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Examining the effectiveness of mindfulness practice in simulated and actual natural environments: secondary data analysis

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Abstract

This study compared mindfulness practice outcomes retrieved from the authors' earlier studies in simulated and actual natural environments. We found that both simulated and actual natural environments boosted these outcomes. However, the actual natural environment was associated with larger decreases in stress and greater increases in nature connectedness than the simulated natural environment. The findings evidence the potential value of simulated as well as actual natural environments as settings for the enhancement of the delivery of health care and complementary therapeutic programmes. Whilst actual natural environments are most effective, the development and use of simulated natural environments may support groups who would for mobility or other reasons have difficulty in accessing a natural environment.

Keywords: Nature, mindfulness practice, mental health, wellbeing, nature connectedness

1. Introduction

Mindfulness-based intervention is one of the therapeutic programmes recommended by the National Health Service in England, effective in supporting mental wellbeing and dealing with stress (Mindfulness Initiative, 2015). Mindfulness-based intervention offers an intensive 8-week or brief 4-6-week programme involving a range of mindfulness practices such as formal mindfulness meditation and mindful movement exercises (Keng *et al*., 2011; Mindfulness Initiative, 2015). The development of mindfulness skills leads to non-judgemental awareness of all experiences, which in turn increases emotional balance and psychological wellbeing (Baer, 2003). Extensive research has shown the health and wellbeing benefits of mindfulness practice including stress reduction, relief from emotional distress, depression, anxiety and the improvement of cognitive performance (e.g. Song and Lindquist, 2015; Simpson *et al*., 2017). Recently, some studies have investigated the effect of combining mindfulness practice with the salutogenic effects of the natural outdoor environment. Nisbet *et al*. (2019) found that participants who combined a guided 20 minutes' mindfulness practice with walking in a natural environment reported greater awareness of their surroundings, stronger nature

connectedness and fewer negative emotions than individuals without the natural setting. Individuals who are connected to nature derive a feeling of meaningful existence from that connection, leading to positive health and wellbeing. Han *et al*., (2016) showed that participants doing nature-based mindfulness reported a decrease in pain and depression, and an improvement in quality of life. A meta-analysis by Djernis *et al*. (2019) also showed that mindfulness meditation in natural settings enhances positive effects on psychological, physical, and social outcomes compared with indoor meditation. A study of activity patterns in the UK found that people spend an average of 95.6% of their time staying indoors, and up to 100% of their time in the case of vulnerable individuals including the elderly and people with disabilities (Vardoulakis *et al.*, 2015). Indoor lifestyles are often related to reduced physical activity and increased obesity and diabetes, leading to higher prevalence of mental health problems (Depledge *et al*., 2011). Moreover, indoor lifestyles have disconnected people from nature. Wilson's Biophilia Hypothesis (1984) implies that the lack of connection to nature may be a cause of poor mental health and wellbeing as people are inherently connected to nature (Capaldi *et al*., 2014). Thus, connection with nature should benefit human wellbeing and mental development. Beyer *et al*. (2014) found that higher levels of neighbourhood greenness were associated with lower levels of depression, anxiety and stress, and Van den Berg *et al*. (2016) found that more time spent in green space was associated with greater mental health and vitality. Recently, Ibes and Forestell (2020) found the college students who infrequently recreate outside experienced reduced mood disturbance when getting outdoors, regardless of activity. Fields in Trust (2018) also reported that green spaces (e.g. parks, woods and playing fields) across the UK were estimated to offer over £34 billion in health and wellbeing benefits. However, the need for nature is often incompatible with some settings, e.g. the workplace, hospital or private residence, where a natural environment is not always available. In these environments simulations of nature are often provided e.g. potted plants, artificial plants or pictures of nature. Ulrich's (1984) seminal work exploring the restorative influence of window views on post-operative recovery of patients following cholecystectomy found that patients with a view of trees spent less time in hospital and required less analgesic medication than those without such views. Similarly, an early study of indoor plants found that they improved psychological and physiological health and reduced symptoms of discomfort (Fjeld *et al.*, 1998).

Recently, simulated/virtual environments have been widely used to study the restorative effect of environmental exposures. Brown *et al*. (2013) utilised slideshow images to depict scenes of natural and built environments, revealing that viewing natural images enhanced stress recovery. Van den Berg *et al*. (2014) made use of short slideshows combined with video presentations to simulate the experience

of walking through built and natural urban spaces. The participants reported better stress recovery and restorative state in the natural settings compared to the urban street setting. Ray *et al*. (2020) recently found that meditation during exposure to stimuli reminiscent of the natural environment (i.e. nature sounds) enhanced nature connectedness, leading to pro-environmental behaviour. Virtual reality (VR) has also been applied to offer a more immersive experience of exposure to natural settings. For example, Valtchanov *et al*. (2010) found that the participants exposed to a virtual computer-generated forest setting had reduced stress and increased positive feelings compared with those who viewed art paintings. In Small *et al.* (2015)'s study, patients reported a reduction in worst pain scores experienced during dressing changes by VR distraction containing nature scenery. Thus far these studies indicate that simulated/virtual natural environments enhance health and wellbeing by providing restorative benefits.

However, the question of whether simulated natural environments are satisfactory substitutes for real environments has hardly been addressed. Several aspects of simulated natural environments make them different from 'actual nature', for example, limited sensory aspects, lack of interactivity with the environment, and image resolution. These limitations make a simulated environment feel less 'real' and different from the experience of actually being in that environment. Kahn *et al.* (2008) assessed physiological responses to embedding a real-time natural view via a "*plasma window*". They found that working in an office space with an actual window had a better restorative effect than working in an office with a blank wall; and that the "*plasma window*" failed to produce a similar effect to the actual window. A study by Gatersleben and Andrews (2013) showed that a walk in an actual natural environment gave better recovery from attention fatigue and greater reduction in feelings of sadness than a simulated walk did. Kjellgren and Buhrkall (2010) also examined the beneficial effect of 30-minute relaxation in simulated and actual natural environmental settings. Although both settings showed stress reduction, the actual natural environmental settings yielded greater benefits for the level of energy. Similarly, Browning *et al*. (2020) compared the effects of 6 min of outdoor nature exposure with 6 min of exposure to a 360-degree VR nature video. They found an increase in physiological arousal in both types of nature exposure; however, positive mood levels increased more in the outdoor exposure than the virtual one. The evidence, therefore, suggests that actual natural environments might have greater restorative benefits than simulated/virtual natural environments. So far, however, there is still very little understanding of differences in experience between actual and simulated/virtual natural environments. Furthermore, there is still uncertainty as to whether simulated natural environments are satisfactory substitutes for real environments in medical and clinical settings. By employing secondary

data, we compare simulated and actual outdoor experiences and examine their different effects on health and wellbeing outcomes.

This paper therefore investigates whether the mental health and wellbeing outcomes of three weeks' mindfulness practice changed when it was carried out in an actual natural environment as opposed to a simulated natural environment. We also hypothesised that participants practising mindfulness in an actual natural environment show greater nature connectedness than those experiencing a simulated natural environment. To answer these questions, we compared quantitative data from the authors' earlier studies.

2. Methods

2.1 Participants and data selection A secondary data analysis (Hinds *et al*., 1997) was conducted by incorporating data retrieved from the authors' earlier studies. Participants were recruited from staff and students in the University of Sheffield aged 18 years and over. The experimental procedure was explained to potential participants in a recruitment email which required them to send their informed consent before their participation. For study 1, 140 of 355 applicants were randomly selected by stratified random sampling. Eighteen participants who did not complete the baseline questionnaire were excluded. This resulted in 122 participants being included in study 1 (51 males, 70 females and 1 'prefer not to say'). The participants were randomly assigned to one of two intervention groups (mindfulness, relaxation group) under different simulated environmental conditions (natural, non-natural environments) during an intervention lasting three weeks. For study 2, 113 students and staff agreed to participate. A sample of 99 participants was randomly selected by stratified random sampling and completed the baseline questionnaire (37 males, 62 females). The participants were randomly assigned to a weekly one-hour mindfulness-based stress reduction programme (MBSR) in one of three different environments (i.e. natural outdoor, built outdoor and indoor environments) over six weeks. In both studies, baseline data was collected at the beginning of MBSR programme and the same suite of outcome measures were applied after the third MBSR session.

Figure 1 illustrates the data selection process. A total of 96 responses were included the analysis (45 males, 51 females; mean age of 30.97; age range 18-62), 34 of whom derived from a sample of participants who completed three mindfulness sessions within a simulated parkland environment (study 1; Choe *et al*., 2020a), whereas 30 responses came from a sample who completed three mindfulness sessions within a similar actual parkland environment (study 2; Choe *et al*., 2020b). To compare the

effects of natural environments with an alternative physical setting, 32 responses from indoor setting from study 2 were also included the analysis.

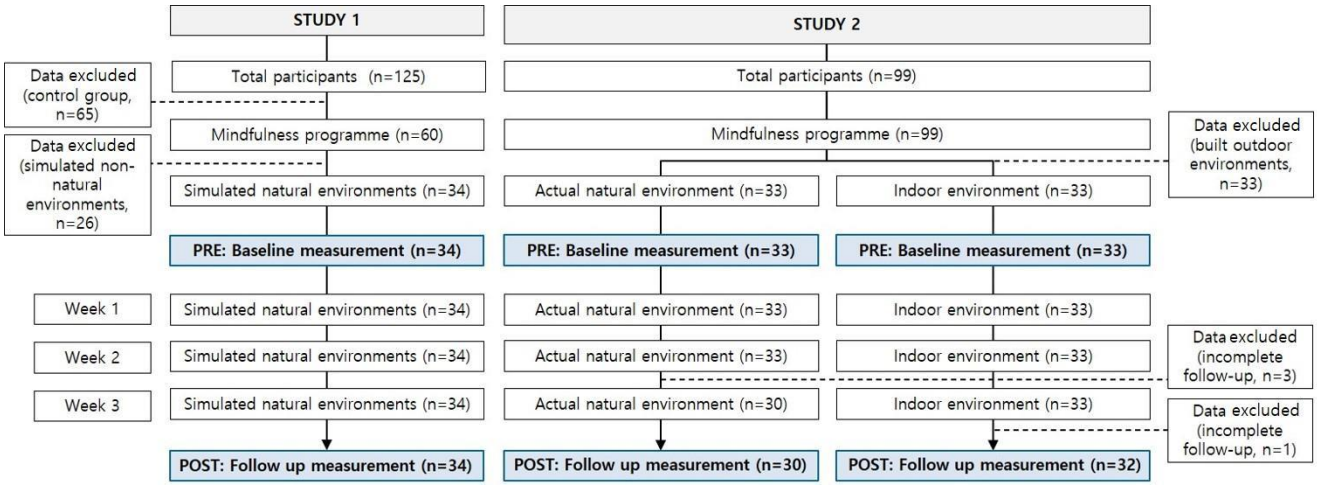


Figure 1 Flow diagram of the data selection process

2.2 Measures

The data were derived from four validated scales: Depression Anxiety Stress Scales (DASS-21), Positive and Negative Affect Schedule (PANAS), Five Facet Mindfulness Questionnaire (FFMQ-SF), and Nature Relatedness Scale (NR-6) at baseline and after the third mindfulness session.

2.2.1 Depression Anxiety Stress Scales (DASS-21)

The Depression Anxiety Stress Scales (DASS-21) contain psychological measures related to the negative emotional states associated with depression, anxiety and stress (Lovibond and Lovibond, 1995; Antony *et al.*, 1998), in the form of 21 questions. DASS-21 is a set of three self-report subscales designed to assess the negative emotional states of depression, anxiety and stress on a four-point scale (0= never, 3= almost always). The depression scale assesses feelings of unhappiness, hopelessness, and lack of interest. The anxiety scale measures subjective experiences of insecurity and uncertainty. The stress scale measures difficulty relaxing, being easily upset, irritable and over reactive.

2.2.2 Positive and Negative Affect Schedule (PANAS)

The Positive and Negative Affect Schedule (PANAS: Watson *et al*., 1988) is a self-reported adjective checklist that contains two 10-item subscales designed to measure positive (interested, excited, strong, enthusiastic, proud, alert, inspired, attentive, determined and active) and negative affect (distressed, upset, guilty, scared, hostile, irritated, ashamed, nervous, jittery and afraid). In relation to each of the 20 emotions respondents were asked to what extent they felt this way over the past week, (1= not at all, 5= extremely).

2.2.3 Five Facet Mindfulness Questionnaire (FFMQ-SF)

The Five Facet Mindfulness Questionnaire (FFMQ-SF: Bohlmeijer *et al*., 2011) assesses the efficacy of mindfulness in daily life. It consists of 24 items that measure its five facets: non-judging, non-reactivity, acting with awareness, describing and observing, measured on a five-point scale (1= never or rarely true, 5= very often or always true). A total FFMQ-SF score provides an estimate of the level of the participants' mindfulness.

2.2.4 Nature Relatedness Scale (NR-6)

The Nature Relatedness Scale (NR-6: Nisbet and Zelenski, 2013) measures affective, cognitive, and experiential aspects of 'connectedness to nature'. NR-6 is widely used to capture the feeling of connectedness to nature and predict environmental behaviours and psychological health and wellbeing. The scale contains 6 items, comprising 'a sense of identification with nature' and 'contact with nature' dimensions, measured on a five-point scale (1= disagree strongly, 5= agree strongly).

2.3 Environments

2.3.1 Simulated natural environment

In the simulated environment laboratory located at the university campus, an image was displayed on a 5.8 m x 2.2 m screen to simulate the experience of being exposed to the natural environment. The image was a view of parkland containing trees and shrubs at the edge of an open expanse of mown grass (Figure 2). Background sound was added using audio clips to convey nature-related sounds, for example, birds tweeting and wind rustling the leaves of trees.

2.3.2 Actual natural environment

Weston Park, a public park situated near the university, was selected for the actual natural environment. Like the simulated natural environment, this park consists of a well-managed green space that is filled with trees, shrubs and lawns. The experiment was performed in a location defined by planted areas that contained shrubs and small trees, as well as overlooking several distant views. Background sound was also present during the experiment, for instance, birds chirping and people talking in the distance.

2.3.3 Non-natural indoor environment

In order to give a sense of the real marginal benefit of natural environments, we conducted the same intervention in a non-natural indoor environment. This setting was a white painted room without windows in the basement of the university building. It contained a neutral-coloured picture, lights and no vegetation.

a) *Simulated* natural environment b) *Actual* natural environment c) *Non-natural* environment

Figure 2 Different experimental settings for the mindfulness practice

2.4 Analysis strategy

Before proceeding with the ANCOVAs, preliminary checks were carried out for normality, linearity, homogeneity of variances, and the reliability of covariates. First, Chi-square and ANOVA were then employed to examine differences at baseline (i.e. pre-intervention). Next, a one-way ANCOVA was performed to compare the impacts of two environments (simulated and actual natural environments) had on mindfulness outcomes, whilst controlling for pre-intervention scores. Finally, paired samples t-tests were used to evaluate the effect of mindfulness practice in each group and to compare the effects

192 to those from the indoor reference group. The study analyses were conducted using SPSS for Windows
193 version 24.0 with an alpha of .05.

194 ## 3. Results

195 ### 3.1. Preliminary analysis

196 No significant variance was noted for age (χ^2= 35.56, p= .10) and gender (χ^2= 1.76, p= .42) between
197 the three assessed environments at baseline. Table 1 shows the values for the mean and standard
198 deviation for all the outcome measures before and after the three weeks' mindfulness practice and
199 provides the Paired T-test and ANCOVA results.

200 Table 1 Mean scores (and standard deviation), Paired T-test and ANCOVA results for pre-post
201 measures

Outcome measures	Group	Mean (SD)		T-test		ANCOVA		
		Pre-intervention	Post-intervention	Mean difference (95% CI)	t	F *(1,61)*	p	η^2
DASS-21 – Depression	Simulated Nature	9.73 (7.64)	6.67 (6.22)	-3.07 (-5.51, -0.63)	-2.57*	0.50	0.48	0.01
	Actual Nature	11.18(9.35)	6.53 (6.35)	-4.65 (-6.87, -2.42)	-4.25**			
	Indoor (reference)	9.38 (8.21)	7.31 (6.36)	-2.06 (-3.68, -0.45)	-2.61*			
DASS-21 – Anxiety	Simulated Nature	8.13 (5.80)	6.93 (4.26)	-1.20 (-3.79, 0.99)	-1.01	0.49	0.49	0.01
	Actual Nature	11.71 (7.78)	9.36 (6.78)	-2.35 (-4.36, -0.35)	-2.39*			
	Indoor (reference)	8.72 (8.71)	7.44 (7.55)	-1.28 (-2.46, -0.11)	-2.07			
DASS-21 – Stress	Simulated Nature	15.12 (8.30)	13.88 (6.91)	-1.24 (-3.79, 1.32)	-0.98	8.47	0.01*	0.12
	Actual Nature	16.20 (7.71)	10.47(4.19)	-5.73(-8.52,- 2.95)	-4.21**			
	Indoor (reference)	14.66 (9.81)	13.44 (7.98)	-1.22 (-2.59, 0.15)	-1.82			
PANAS - Positive affect	Simulated Nature	31.47 (6.99)	32.60 (8.27)	1.13 (-0.87, 3.14)	1.16	1.42	0.24	0.02
	Actual Nature	31.91 (6.42)	34.59(5.79)	2.68 (0.29, 5.07)	2.28*			
	Indoor (reference)	31.94 (6.28)	32.91(7.11)	0.97 (-1.52, 3.45)	0.80			
PANAS - Negative affect	Simulated Nature	25.68 (6.59)	22.85 (7.09)	-2.82 (-5.07, 0.58)	-2.55*	1.62	0.21	0.03
	Actual Nature	25.13 (8.43)	20.80 (5.43)	-4.33 (-7.55, -1.12)	-2.76*			
	Indoor (reference)	25.75 (7.98)	22.53 (7.08)	-3.22 (-5.28, -1.16)	-3.18*			

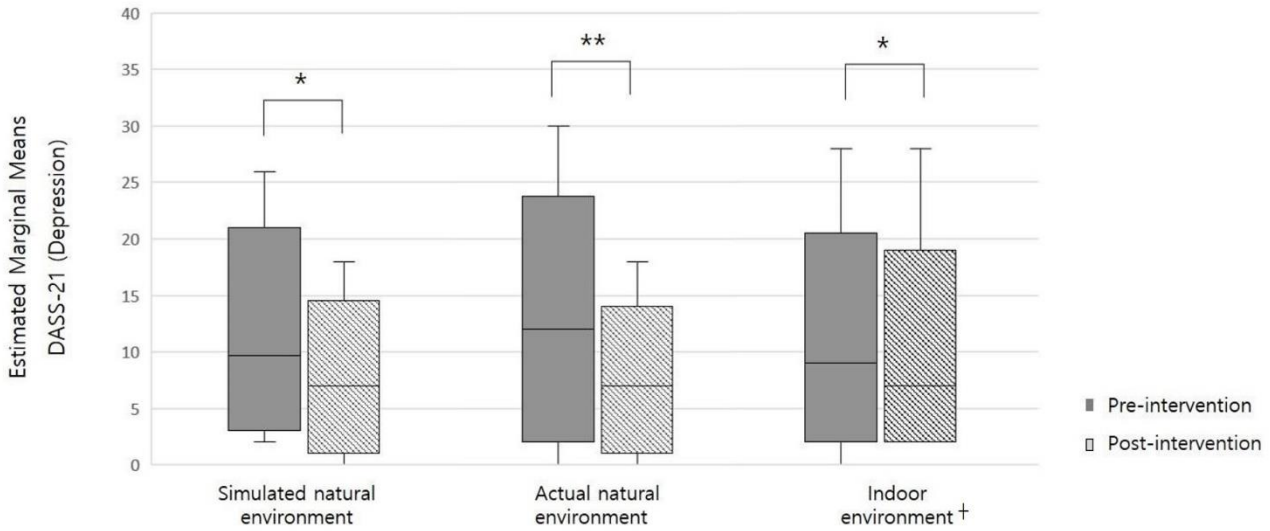
FFMQ-SF - Mindfulness	Simulated Nature	15.52 (2.47)	16.15 (1.77)	0.63 (-0.40, 1.66)	1.25*	0.08	0 .78	0.001
	Actual Nature	15.43 (2.14)	16.01 (1.81)	0.58 (0.02, 1.13)	2.10*			
	Indoor (reference)	15.33 (2.59)	15.18 (2.20)	-0.15 (-1.09, 0.79)	-0.32			
NR-6 - Nature connectedness	Simulated Nature	3.65 (0.69)	3.78 (0.62)	0.13 (-0.03, 0.28)	1.67	5.70	0.02*	0.09
	Actual Nature	3.35 (0.91)	3.85 (0.76)	0.50 (0.28, 0.72)	4.65**			
	Indoor (reference)	3.36 (0.76)	3.39(0.75)	0.03 (-0.11, 0.16)	0.40			

202 * p< .05, ** p< .001

203 **3.2 Depression, anxiety and stress**

204 ***3.2.1 Depression***

205 The results of the ANCOVA indicated that there was no significant difference between simulated and
206 actual natural environments on the post-intervention score for depression (DASS-21) after controlling
207 for pre-intervention score. Paired t-tests were used to further investigate the impact of mindfulness
208 within the group. All the groups showed a statistically significant decrease in depression from pre-
209 intervention to post-intervention. As shown in Figure 3, the group in the actual natural environment
210 showed a greater decrease in depression (42%) than the groups in the simulated natural (32%) and
211 indoor (22%) environments.



212

213 Figure 3 Change in depression by environment; Error bars denote using a 95% confidence interval. *
214 p< .05, ** p< .001, +reference group

3.2.2 Anxiety

There was no significant difference between simulated and actual natural environments on the post-intervention score for anxiety (DASS-21) after adjusting for the pre-intervention score. However, the group in the actual nature environment showed improvement in anxiety whereas the simulated nature environment and indoor groups did not (Figure 4).

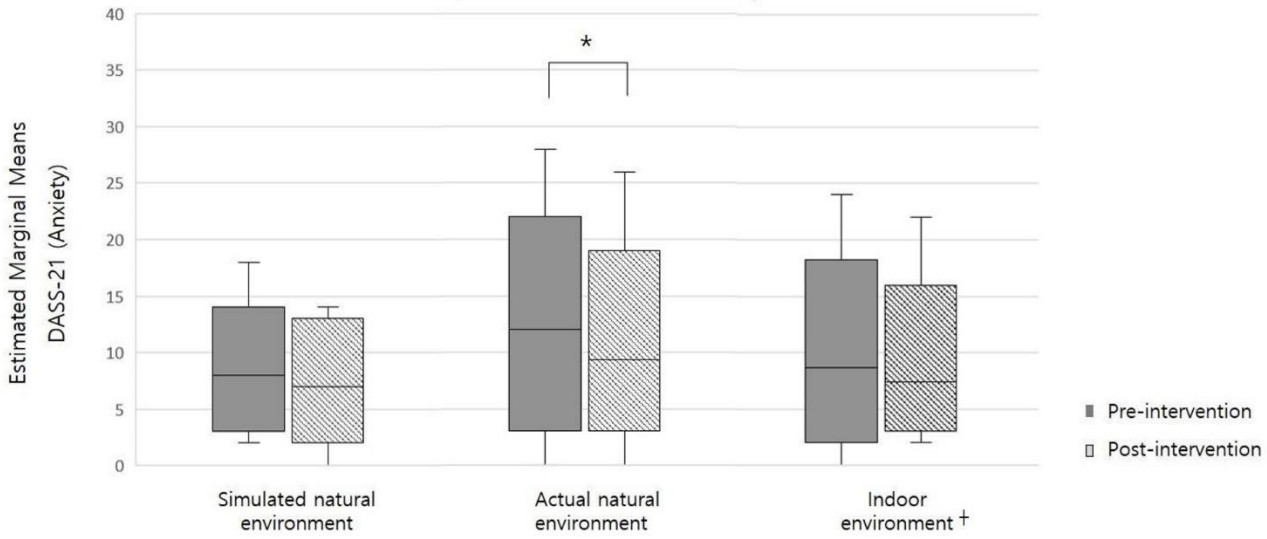


Figure 4 Change in anxiety by environment; Error bars denote using a 95% confidence interval. * p< .05, ** p< .001, +reference group

3.2.3 Stress

After adjusting for the pre-intervention score, a significant difference between the environments on the post-intervention score for stress (DASS-21) was found. Within the group in the actual nature environment, there was a statistically significant decrease in stress from pre-intervention to post-intervention (35%), but no significant decreases in the simulated environment (8%), or indoor environment (8%). Figure 5 shows that the actual environment was more beneficial in reducing stress than the simulated environment as well as the indoor.

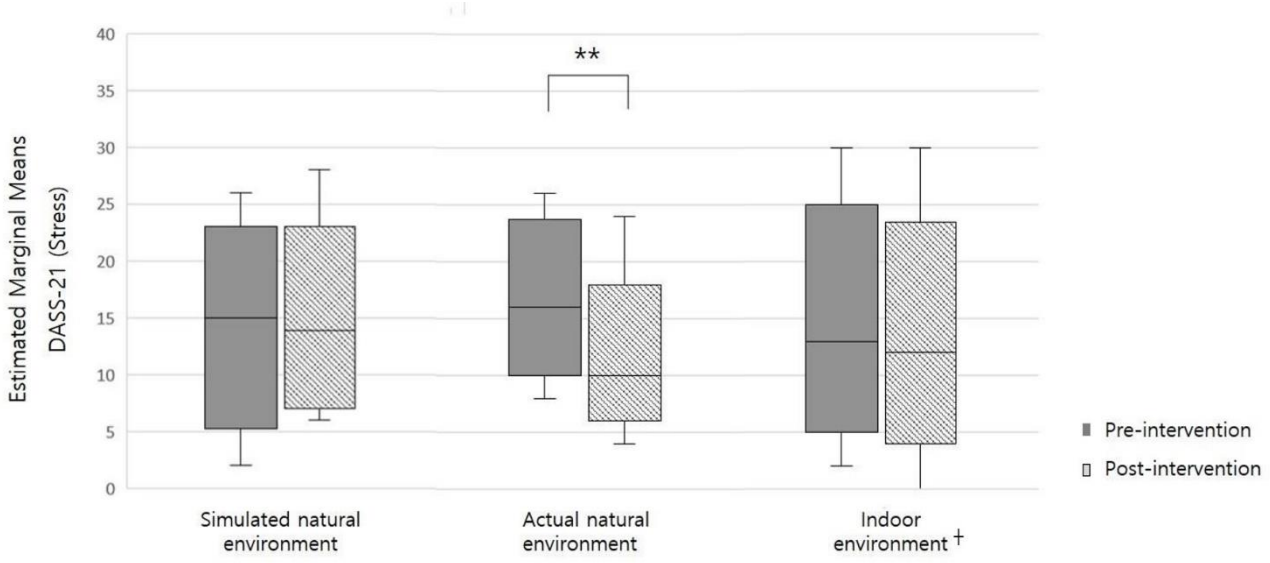


Figure 5 Change in stress by environment; Error bars denote using a 95% confidence interval. * p< .05, ** p< .001, +reference group

3.3. Positive and negative affect

3.3.1 Positive affect

After adjusting for the pre-intervention score, no significant difference between the simulated and actual natural environments on the post-intervention score for positive affect (PANAS) was found. Paired t-tests showed a statistically significant increase in positive affect within the group in the actual environment, but no significant increase in the other groups (Figure 6).

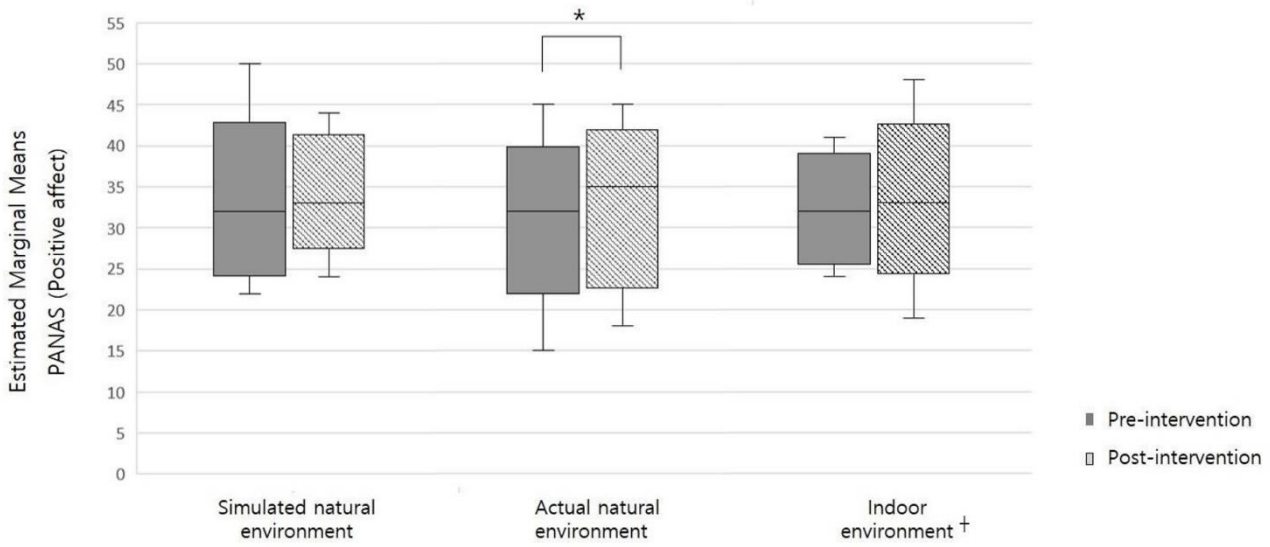


Figure 6 Change in positive affect by environment; Error bars denote using a 95% confidence interval. * p< .05, ** p< .001, ┼reference group

3.3.2 Negative affect

There was no significant effect of environment on the post-intervention score for negative affect (PANAS) after controlling for pre-intervention scores. However, all the groups showed a statistically significant decrease in depression from pre-intervention to post-intervention (Figure 7).

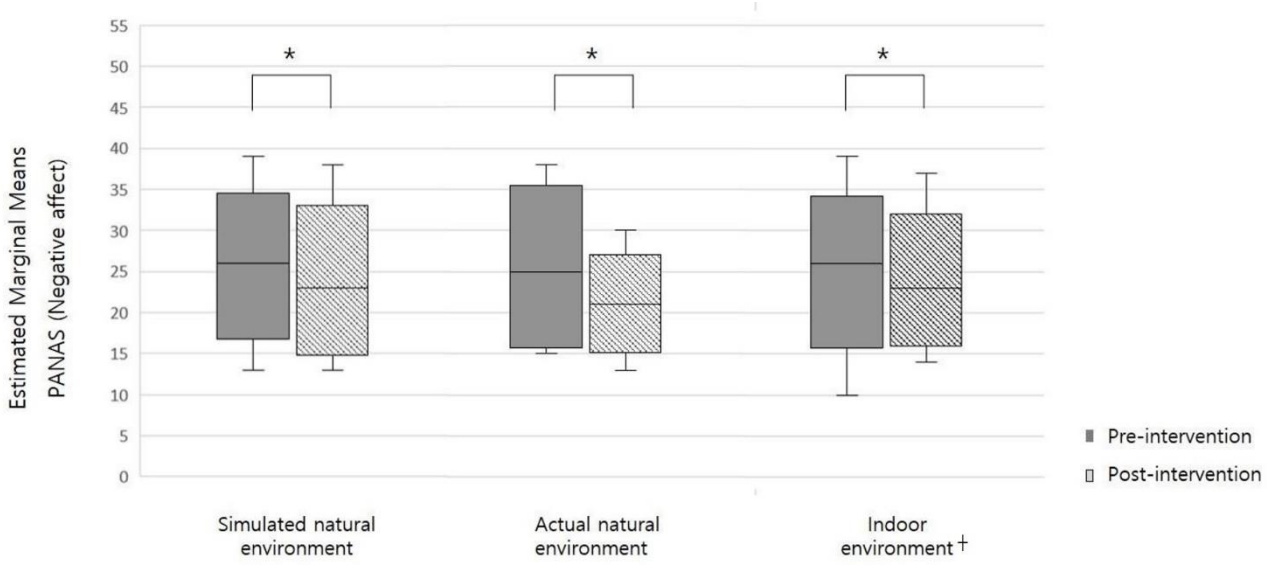


Figure 7 Change in negative affect by environment; Error bars denote using a 95% confidence interval. * p< .05, ** p< .001, ┼reference group

3.4 Level of mindfulness

After adjusting for the pre-intervention score, there was no significant difference between the simulated and actual natural environments on the post-intervention score for mindfulness (FFMQ-SF). However, Paired t-tests revealed that both natural environments were beneficial in improving mindfulness whereas the indoor environment was not (Figure 8).

254

255 Figure 8 Change in mindfulness by environment; Error bars denote using a 95% confidence interval. *
256 p< .05, ** p< .001, †reference group

257 **3.5 Nature connectedness**

258 There was a significant difference between the environments on the post-intervention score for natural
259 relatedness (NR-6) after controlling for pre-intervention score. Paired t-tests revealed that there was a
260 statistically significant increase (15%) in nature connectedness within the group in the actual nature
261 environment, from pre-intervention to post-intervention. However, no significant differences were
262 found within the groups in the simulated nature (4%) and indoor environments (1%). This indicates
263 that the actual natural environment was more effective in increasing natural connectedness than the
264 simulated environment and the indoor (Figure 9).

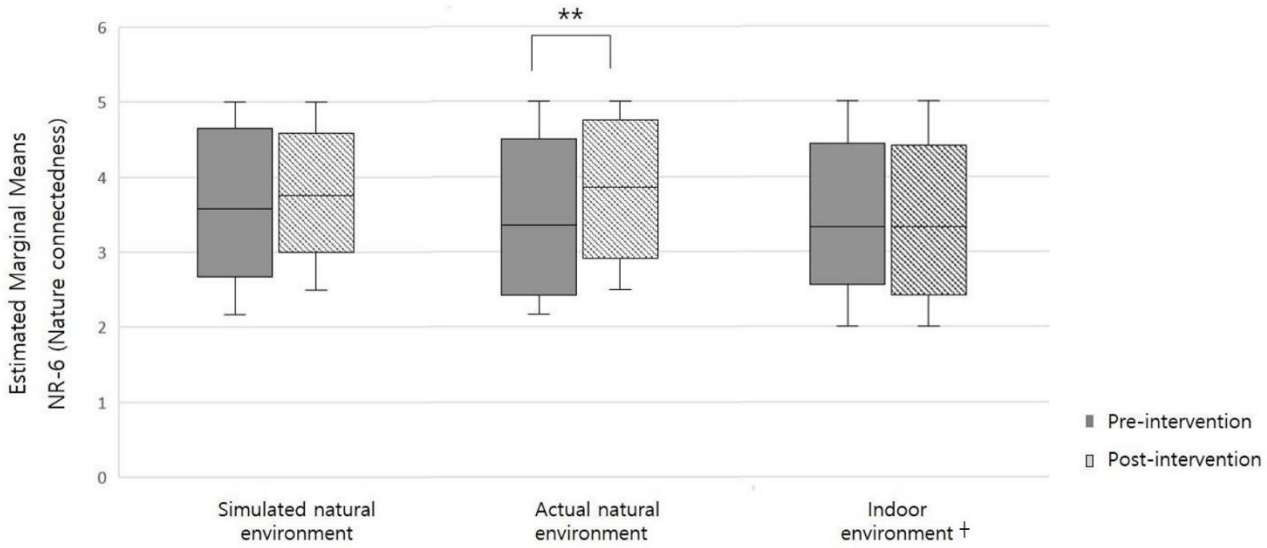


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Figure 9 Change in nature connectedness by environment; Error bars denote using a 95% confidence interval. * p< .05, ** p< .001, †reference group

4. Discussion and conclusion

Consistent with the literature, this study found that both simulated and actual natural environments were settings in which participants could accrue benefits on mindfulness practice outcomes. Improvements were significant and medium to large in size, in all cases. These changes support the notion that conducting a mindfulness programme in natural environments results in improvements in psychological health and wellbeing. A study by Lymeus *et al*. (2019) found that a natural meditation setting improves compliance and restorative nature experience with mindfulness training. Similarly, Nisbet et al. (2019) showed that a group with a guided 20 minutes' mindfulness practice in a natural environment were better at dealing with negative emotions than individuals without the natural setting. Whilst the analysis in the current study was not intended to compare natural and non-natural environments, in their previous laboratory experiment involving simulated environments, Choe *et al.* (2020a) also found that a three-week mindfulness programme in simulated woodland and parkland settings led to greater stress reduction compared with those in a simulated non-natural setting.

The present study was designed to examine whether the outcomes of the three-week's mindfulness practice improved when it was carried out in an actual natural environment as opposed to a simulated natural environment. In particular, we compared changes in depression, anxiety, stress, positive and negative mood, nature connectedness and mindfulness following a mindfulness practice in a simulated natural environment compared to an actual natural environment. For most outcomes the benefits were similar, but the actual natural environment was associated with larger decreases in stress and greater increases in nature connectedness than the simulated natural environment. There were decreases in depression scores in all three conditions, but these were smallest indoors (22%) and greatest in the actual natural environment (42%); the simulated nature environment was associated with intermediate benefits (32%). There were also decreases in stress in the actual nature environment (35%) but not the simulated natural (8%) or indoor (8%) environments. Similarly, there were increases in nature connectedness in the actual natural environment (15%) but not the simulated natural (4%) or indoor (1%) environments. Kjellgren and Buhrkall (2010) and Gatersleben and Andrews (2013) found that walking or relaxation in actual natural environments gave greater benefits than the same activities performed in simulated natural environments, such as increases in energy and reductions in negative

297 feelings. Based on Kaplan's Attention Restoration Theory, Kjellgren and Buhrkall (2010) suggest that
298 the simulated environment has a deficit of '*actual*' natural scenery, therefore it provides less fascination
299 (one of the characteristics for a restorative environment). Accordingly, people need to expend more
300 effort to focus on the simulation in a simulated environment, compared to an actual natural
301 environment.

302 In this study, audio-visual simulation could help people to feel calm and relaxed but may fail to deliver
303 the same multisensory and immersive experience that the actual environment can offer. Simulation
304 only seems to induce general relaxation, instead of offering a more intense natural experience that can
305 strengthen feelings of connection to nature. This finding suggests that further research is needed to
306 identify the cues and affordances in the actual natural environments that lead to psychological benefits
307 – including sounds (e.g. birds singing or water flowing), scents of nature (e.g. the scent of flowers or
308 wet grass), air movement, humidity, touch and light. Indeed, the application of virtual environments
309 appears to still be limited to environmental science and technology contexts, and are only just starting
310 to be used in everyday living, health or social care environments. For example, in a pilot study
311 conducted by Depledge *et al*. (2011), simulated natural environments were used to enhance mental
312 health and wellbeing as part of Virtual Restorative Environment Therapy (VRET). Recently, Seabrook
313 *et al.* (2019) examined the effectiveness of a VR mindfulness app using an omnidirectional video of a
314 peaceful forest environment accompanied by guided mindfulness practice. Participants reported that
315 the virtual environment (VE) was helpful in supporting their mindfulness practice.

316 The findings of our study highlight the value of natural environments as settings for the enhanced
317 delivery of health care and complementary therapy and lay the groundwork for future research on
318 simulated/virtual natural environments. However, some limitations of this study need to be considered.
319 Secondary data analysis in health research has grown massively in recent years, but there are some
320 disadvantages (Dunn *et al.*, 2015). Our data are drawn from the authors' earlier studies that originally
321 had slightly different purposes. Differences, such as research aims or questions, participant type and
322 recruitment, length of study and experimental settings, could all influence the results of our secondary
323 analysis in some way. For example, in terms of length of study, in Study 1 participants signed up for a
324 three-week intervention programme and in Study 2, a six-week programme. Participants in the second
325 study could not be assumed to be responding from the same mind-set, expecting that there were three
326 weeks of the intervention still to come, unlike in the first study where they thought it was all over after
327 three weeks. Further studies are needed to corroborate our findings and provide more definitive

evidence of the potential of simulated/virtual natural environments. Meta-analyses and studies that incorporate simulated and actual natural environments within the same study design are also suggested. Another limitation of the study is the small sample size and the brief mindfulness programme. As the data were derived from previous experiments through a specific data selection process, the sample size is relatively small. Moreover, a brief mindfulness programme has been introduced to full time workers and students to overcome time and schedule requirements, but the effectiveness of a low-dose and brief format programme has not been consistent (Bergen-Cico et al., 2013), raising questions about the use of brief format mindfulness practice in this study. Consequently, this study should be regarded as a precursor to further research examining interventions in virtual or augmented natural environments.

This study suggests that both simulated and actual natural environments have a role to play in healthcare and therapeutic settings. Whilst actual natural environments may be more effective for some measures, notably nature connectedness, the development and use of simulated natural environments may support groups who would for mobility or other reasons would have difficulty in accessing a natural environment.

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