Effectiveness of mindful walking intervention on nature on sleep quality and mood among university student during Covid-19

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Original Research

Effectiveness of mindful walking intervention in nature on sleep quality and mood among university student 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 lockdown of 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 environments. 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, and participants' perspectives and suggestions about the intervention, were collected.

Results: Findings suggest that both groups exhibited significant improvements on participant's trait mindfulness, sleep quality and mood after the intervention. However, mindful walking in nature did not bring additional mental health benefits to participants than those who walked in urban environment. Participants reflected their perspectives about the intervention, which will assist with further intervention development.

Conclusions: Findings contribute to the evidence base for the effectiveness of outdoor mindful walking interventions on mental health. Especially these findings add new knowledge of how mindful walking outdoors reduces university students' mood disturbances and improves their sleep quality and mindfulness level during the pandemic.

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 no significant 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 is 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 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

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experimental study indicated that natural scenery has a lesser 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 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 undoubtedly 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]. It is urgent 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 significantly improve greater levels of mood, sleep quality, mindfulness, and nature connectedness than urban walking.

Materials and methods

Participants

Using G*power software[26], a-priori power analyses assumed 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 campuses and student accommodations and promoted via social media to recruit potential participants. The researcher contacted various departmental administrators who helped to spread words (i.e., retweet the Twitter, email the students) about 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 has been 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 in follow-up. For the online questionnaire, 38 and 47 participants completed the survey in nature and urban group 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.

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 to be not suitable for participation.

Ethical considerations

Ethical approval was granted by the relevant Ethics Committee at the University (reference number: CLIN813). As this study was conducted after lockdown and during the Covid-19 pandemic, participants in both walking groups were reminded to follow the latest government rules (two-metres social distancing). The participants chose their own times for walking, did not meet each other, were not accompanied by the researcher and 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 low in any case since 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 filled in 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 of the current study 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), comprising a large area of open grassland crossed by a line of trees; it covers 58.4 acres in total. The urban route was designed by the researcher (see Fig. 2.2). The latter is the city's busiest commercial street, comprising many shops, tall buildings, crowds of tourists and shoppers, 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 each took roughly 30-35 minutes to walk at a moderate pace.

A guide on mindful walking was developed by the researcher based

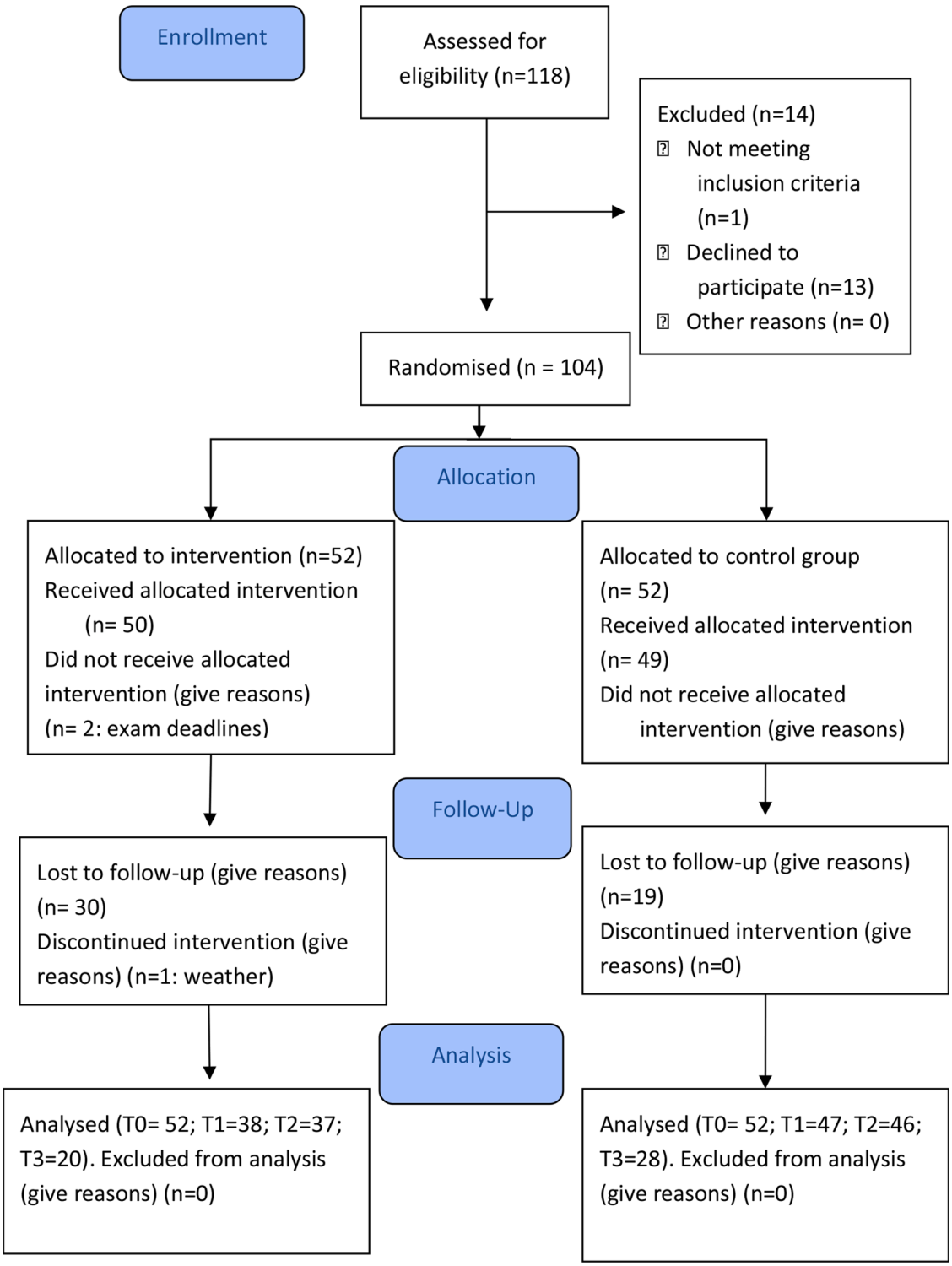

Fig. 1. CONSORT flow diagram. Randomised allocation to intervention environment (natural/urban) from enrolment to allocation time and to the follow-up test.

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 the present moment. The researcher gave clear guidance in advance regarding the way to be mindful during the walking to ensure the participants fully understand how to mindfully walk and be involve in the environment around them. Additionally, for participants' safety and for the consistency of the intervention, participants were asked to walk during the daytime.

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

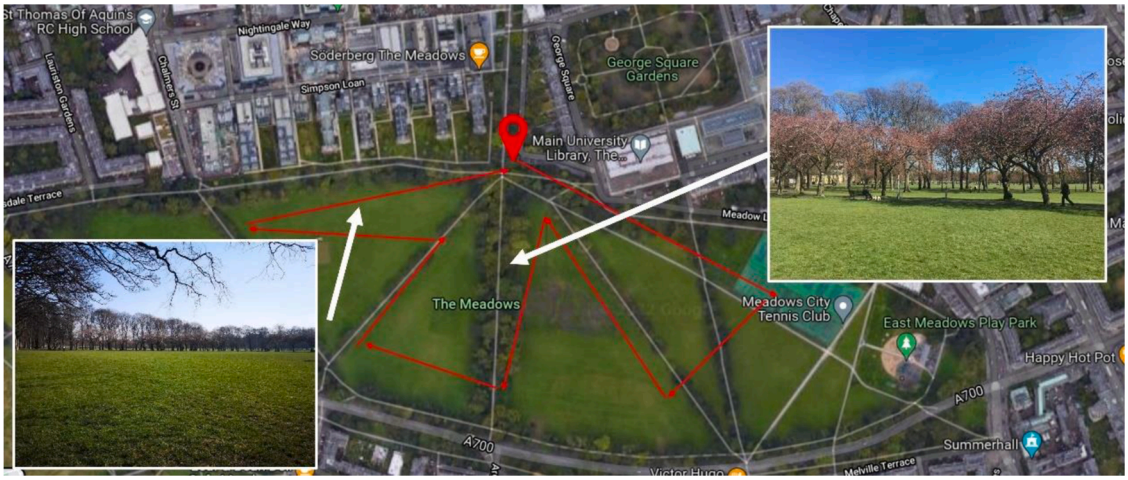

Fig. 2.1. Route map and inset photographs of the natural environment walk. The designed route displayed in red line. The photo in left hand and right hand were taken in February and May of 2021, respectively, by the researcher of this study. Copyright of these photos are reserved.

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.

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 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 scale 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 (α = .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 (α = .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, which are: 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), pre-study 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 timepoints. 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 duration, participants could do as little physical activity as they can, and the researcher did not monitor this element. 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 group participants on 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 able to be counted as a co-variant in data analysis of the following part (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

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) [4.31; 6.33]	3.89 (2.42) [3.08; 4.70]	5.0 (2.16) [4.12; 6.18]	5.09 (2.67) [4.27; 5.91]	4.57 (3.14) [3.49; 5.37]	5.71 (2.88) [4.60; 6.83]
MAAS	2.77 (1.14) [2.19; 3.17]	3.0 (.88) [2.72; 3.31]	3.11 (.77) [2.74; 3.47]	2.64 (.92) [2.35; 2.92]	3.02 (.70) [2.80; 3.24]	3.13 (.83) [2.80; 3.45]
NR-6	2.50 (.68) [2.28; 2.73]	2.77 (.73) [2.53; 3.02]	-	2.53 (.84) [2.25; 2.77]	2.58 (.79) [2.33; 2.81]	-
TMD	29.77 (4.27) [28.20; 30.99]	27.34 (3.95) [26.12; 28.76]	26.40 (3.24) [24.89; 27.92]	29.16 (4.37) [27.83; 30,49]	27.77 (3.74) [26.64; 28.91]	26.70 (3.88) [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.

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 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 sleep scores more than the urban group, indicating that after the 7-day intervention, sleep quality of nature group improved more than urban group on average (See Fig. 3.1).

Mood. There was no significant interaction between group and time on the 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 however a significant main effect of time with medium effect size, F (1, 80) = 8.09, p <.01, $\eta 2$=.09, suggesting that all 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).

State mindfulness. This variable was measured before and after each single walking intervention. In terms of the subscale curiosity, results suggested no significant interaction between group and time, F (1,99) = .30, p = .59, $\eta 2$ < .01, main effect on group, F (1, 99) = .29, p = .59, $\eta 2$ < .01, or main effect of time, F (1, 99) = .01, p = .91, $\eta 2$ < .01, were found for curiosity. 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) were found 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

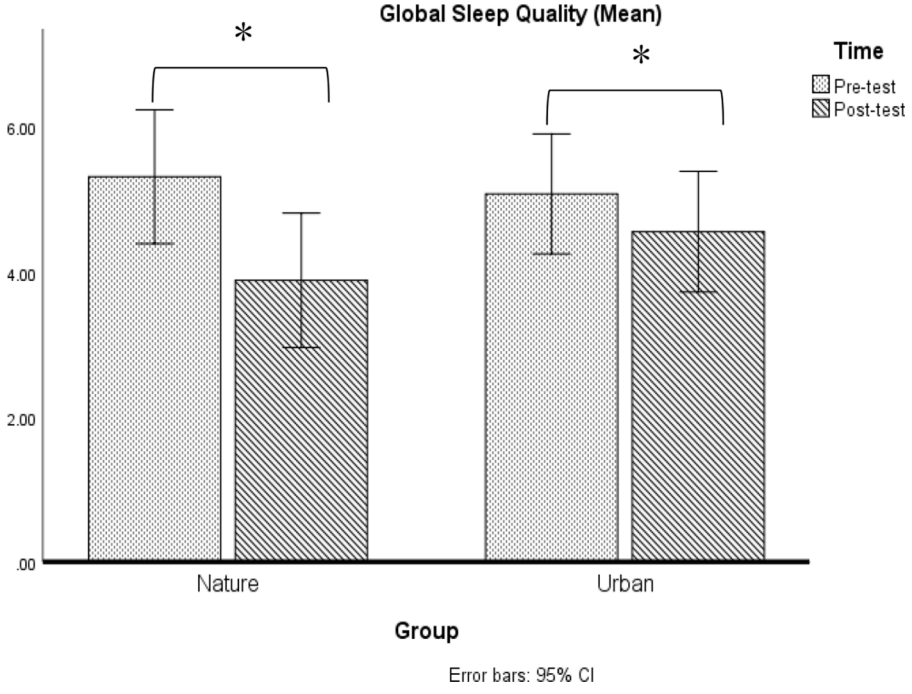

Fig. 3.1. Intervention effectiveness measured by sleep quality.

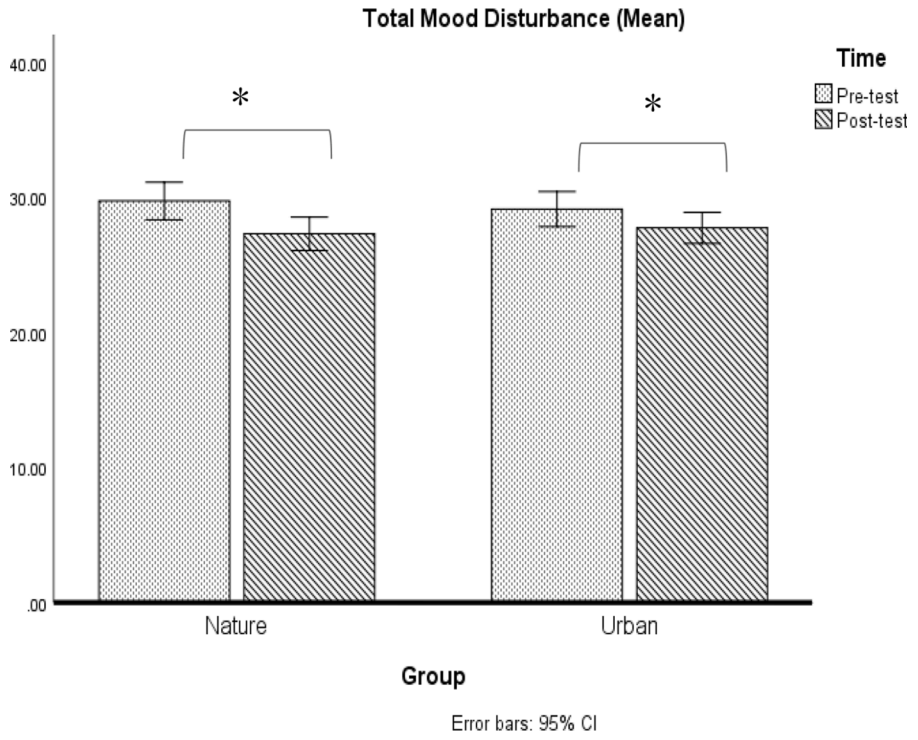

Fig. 3.2. Intervention effectiveness measured by TMD.

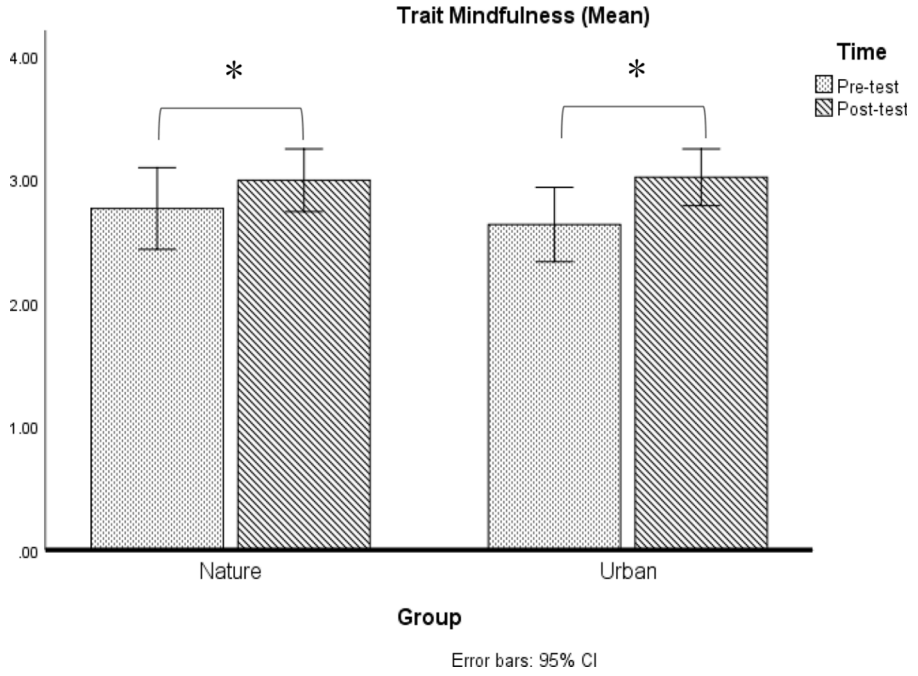

Fig. 3.3. Intervention effectiveness measured by trait mindfulness.

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), but 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 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 mood were sustained from

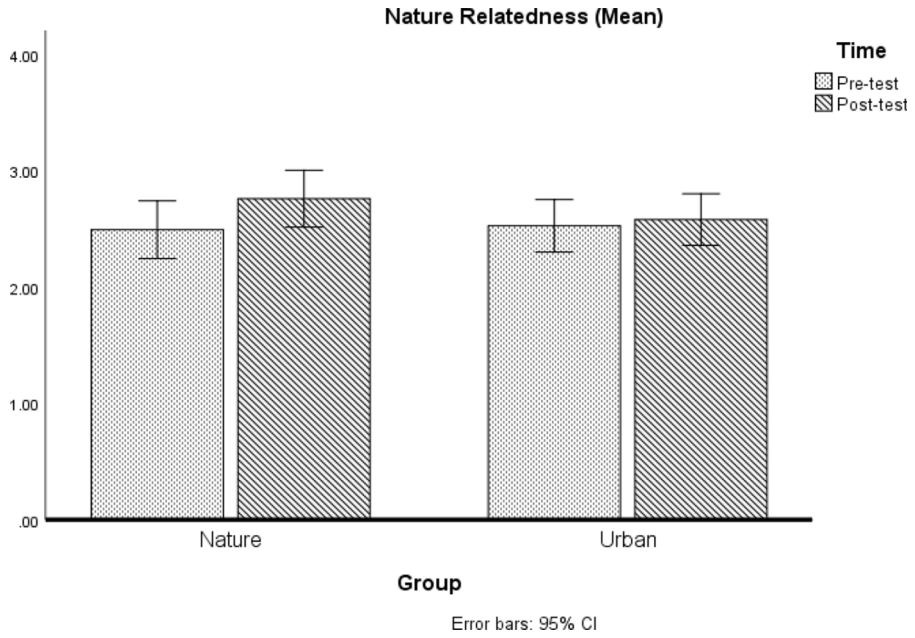

Fig. 3.4. Intervention effectiveness measured by nature relatedness.

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.

the post-intervention to the follow-up timepoints

Qualitative data analysis

Feedback forms collected participants' views and suggestions towards mindful walking interventions (see Appendix B). Thirty-eight open answers were analysed using content analysis method. Six and three themes regarding the 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 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 outdoor environment, breath 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 of the walks, and two participants reflected that mindful walking intervention were not very effective on sleep quality improvement. Overall, the positive themes are more prevalent than themes regarding the negative aspect of the intervention. Example quotes can be found at Table 4.

Participants also suggested to improve the follow-up timepoint of the intervention. They mainly advised that the further research could use mobile Apps to track participants' walking routes and physical exercise data to increase accuracy. Further studies may consider adding objectives measurement to track all walking data to control anticipated confounder variables. Additionally, participants suggested to reduce the frequency of the intervention as some of them felt tried after seven consecutive walking interventions.

Discussion

General discussion

As the university students experienced frequent lockdown, 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 assumed 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 have shown that outdoor mindful walking for in both groups can improve 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 natural environment does not bring additional psychological benefits to the participants compared with those who walked in urban environment.

These findings support other findings from the studies showing that outdoor walking can improve mood regardless of environment[4,56,57].

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

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 finding was similar but inconsistent with a previous study which showed that only nature walking can reduce negative mood, rumination, and anxiety, and improve positive affect[3,58]. The 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 better than a single session.

The present study not only conducted two types of outdoor walking (nature versus urban), but it also involves 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 assert the 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 not significantly improved after walking for four times, however, it significantly increased when participants walked for eight weeks[60]. That study implied that longer the forest walking, the greater levels of nature relatedness that participants may perceive. It is still unclear how frequent that nature walking can boost more sense of nature relatedness. Further studies can investigate the impact of frequency, intensity and duration of nature expose with mindful walking on participants' perception of nature relatedness.

The social distance policy regarding 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 has increased the similarity of the two walking locations. Like one previous related 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]. Further study should select urban walking route in inner city area 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 collected qualitative data, including the perceived positive and negative aspects about the intervention, will assist researchers to frame further mindful walking interventions.

Several limitations of the present study were identified, which are unbalanced gender distribution of participants, high homogeneous walking locations (nature versus urban), the exclusive use of self-report measures, and the under-investigations of changes of weather. More specifically, as the participants were largely female, the effects of the intervention in gender differences were not feasible to be investigated. Previous studies indicated gender differences on outdoor recreation activities – males are more likely to participate in nature-based activities (e.g hiking, hunting, camping) than female[65]. However, one empirical study reckoned the importance of gender-equality in outdoor activities and found that women were highly valued and benefited from the

experience of walking outdoor[66]. Nevertheless, regarding the limitation of the present study, further studies are encouraged to recruit more male participants and explore the gender differences on effectiveness of mindful walking intervention.

Furthermore, the seasonal changes and health routine data were not measured in the current study. Although the differences of season may influence on effects of outdoor mindful intervention, 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 the data collection. Nevertheless, further studies should evaluate weather as a co-variant to better understand the effect size of the intervention. Similarly, as the baseline data was collected, the life routine data was not further evaluated. However, the further studies are encouraged to include 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 of health statuses impact on effectiveness of the intervention.

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 the afternoon, walking patterns can be constant throughout the day[67]. Arguably, 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. Further studies may benefit from evaluating whether the walking time and circadian chronotype of the participants influence on the effectiveness of the mindful walking intervention.

Additionally, 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 recommended. An intervention study conducted an one-month mindful walking amongst elder adults, comprising eight walking sessions, which found to be effective on reducing negative affect[70]. Therefore, seven consecutive mindful walking sessions in the present study can be effective, although further studies could investigate the best dose and frequency of mindful walking for young adults.

Clinical implications and further direction

Firstly, as sleep difficulties and mood problem are prevalent amongst university students[71], which 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 outdoor 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 a self-guided and easy way to engage in, students' welfare services can encourage their students to self-help if they need.

Lastly, qualitative data highlighted that most participants perceived outdoor mindful walking fostered a healthier lifestyle and encouraged them to be more active, enhanced subjective sleep quality and improved their mood. Some negative aspects of the intervention were also mentioned by participants, which are useful for the professionals to shape the further intervention to be more acceptable for the university students. For example, we recommend further mindful walking in nature with multiple walking routes in quite places; and the mindful walking is better to be organised either with less frequency or for shorter period (less than 45 minutes).

Further studies should examine the effectiveness of nature walking intervention amongst other types of population. It is also worthwhile to add non-active group in a RCT study (i.e., group participants practise mindfulness without walking outdoor; or indoor mindful walking group without views, etc.), to compare the effectiveness of different types of mindful walking (indoor versus outdoor), as well as various forms of mindful practise (with or without physical activity) in terms of developing helpful 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 to cope with sleep difficulties and mood disturbance. Further similar RCT studies with non-active control group are needed to confirm the best dose of outdoor mindful walking on improvement of 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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