| | Moderate | 165 (135.83) | -3.66, 333.66 | .64 |
| | Walking | 204 (138.13) | 32.49, 375.51 | .26 |
| | Sedentary | 420 (120) | 271, 569 | .44 |
| Mood (mean/SD) | Total mood disturbance (TMD) | 28.58 (3.80) | 23.87, 33.3 | .19 |
| | Depression | 083 (1.03) | -.46, 2.11 | .04 |
| | Vigour | 2 (.66) | 1.18, 2.82 | .64 |
| | Confusion | 1.90 (.96) | .69, 3.09 | .06 |
| | Tension | 1.57 (.81) | .55, 2.58 | .87 |
| | Anger | .54 (.71) | -.34, 1.42 | .12 |
| | Fatigue | 1.76 (.74) | .84, 2.68 | .98 |

### *The effectiveness of the intervention*

A series of 2 (Group type: Nature, Urban) × 2 (Time: $T_1$, T2) ANOVAs with repeated measured on the Time was conducted on the sleep quality, mood, nature connectedness, and mindfulness scales. Results s revealed significant effects of time on improvement of sleep, mood, and trait mindfulness. However, there was no significant interaction effect on group and time for the measured outcomes.

**Sleep quality.** There was no significant interaction between group and time on sleep quality, $F$ (1, 81) = 1.49, $p = .23$, $\eta 2 = 0.02$, or main effect of group, $F$ (1, 81) = .19, $p = .67$, $\eta 2 < .01$. Significant effect of time was found with medium effect size, F (1, 81) = 6.86, $p = .01$, $\eta 2$ =.08, driven by a reduction of sleep quality of both groups from pre-intervention to post-intervention. The mean scores of sleep quality of

**Table 2**
Summary results table of outcome means and SD from $T_1$ to $T_3$.

| Outcome measures Mean (SD) [95%CI[a]] | Nature | | | Urban | | |
|---|---|---|---|---|---|---|
| | T1(n= 38) | T2(n = 37) | T3(n = 20) | T1(n = 47) | T2(n = 46) | T3(n = 28) |
| PSQI | 5.32 (3.03) | 3.89 (2.42) | 5.0 (2.16) | 5.09 (2.67) | 4.57 (3.14) | 5.71 (2.88) |
| | [4.31; 6.33] | [3.08; 4.70] | [4.12; 6.18] | [4.27; 5.91] | [3.49; 5.37] | [4.60; 6.83] |
| MAAS | 2.77 (1.14) | 3.0 (.88) | 3.11 (.77) | 2.64 (.92) | 3.02 (.70) | 3.13 (.83) |
| | [2.19; 3.17] | [2.72; 3.31] | [2.74; 3.47] | [2.35; 2.92] | [2.80; 3.24] | [2.80; 3.45] |
| NR-6 | 2.50 (.68) | 2.77 (.73) | - | 2.53 (.84) | 2.58 (.79) | - |
| | [2.28; 2.73] | [2.53; 3.02] | | [2.25; 2.77] | [2.33; 2.81] | |
| TMD | 29.77 (4.27) | 27.34 (3.95) | 26.40 (3.24) | 29.16 (4.37) | 27.77 (3.74) | 26.70 (3.88) |
| | [28.20; 30.99] | [26.12; 28.76] | [24.89; 27.92] | [27.83; 30,49] | [26.64; 28.91] | [25.17; 28.13] |

*Note.* [a] CI: Confidence Interval. For the PSQI and TMD, the lower scores indicate better sleep quality and less mood disturbance, respectively. For the MAAS and NR-6, the higher scores indicate greater levels of trait mindfulness and nature relatedness, respectively.

both intervention groups reduced from the pre-intervention to the post-intervention indicating improvement in sleep quality. Inspection of means indicated that Participants in the nature group decreased in mean sleep scores more than the urban group, indicating that sleep quality of the nature group improved more than urban group on average (See Fig. 3.1).

**Mood.** There was no significant interaction between group and time on total mood disturbance (TMD), $F$ (1, 80) = .61, $p$ = .44, $\eta 2$<.01, or main effect of group, $F$ (1, 80) = .02, $p$ = .89, $\eta 2$<.01. There was a significant main effect of time with medium effect size, $F$ (1, 80) = 8.09, $p$ <.01, $\eta 2$=.09, suggesting that participants, regardless of group, reported a reduction in mood disturbance (See Fig. 3.2).

**Trait Mindfulness.** There was no significant interaction between group and time on trait mindfulness, F (1, 82) = .33, $p$ = .57, $\eta 2$ < .01, or main effect of group, $F$ (1, 82) = .13, $p$ = .72, $\eta 2$ < .01. There was a significant main effect of time with medium effect size, $F$ (1, 82) = 5.15, $p$ = .03, $\eta 2$ = .06 (See Fig. 3.3). This showed that for both walking conditions trait mindfulness scores improved following the intervention.

**Nature Relatedness.** There was no significant interaction effect ($F$ (1,82) = .86, $p$ = .36, $\eta 2$ = .01), main effect of group ($F$ (1, 82) = .36, $p$ = .55, $\eta 2$ < .01), or main effect of time ($F$ (1, 82) = 1.95, $p$ = .17, $\eta 2$ = .02) (See Fig. 3.4) for nature relatedness.

**State mindfulness.** This was measured before and after each walking session. For the subscale curiosity there was no significant interaction between group and time, $F$ (1,99) = .30, $p$ = .59, $\eta 2$ < .01, main effect of group, $F$ (1, 99) = .29, $p$ = .59, $\eta 2$ < .01, or main effect of time, $F$ (1, 99) = .01, $p$ = .91, $\eta 2$ < .01. Similarly, no significant interaction effect ($F$ (1,80) = .10, $p$ = .76, $\eta 2$ < .01), main effect of group ($F$ (1, 80) = 1.78, $p$ = .19, $\eta 2$ < .01) or time ($F$ (1, 80) = .01, $p$ = .94, $\eta 2$ < .01) for the subscale decentring (see Table 3).

*Follow-up analysis*

Two-way ANOVAs: 2 (Group type: Nature, Urban) × 2 (Time: $T_2$, $T_3$) were conducted to investigate the effectiveness of the mindful walking from the post-intervention to the follow-up timepoints.

**Sleep quality.** No significant interaction effect between group and time, $F$ (1, 45) = .04, $p$ = .85, $\eta 2$ < .01, nor main effect of group was found, $F$ (1, 45) = 1.29, $p$ = .26, $\eta 2$ < .01. A significant main effect of time was found with large effect size, $F$ (1, 45) = 18.25, $p$<.01, $\eta 2$ = .29, suggesting that the sleep quality for both groups increased from the post-test to the follow-up.

**Mood.** There was no interaction effect between group and time ($F$ (1, 45) = .03, $p$ = .86, $\eta 2$ < .01), main effect of intervention group ($F$ (1, 45) = .33, $p$ = .57, $\eta 2$ < .01), or main effect of time ($F$ (1, 45) = .19, $p$ = .67, $\eta 2$ < .01), indicating that the effects of the intervention on mood maintained after the post intervention to the follow-up timepoints.

**Trait Mindfulness.** Similarly, from the post intervention to the

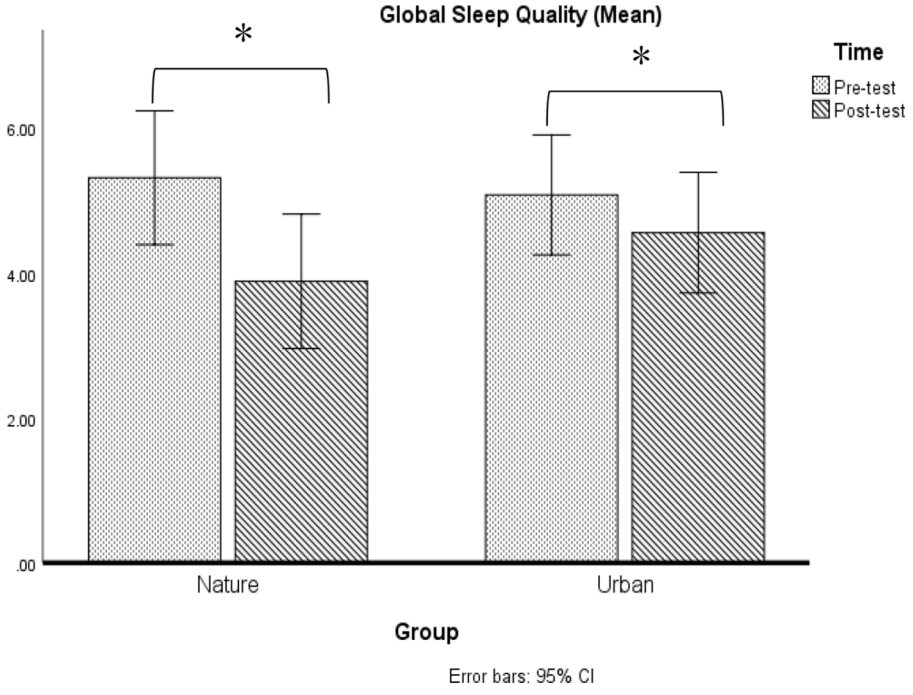


**Fig. 3.1.** Intervention effectiveness measured by sleep quality.

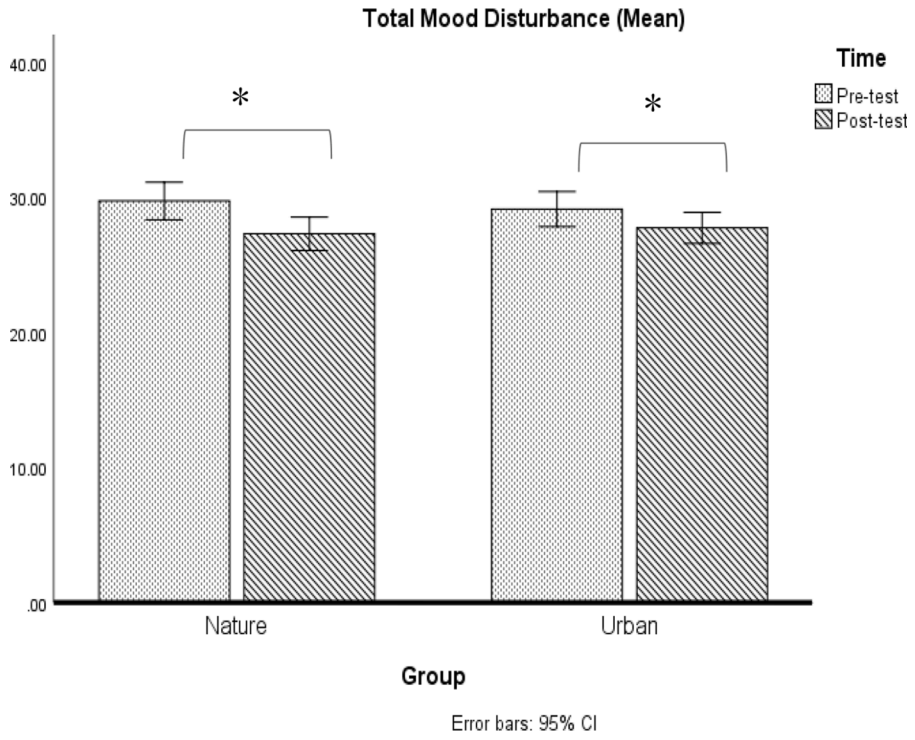


**Fig. 3.2.** Intervention effectiveness measured by TMD.

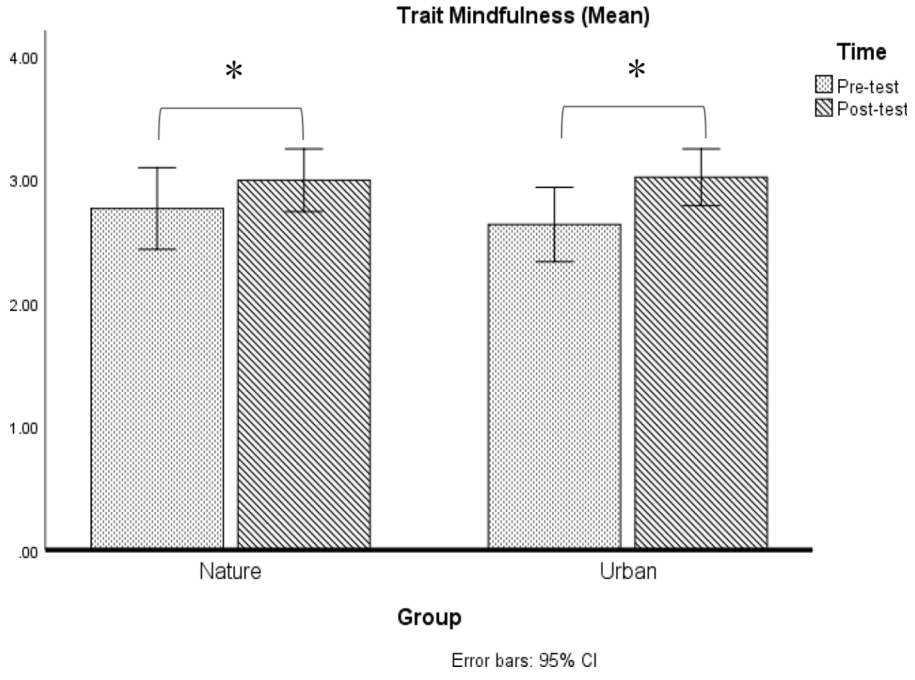


**Fig. 3.3.** Intervention effectiveness measured by trait mindfulness.

follow-up test, there was no significant interaction effect between intervention group and time ($F$ (1, 46) = .98, $p$ = .33, $\eta 2$ <=.02), no significant main effect of intervention group ($F$ (1, 46) = .39, $p$ = .53, $\eta 2$ < .01) and no main effect of time ($F$ (1, 46) = .25, $p$ = .62, $\eta 2$ < .01). It indicates that the intervention's effects on trait mindfulness were sustained from the post-intervention to the follow-up timepoints.

*Qualitative data analysis*

Feedback forms collected participants' views and suggestions about mindful walking interventions (see Appendix B). Thirty-eight open-ended answers were analysed using content analysis. Six and three themes regarding positive and negative perspectives about mindful walking were generated, respectively.

Participants perceived their sleep quality improved after the intervention. Positive mood improved and anxiety and stress were perceived

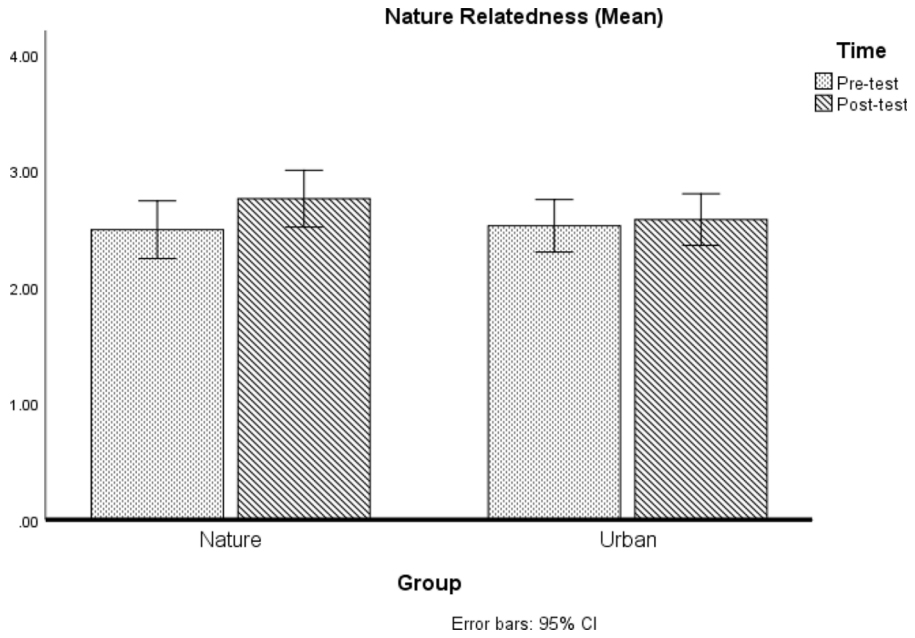


**Fig. 3.4.** Intervention effectiveness measured by nature relatedness.

**Table 3**
State mindfulness before and after each single walking intervention.

| TMS Outcome | Nature(n = 52) | | | | Urban(n = 49) | | | |
|---|---|---|---|---|---|---|---|---|
| | Curiosity | | Decentring | | Curiosity | | Decentring | |
| | Pre | Post | Pre | Post | Pre | Post | Pre | Post |
| Mean (*SD*) | 13.53 | 14.04 | 15.30 | 15.50 | 14.11 | 13.78 | 14.78 | 14.57 |
| | (3.68) | (3.41) | (3.49) | (2.81) | (3.01) | (3.46) | (3.59) | (3.44) |
| 95%CI[a] | [12.38; 14.67] | [12.98; 15.1] | [14.2; 16.39] | [14.62; 16.37] | [13.11; 15.12] | [12.63; 14.94] | [13.58; 15.97] | [13.43; 15.72] |

*Note.* [a] CI: Confidence Interval. Mean summary scores were adopted to represent the trait mindfulness level for each subscale; higher scores indicate greater levels of state mindfulness.

as decreasing following the intervention. Moreover, mindfulness practise during the walking was perceived as cultivating their sense of mindfulness and their concentration. Participants reported that it was enjoyable to stay in outdoor environments, breathe fresh air and be close to nature. In addition, the daily walk was perceived as regulating their life and bedtime, and some participants felt they became more regular and healthier. The negative feelings regarding mindful walking were described as crowded walking places, time/energy consumed by the walks, and two participants reflected that mindful walking intervention were not very effective for sleep quality improvement. Overall, the positive themes were more prevalent than themes regarding the negative aspect of the intervention. Example quotes can be found at Table 4.

Participants also recommended improving the follow-up timepoint of the intervention. They also advised that further research could use mobile Apps to track participants' walking routes and physical exercise data to increase accuracy. Future studies may consider adding objective measurements to track all walking data to control anticipated confounder variables. Additionally, participants suggested reducing the frequency of the intervention as some of them felt tried after seven consecutive walking sessions.

## Discussion

### *General Discussion*

As the university students experienced frequent lockdowns, quarantine, and accommodation relocations during the Covid-19 pandemic, their experience of depression, anxiety, negative emotions, and attention incapacity increased, which were threatening their mental health[49–52]. Sleep difficulties and mood disturbance became more prevalent than before because of the Covid-19 pandemic[53–55]. Incorporating outdoor walking in nature with mindfulness practise was hypothesised to improve university students' sleep quality and mood. Therefore, this randomised control study investigated the effectiveness of outdoor mindful walking intervention in nature on sleep quality, mood, mindfulness, and degree of nature relatedness amongst adult university students in the U.K.

Results showed that outdoor mindful walking for both groups improved university students' sleep quality, mood, and trait mindfulness levels regardless of environment. There were no significant interaction effects of group (nature versus urban walking route) and time were found for all measured outcomes, indicating that mindful walking in a natural environment does not bring additional psychological benefits to the participants compared with those who walked in an urban environment.

These results support other findings from other studies showing that outdoor walking can improve mood regardless of environment[4,56,57]. Most earlier studies have employed time-series designs or single group within-subject designs to evaluate the effectiveness of nature walking on mental health outcomes measuring participants' mood, depression, rumination, well-being and have shown that nature walks were more effective than urban walking on improvement of mood and rumination[1,4]. Only Berman and colleagues[4] and Johansson and colleagues[57] indicated that both types (rural and urban environments) of walks benefit mood improvement and rumination reduction without significant group differences. However, few studies measured both trait and state mindfulness, as well as degree of nature connectedness and level of sleep quality.

The present findings were inconsistent with a previous study which showed that only nature walking reduced negative mood, rumination, and anxiety, and improved positive affect[3,58]. This discrepancy may be due to different intervention design. Bratman and his colleague's' study[3,58] only used a single walking session, while the present study designed a consecutive mindful walking intervention for each day over one week. Therefore, it appears that multiple sessions of the mindful walking intervention would be more effective than a single session.

The present study not only conducted two types of outdoor walking (nature versus urban), but it also involved self-monitored mindful practise during the walking. After one week of walking, the mindful outdoor walking intervention was found to be effective in improving trait mindfulness, which supports the previous study that asserts that consecutive mindful walking in nature improves both positive mood and mindfulness level[59].

Few of previous studies have conducted mindful walking in nature and measured the effects of nature connection on improvement of mindfulness. The present study has extended previous literature by using a wider range of outcome variables including mindfulness. One unexpected finding was that there was no significant improvement of nature relatedness for participants in nature group after seven consecutive walking. This finding is partly consistent with one study, which has shown that the degree of nature relatedness did not significantly improve after walking for four times, however, it significantly increased when participants walked for eight weeks[60]. That study implied that the longer the forest walking, the greater the level of nature relatedness that participants may perceive. It is still unclear whether frequent that nature walking can boost a more sense of nature relatedness. Further studies should investigate the impact of frequency, intensity and duration of nature exposure with mindful walking on participants' perception of nature relatedness.

The social distance policies during Covid-19 has reduced human traffic in the study location, resulting in the urban walking route being less busy and the nature walking route being more crowded than usual. This may have increased the similarity of the two walking locations. Like one previous study concluded, if the urban walking route was not urban enough, it may potentially decrease the effect size of group differences on mood improvement[61]. Future studies should select urban walking routes in inner city areas without significant naturalised places, and choose nature walk routes in more naturalised green spaces.

### *Strengths and Limitations*

The present study has several strengths. First, repeated walks have been conducted in the intervention compared with previous research most of which only used single walking session[1,2,62–64]. Second, the randomised control study design reduces potential confounder biases which may hamper the effects of the intervention detected. Third, the qualitative data, including the perceived positive and negative aspects of the intervention, to assist future researchers develop effective mindful walking interventions.

Several limitations of the present study were identified, including: unbalanced gender distribution of participants; high homogeneous walking locations (nature versus urban); the exclusive use of self-report measures; and the under-investigation of changes of weather. More specifically, as the participants were largely female, the effects of the intervention on sex differences could not be investigated. Previous studies indicated sex differences in outdoor recreation activities – males are more likely to participate in nature-based activities (e.g., hiking, hunting, camping) than females[65]. However, one empirical study highly valued and benefited from the experience of walking outdoor[66]. Further studies are encouraged to recruit more male participants and explore the sex differences on effectiveness of mindful nature walking.

Seasonal changes and health routine data were not measured in the current study. Although the differences of season may influence the effects of outdoor mindful interventions, the present study was conducted in Edinburgh city, where the weather changes and the greenery of the urban park involved in this study were not dramatically changed during data collection. Nevertheless, further studies should evaluate weather as a co-variant to better understand the effect of the intervention. Similarly, as the baseline data was collected, daily routine data was not further evaluated. However, future studies are encouraged to include

**Table 4**
Description, frequency, and percentage of participants' views of the intervention.

| Content | Description | Examples (Quotes) | N | % |
|---|---|---|---|---|
| **Positive aspects** | | | | |
| Sleep quality improvement | Participants feel that were sleeping better and falling asleep more quickly. | *"It helps me sleep better at night"* *"I can fall asleep more quickly than before"* | 7 | 18.42 |
| Mood improvement | Participants felt relaxed, calm, and improvement of positive mood; walking interventions reduce negative emotion, stress, pressure, and anxiety. | *"The walking was very helpful in terms of relieving me from the pressure of essay writing"* *"This is a good way to release stress especially during the pandemic period"* | 25 | 65.79 |
| Mindfulness cultivation | Mindful walking helped participants be more concentrated/ focused to observe inner mind and outdoor environment. | *"Feel more mindful and relaxed…than before"* *"I started to look at the flowers on the road and the expressions of people coming and going"* *"These walking sessions help me relax my mind and pay more attention to my emotions and feelings"* | 11 | 28.95 |
| Healthy lifestyle | Participants' life became more regular than before – regular bedtime and walking exercise; it is motivated to go outside and keep regular exercise. | *"I can force myself to go outside and feel fresh air"* *"It really helps me to sleep early and get up early"* *"It helps me take daily exercise somehow"* | 15 | 39.47 |
| Being active | Being more active in mentally and physically | *"After that I feel more active than before"* *"Walking outside helps lift up my spirit"* | 4 | 10.53 |
| Outdoor environment | Stay outdoors for fresh air and nice weather; close to nature. | *"I can breathe the fresh air and feel closer to nature"* | 6 | 15.79 |
| **Negative Aspects** | | | | |
| Walking environment | A little bit far, crowded, busy and noisy sometimes. | *"Walking environment are crowded and noisy sometimes"* | 4 | 10.53 |
| Time/Energy-consuming | Walking interventions were sometimes time-consuming and lead to feeling of tiredness. | *"I always feel tired at night, because I spent time walking about 30mins…"* | 5 | 13.16 |
| Non-improvement of sleep | A few of participants felt walking interventions did not improve their sleep quality. | *"I think it only worked a little to help sleep at night"* | 2 | 5.3 |

daily health status data, such as body temperature, feeling of tiredness, levels of vigorousness, and heart rate, which may provide valuable information of how individual differences in health status impact intervention effectiveness.

Moreover, the time of walking may influence the effects of the intervention. One previous study indicated that although people's fatigue increases from morning to afternoon, walking patterns can be constant throughout the day[67]. Another experimental study demonstrated that chronotype (morning-type, evening-type, or neither-type) is likely to affect one's psycho-biological exercise responses[68]. In the present study, participants mostly walked from 4 pm to 5 pm, which were chosen by themselves, and might reflect their general circadian chronotypes. Future studies may benefit from evaluating whether walking time and circadian chronotype of participants influence the effectiveness of mindful walking intervention.

Finally, one meta-analysis suggested the best dose of the green exercise is from 10 to 60 minutes in a day[69]. However, the most effective duration of mindful walking in nature has rarely been examined. An intervention study conducted a one-month mindful walking amongst elder adults, comprising eight walking sessions, which found to be effective on reducing negative affect[70]. The seven consecutive mindful walking sessions in the present study were effective, so future studies could further investigate the best dose and frequency of mindful walking for young adults.

*Clinical implications and further direction*

Firstly, sleep difficulties and mood problems are prevalent amongst university students[71], and may compromise their academic ability[72]. Additionally, research has suggested that sleep patterns have changed, and sleep efficiency was poorer than usual during the Covid-19 pandemic among the university students[73,74], which was related to increased stress and anxiety levels[74,75]. The current study suggests that mindful walking outdoors could be an effective way to support university students and young adults to cope with their sleep problems and mood disturbances. Outdoor mindful walking is self-guided and easy to engage in, so students' welfare services can encourage their students to self-help using this activity.

Qualitative data highlighted that most participants perceived outdoor mindful walking as fostering a healthier lifestyle and encouraging them to be more active. It enhanced subjective sleep quality and improved their mood. Some negative aspects of the intervention were also mentioned by participants, which are useful for professionals to shape future interventions to enhance acceptability among university students. For example, we recommend mindful walking in nature with multiple walking routes in quiet places; and mindful walking either with less frequent sessions or for shorter periods (less than 45 minutes).

Future studies should examine the effectiveness of nature walking interventions with other populations. It is also worthwhile adding nonactive control groups in a RCT study (i.e., group participants practise mindfulness without walking outdoors; or indoor mindful walking group without views, etc.). Finally, comparing the effectiveness of different types of mindful walking (indoor versus outdoor), as well as various forms of mindful practise (with or without physical activity) could inform the development of effective interventions for improving university student's mental health outcomes.

## Conclusions

Outdoor mindful walking in either a natural environment or an urban area for one week is associated with improvements in sleep quality, trait mindfulness and mood among university students in the U. K. Upon further evaluation and development, walking interventions can be implemented to support university students cope with sleep difficulties and mood disturbance. RCT studies with non-active control groups are needed to confirm the best dose of outdoor mindful walking to improve sleep, mood, mindfulness and other mental health outcomes among university students and other populations.

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## Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request (not available for commercial use due to ethical restrictions).

## Declaration of Competing Interest

No conflict interests.

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## Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.explore.2022.08.004.

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