TOPICS IN EXERCISE SCIENCE AND KINESIOLOGY

Original Research

A Pilot Study on the Measurement of Connectedness to Nature Around Nature Immersion with Green Exercise on Desert Trails

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ABSTRACT

Topics in Exercise Science and Kinesiology Volume 5: Issue 1, Article 5, 2024. Studies have reported that non-exercise nature immersion (e.g., sitting) and green exercise increase connectedness to nature. The sitting was long, and the exercise was moderate-to-vigorous. And whether the scales used are valid and test-retest reliable is unclear. The main purpose of this study was to determine whether brief sitting and walking in green space affects connectedness to nature. The second purpose was to evaluate the concurrent validity of the Visual Analog Scale-Nature (VAS-N) with the Love and Care for Nature Scale (LCN). The third purpose was to assess the test-retest reliability of both scales. Participants completed both scales upon arriving (pre-sit), after a 10-min sit (post-sit), and after a 10-min walk (post-walk). The LCN scores increased from pre-sit to post-sit (p = .003, d = 0.28) and post-walk (p < .001, d = 0.48; 17.5% of participants increased beyond the minimal detectable change). The VAS-N and LCN scores were correlated (ρ = .71–.78, p < .001). Only the LCN had evidence of test-retest reliability (pre-sit, post-sit). Immersion in green space may have increased some people's connectedness to nature. Evidence supported the VAS-N's concurrent validity with the LCN, but the overall evidence for both scales' test-retest reliability was weak.

KEY WORDS: Outdoor recreation, nature-based interventions, psychometric evaluation, scale validation, test-retest reliability, ecopsychology, environmental psychology

INTRODUCTION

Green exercise (GE) is a term coined in 2003 to mean "physical activities whilst at the same time being directly exposed to nature" (Pretty et al., 2003, 2005). Since then, the term's definition has been dynamic (Barton & Pretty, 2010; Calogiuri et al., 2016; Gladwell et al., 2013; Lahart et al., 2019; Salatto, 2021; Salatto et al., 2021). One GE researcher recently stated that many definitions of GE are acceptable, and that GE can occur in various biomes, including coasts, forests, mountains, urban cities and parks, or any other outdoor environment (Salatto, 2021). Salatto et

al. (2021) recently specified that GE is exercise outdoors in natural environments, and that those places need not be mostly or totally green. The GE literature is nascent but has grown exponentially in the last decade. Based on PubMed searches, the earliest peer-reviewed journal article with "green exercise" in the title was published in 2005 (Pretty et al., 2005). Only two more articles were published through 2010. Since 2011, 34 articles were published, with a third of them arriving in 2019. The spike in articles about GE illustrates its growing popularity and the rising interest in GE as an approach to improve chronic diseases and mental health conditions.

The effect of exercise location on outcomes is unclear because researchers have quantified that role less extensively than the roles of exercise frequency, intensity, time, and type. The literature shows that GE is enjoyable and changes people's inner experience of exercise. Pretty et al. (2007) reported that outdoor walking, cycling, and horse-riding among people in the United Kingdom increased mood and self-esteem acutely. Shin et al. (2013) reported that young South Korean women felt happier after walking in a forest than after walking in a gym. Navalta et al. (2021) reported that college students felt calmer and more comfortable after sitting and walking in a mountainous green space than in a laboratory or outdoor urban area. These studies show that GE affects people's inner experience differently than indoor exercise.

Part of a person's inner experience is determined by their perceived love for and emotional connection to nature, called connectedness to nature (Perkins, 2010). Perkins (2010) introduced the Love and Care for Nature Scale (LCN) to measure connectedness to nature, specifically the "explicitly affective or emotional aspect of the human–nature relationship." The initial validation studies showed that LCN scores correlated with environmentally altruistic values and behaviors and predicted people's willingness to make lifestyle sacrifices to protect the environment (Perkins, 2010). Correlations do not imply causation, but the finding generated the hypothesis that increasing connectedness to nature could strengthen pro-environmental attitudes and increase the frequency of related actions. Investigating whether GE increases connectedness to nature is a novel research focus.

To the authors' knowledge, only two studies measured how GE affects connectedness to nature (Salatto, 2021; Salatto et al., 2021). In the first study (Salatto et al., 2021), significantly higher LCN scores were reported after participants sat for 45 minutes and then hiked at a moderate-to-vigorous intensity for a distance of 0.8 kilometers (km). The second study reported significantly greater LCN scores after mountain biking for two vigorous, 1.6-km rides separated by 10 min (Salatto, 2021). These studies evaluated a long inactive immersion and moderate-to-vigorous GE. The effects of shorter immersions and lower-intensity GE on connectedness to nature are still unclear. Additionally, the test-retest reliability of the LCN and its association with a person's attention to their inner experience are uncertain. Understanding test-retest reliability is essential because changes in measurements are meaningful only when measured on a consistent scale. Learning whether connectedness is related to a person's attention can offer valuable insights into the associated factors, which can inform future research on interventions to enhance connectedness. One hypothesis is that people who feel most connected to nature pay the most

attention to their inner experience (Nisbet et al., 2019; Van Gordon et al., 2018). The measure of attention most relevant to GE is state mindfulness. State mindfulness is a dynamic, behavior-like, and context-specific construct (Ruimi et al., 2022; Tanay & Bernstein, 2013). It is how mindful someone is in the present moment. Being mindful is cultivating an awareness of the present moment by paying attention on purpose, moment-by-moment, and as non-judgmentally, non-reactively, and openheartedly as possible (Kabat-Zinn, 2015). Attention is paid to the thoughts, feelings, and bodily sensations.

The present study had the overarching goal of blending and building on the GE and mindfulness literature by evaluating perceptual scales and their relationships in a real-world, non-laboratory outdoor setting, such as green space. The study had four aims to determine if or how the scales should be applied in research. The primary aim was to assess if LCN scores would change after brief sitting and light-to-moderate-intensity walking on desert trails. Causal relationships cannot be inferred from an uncontrolled study, but the authors evaluated the feasibility of their research design and the suitability of the LCN for repeated measures with short intervals between measurements in the field. The secondary aim was to assess the concurrent validity of the newly developed one-item Visual Analog Scale-Nature (VAS-N) with the LCN. The goal was to reveal whether the VAS-N could serve as a substitute for the LCN in future studies, potentially reducing the response burden when completed repeatedly over short periods. The tertiary aim was to assess the test-retest reliability of both the LCN and VAS-N, which is crucial for showing these scales' consistency and stability over time. Lastly, the quaternary aim was to measure and report the relationship between connectedness to nature and state mindfulness, shedding light on the potential interplay between these two psychological constructs.

METHODS

Before conducting the present study, the authors obtained approval from the Institutional Review Boards of the University of Nevada, Las Vegas (UNLV, approval #UNLV-2021-29 and #UNLV-2021-39) and Southern Utah University (SUU, approval #08-142021). All the methods were performed per the relevant guidelines and regulations. Specifically, this study was carried out fully in accordance with the Board-approved protocol, Declaration of Helsinki of 1964 and its amendments, and the ethical standards outlined in the *International Journal of Exercise Science* (Navalta et al., 2020).

Participants

The researchers used G*Power 3.1 (G*Power 3.1, University of Düsseldorf, Düsseldorf, Germany) to estimate the sufficient sample size (Faul et al., 2007), based on published effect sizes for a population and location similar to those of the present study. Salatto et al. (2021) had participants sit for 45 min and hike 0.8 km at the Thunderbird Gardens Trailhead. The effect size on LCN scores was $\eta^2_p = 0.21$, so the present study needed 37 participants for 80% power and an α level of .05 in the repeated measures analysis of variance.

The target population was adults aged 18–64 years who were any biological sex, race, height,

mass, or body mass index. The researchers excluded anyone who was outside of the age range or needed medical clearance before any exercise, based on the American College of Sports Medicine Preparticipation Health Screening Questionnaire for Exercise Professionals (American College of Sports Medicine, 2017, p. 36). Also excluded were people who reported pregnancy, lactation, a cognitive or intellectual disability, or a physical limitation that impaired walking or made it dangerous or painful.

The present study had a convenience sample (N = 42) made up of two subsamples, one from each of the two study sites: the Thunderbird Gardens Trailhead (n = 19) and the Clark County Wetlands Park (n = 23). The subsamples had identical target populations and inclusion criteria and a similar baseline age, height, weight, and body mass index. At each study site, data collection took place across two days. One participant at each site dropped out after the first day (attrition: 5% at Thunderbird Gardens Trailhead, 4% at Wetlands Park). The statistical tests for the primary, secondary, and quaternary aims were run on the overall sample. The statistical tests for the tertiary aim were run only on the Wetlands Park subsample because, at that site, participants completed an identical immersion protocol on two subsequent days, allowing researchers to assess the scales' test-retest reliability.

All the participants read the approved informed consent form and confirmed their informed consent in words and writing. The participants self-reported their age (26.0 ± 9.0 years) and height (169.7 ± 8.7 centimeters) and were weighed clothed but with no shoes or items in the pockets (Tanita TBF-521 Bodyfat Monitor/Scale, Tanita, Tokyo, Japan). The sample body mass and body mass index were 69.6 ± 15.9 kilograms and 23.9 ± 4.5 $kg \cdot m^{-2}$, respectively. The participants also self-reported their biological sex and race. Based on participants' written-in responses, the sample was 52% female, 48% males, 0% intersex, 10% African American or Black, 10% Asian, 45% Caucasian or White, 21% Hispanic or Latino, 2% Mediterranean, 2% Middle Eastern, 7% Multi-Racial, and 2% Polynesian (race percentages do not equal 100% because of rounding).

Protocol

The participants at the Thunderbird Gardens Trailhead in Cedar City, Utah, arrived on October 1st and 2nd, 2021, and the participants at the Wetlands Park in Las Vegas, Nevada, arrived on November 6th and 7th, 2021. At both sites, data were collected each day between approximately 0800 and 1700. The trailhead has the Global Positioning System coordinates 37.690442600284165°, −113.04359862955735°, and an altitude of 1,717 meters (5,632 feet). The trailhead and its trails have boulders, rocks, and soil in various shades of orange, red, beige, and brown. The vegetation includes shrubs and trees, such as junipers and pinyon pines with gray-brown trunks and green foliage. The park has the coordinates 36.10117842658103°, −115.02306610191594°, and an altitude of 488 meters (1,600 feet). The park is a nature preserve that offers a view of Frenchman Mountain and has grass, shrubs, and trees (e.g., Freemont cottonwood). There are also boulders and rocks in combined shades of brown, red, and gray. Table 1 shows the weather at each site.

Table 1 Weather at study sites.

Site	Day	Temperature		Relative Humidity		Wind Speed	
		AM	PM	AM	PM	AM	PM
TGT	1	11 °C (52 °F)	21 °C (70 °F)	37%	20%	0.7 m·s^{-1} (1.5 mph)	0.6 m·s^{-1} (1.4 mph)
	2	15 °C (59 °F)	22 °C (72 °F)	30%	17%	0.6 m·s^{-1} (1.3 mph)	0.9 m·s^{-1} (2.1 mph)
WP	1	27 °C (81 °F)		23%		1.3 m·s^{-1} (3.0 mph)	
	2	30 °C (86 °F)		15%		1.3 m·s^{-1} (2.9 mph)	

Weather documented at TGT twice each day, once in morning between 0900 and 1100 and once in afternoon between 1200 and 1400. Weather documented at WP once each day in afternoon between 1200 and 1300. TGT: Thunderbird Gardens Trailhead; AM: morning; PM; afternoon; °C: degrees Celsius; °F: degrees Fahrenheit; m·s^{-1}: meters per second; mph: miles per hour.

After consenting and passing the eligibility screening, each participant received a one-inch, three-ring binder. The binder had scales for measuring connectedness to nature and state mindfulness at three timepoints: arrival (pre-sit), after 10 min of sitting (post-sit), and after 10 min of walking (post-walk). The order of the scales in each set for each participant was randomized. The present paper reports the connectedness to nature data and its correlations with state mindfulness. The relevant scales were as follows.

Love and Care for Nature Scale (LCN): The LCN is a 15-item Likert-type scale that measures one factor, connectedness to nature, specifically the "explicitly affective or emotional aspect of the human–nature relationship" (Perkins, 2010). The original exploratory factor analysis showed the LCN explained 71.18% of the variance in the solution. However, Perkins (2010) clarified that the LCN and related scales may measure distinct sub-dimensions of a larger, multi-dimensional construct. All 15 of the LCN's items are declaratory statements (e.g., Item 1: I feel joy just being in nature). Respondents report how much they agree or disagree by marking a checkmark or X under the choices 1 (*very strongly disagree*), 2 (*strongly disagree*), 3 (*disagree*), 4 (*neutral*), 5 (*agree*), 6 (*strongly agree*), or 7 (*very strongly agree*). The 15 items are summed with the score ranging from 15 arbitrary units (AU; low connectedness to nature) to 105 AU (high connectedness to nature). Perkins (2010) created the LCN and was the first author to publish evidence to support its internal consistency (Cronbach's $\alpha = 0.97$; corrected item-total correlations = 0.77–0.86) and validity (construct, convergent, criterion-related, and discriminant). Salatto (2021) took LCN scores before and after two rides on a mountain bike separated by 10 min. From post-ride one to post-ride two, the coefficient of variation (CV) and intraclass correlation coefficient (ICC) [95% confidence interval (CI)] were 2.3% and 0.94 [0.85, 0.98], respectively. Based on published CV and ICC thresholds (Aronhime et al., 2014; Koo & Li, 2016), the LCN had good-to-excellent test-retest reliability in the study by Salatto (2021).

Visual Analog Scale-Nature (VAS-N): The VAS-N (Supplementary Appendix A) is a visual analog scale with one statement and one question. The statement is declaratory: "Interacting with nature brings me joy and makes me feel a sense of personal connection to and care for nature." The question asks, "How well does the sentence describe your present feeling?"

Respondents read the statement and answer the question by marking a vertical dash along a non-graduated 100-millimeter (mm) horizontal line. The horizontal line is anchored on the left by the statement *very strongly disagree* and on the right by the statement *very strongly agree*.

State Mindfulness Scale (SMS): The SMS is a 21-item Likert-type scale (Ruimi et al., 2022; Tanay & Bernstein, 2013). Each item has a declaratory statement, such as "I felt that I was experiencing the present moment fully." Respondents report how much they agree or disagree by marking a checkmark or X under the choices 1 (*Not at all*), 2 (*A little*), 3 (*Somewhat*), 4 (*Well*), or 5 (*Very well*). State Mindfulness Total (SMS-Total) is calculated by summing all 21 items, with scores ranging from low state mindfulness at 21 AU to high state mindfulness at 105 AU (Ruimi et al., 2022; Tanay & Bernstein, 2013). The present study only reports SMS-Total and not the subscales. Only choices 1 and 5 had text descriptions because, at the time of data collection, available SMS guidance did not give text descriptions for choices 2–4. Tanay and Bernstein (2013) created the SMS, and both they and Ruimi et al. (2022) reported evidence to support its internal consistency (Cronbach's α = .85–.87), validity (construct, convergent, discriminant, incremental convergent, and incremental predictive), incremental sensitivity to change, and temporal stability. To our knowledge, researchers have reported only bivariate correlations as evidence of the scale's test-retest reliability. We report CVs (5.3–16.2%) and ICCs (.50–.85) for the SMS in another paper submitted elsewhere (unpublished). The CVs were good-to-excellent based on criteria adapted from Aronhime et al. (2014), and the ICCs were poor-to-excellent based on 95% CIs and criteria adapted from Koo and Li (2016). It is worth noting that our other paper discusses the challenges associated with applying measures of test-retest reliability to measures of state mindfulness. Given its dynamic, behavior-like, and context-specific nature (Bishop et al., 2004; Ruimi et al., 2022; Tanay & Bernstein, 2013), state mindfulness is inherently variable.

The present study's intervention was nature immersion with GE. Participants received no information or instructions about mindfulness. Upon receiving their research binders, the participants at both study sites completed the pre-sit set of scales. Nature immersion before this point was minimized by helping participants immediately upon arrival or having them wait in their cars. After completing the pre-sit scales, the participants found a place to sit alone in the green space, away from the researchers and other participants. After sitting for 10 min, the participants completed the post-sit set of scales and at once began walking alone along a trail in the green space for 10 min. Participants were staggered to prevent simultaneous walking and were told not to interact with others. Researchers did not observe any participants breaking this protocol. The participants completed the post-walk set of scales right when 10 min elapsed before returning their binders and leaving. At both sites, the researchers instructed the participants not to use their phones while sitting or walking other than to start and stop timers. The participants at the Wetlands Park arrived approximately 24 hours later to complete the same protocol as on day one. This study design allowed the research team to calculate measures of test-retest reliability for the LCN and VAS-N on the Wetlands Park subsample. The scales completed on day one were removed from the binders before day two so participants could not see their day-one responses.

At both study sites, walking intensity was considered light-to-moderate. This assumption was based on our earlier hiking research in a similar sample to the present study (Manning et al., 2015). After hiking easy and strenuous trails, participants' heart rates were 39% ± 5% and 53% ± 9% of their age-estimated maximum, respectively, indicating a very-light-to-moderate intensity (Garber et al., 2011). Given these findings, we assumed a similar intensity in the present study. We refrained from measuring heart rate with chest- or wrist-worn monitors to avoid distracting participants with wearable technology and confounding the relationship between nature immersion, GE, and connectedness to nature.

Statistical Analysis

The researchers ran the proper parametric and non-parametric statistical tests and, when called for, their respective post hoc tests. All tests were run with an α level of .05 in SPSS (IBM SPSS Statistics v28; IBM, Armonk, NY, United States). Except where stated, all data are reported as sample arithmetic means ± sample standard deviations (SD).

Primary aim (Based on Thunderbird Gardens Trailhead and Wetlands Park Data): The primary aim must be prefaced by stating that no conclusions can or should be drawn about whether the intervention changed connectedness to nature, as the study lacked a control group. The methods of the primary aim simply enabled the researchers to assess how the scales performed and to compare scores between the LCN and VAS-N and between the LCN and SMS. Additionally, the goal was to offer readers a model for evaluating changes over time in a future randomized controlled trial.

The authors ran two separate repeated measures analysis of variance to determine if the mean LCN score or mean VAS-N score differed across time. The one LCN outlier and two VAS-N outliers at post-walk were kept because they seemed to be genuinely unusual values rather than errors. Given that repeated measures analyses of variance are robust to the normality assumption, they were run despite non-normality of the LCN data at two timepoints and the VAS-N data at all three timepoints. The Greenhouse-Geisser method was applied to both repeated measures analyses of variance because of non-sphericity. The effect size was partial omega squared (ω^2_p), calculated from partial eta squared and appraised according to Ferguson et al. (2009): 0.04 = "recommended minimum effect size representing a 'practically' significant effect [RMPE]," 0.25 = moderate effect, and 0.64 = strong effect. The post hoc tests were paired-samples *t*-tests adjusted with the Bonferroni correction. The effect size for the *t*-tests was Cohen's *d*, appraised according to Ferguson et al. (2009): 0.41 = RMPE, 1.15 = moderate, and 2.70 = strong effect (Ferguson, 2009).

Another measure of meaningfulness used was the minimal detectable change based on the 95% CI (MDC_{95}). The LCN and VAS-N each had an MDC_{95}, calculated from each scale's pre-sit standard error of measurement (SEM). Each scale's SEM came from that scale's pre-sit ICC (Tertiary Aim) and pooled SD. The pooled SD was the arithmetic mean of each scale's SD at pre-sit on day one and day two at the Wetlands Park. The MDC_{95} was used to estimate the proportions of participants whose LCN and VAS-N scores changed beyond the expected

measurement error from pre-sit to post-walk (Leslie Gross Portney & Mary P. Watkins, 2009). Because the LCN served as the criterion, the scale's MDC_{95} was used to interpret the potential effect of the intervention. It is important remember, however, that the study was uncontrolled, and causal relationships cannot be inferred.

Secondary Aim (Based on Thunderbird Gardens Trailhead and Wetlands Park Data): The LCN and VAS-N scores met the assumptions of level of measurement, related pairs, and linear relationship. The outliers and lack of normality mentioned above precluded Pearson's correlations (r). Consequently, the authors ran three separate two-tailed Spearman's correlations (ρ) to measure the relationship between the LCN and VAS-N scores at pre-sit, post-sit, and post-walk. The 95% CIs were estimated based on Fisher's r-to-z transformation. When estimating the 95% CIs, the standard error was estimated by using Fieller, Hartley, and Pearson's formula. The results of the LCN and VAS-N analyses of variance were plotted together to see if the mean VAS-N score changed similarly to the mean LCN score across time.

Tertiary Aim (Based on Wetlands Park Data Only): The test-retest reliability of the LCN and VAS-N at pre-sit, post-sit, and post-walk was assessed by calculating relative reliability as the CV and absolute reliability as the ICC. The ICC model, type, and definition were two-way mixed effects, single measurement, and absolute agreement, respectively (Koo & Li, 2016). The CVs were appraised according to the thresholds similar to those published by Aronhime et al. (2014). That group's thresholds were adjusted to not overlap with each other: excellent (≤ 10%), good (11–20%), acceptable (21–30%), and poor (> 30%). The ICCs were appraised according to the 95% CIs and thresholds adapted from those recommended by Koo and Li (2016): excellent (> .90), good (.76–.90), moderate (.50–.75), and poor (< .50).

Quaternary Aim (Based on Thunderbird Gardens Trailhead and Wetlands Park Data): The SMS scores met the assumption of level of measurement, related pairs, and linear relationship. Two SMS outliers and non-normality at post-walk led the researchers to run three separate two-tailed Spearman's correlations to measure the relationship between the SMS and LCN scores at pre-sit, post-sit, and post-walk. The 95% CIs were calculated in the same manner as for the secondary aim.

RESULTS

The completion rates of the LCN, VAS-N, and SMS across the timepoints on each day were 95–100%, 98–100%, and 74–100%, respectively.

Primary Aim: The repeated measures analysis of variance on the LCN scores (n = 39) was significant; $F(2, 63) = 21.36$, $p < .001$, $\omega^2_p = .26$ (

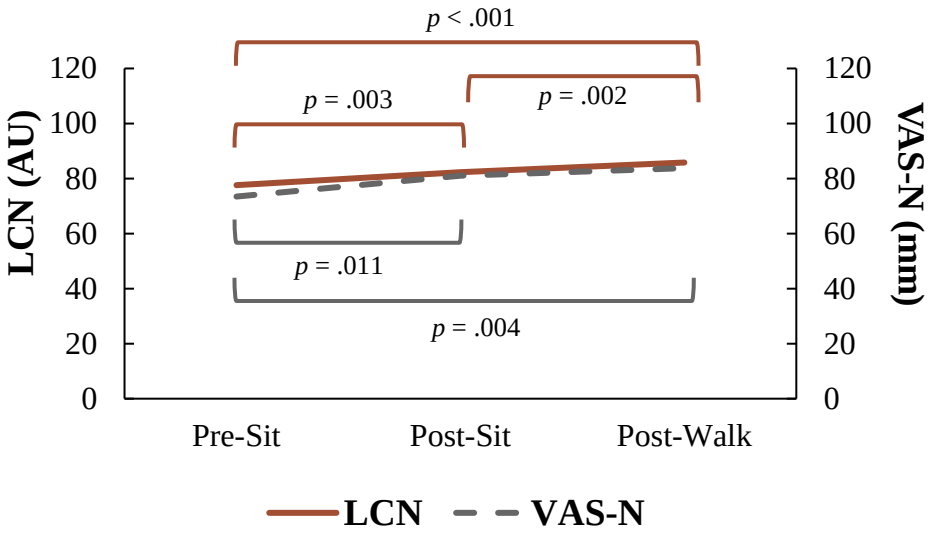

Figure 1). The mean LCN score increased from 77.6 ± 16.6 AU at pre-sit to 82.4 ± 17.4 AU at post-sit (+4.8 AU, 95% CI [1.5, 8.1], p = .003, d = 0.28) and 85.8 ± 17.8 AU at post-walk (+8.2 AU [4.6, 11.9], $p < .001$, d = 0.48). The mean LCN score increased by 3.5 AU [1.1, 5.8] from post-sit to post-walk (p = .002, d = 0.20). The mean VAS-N score changed similarly to the mean LCN score (

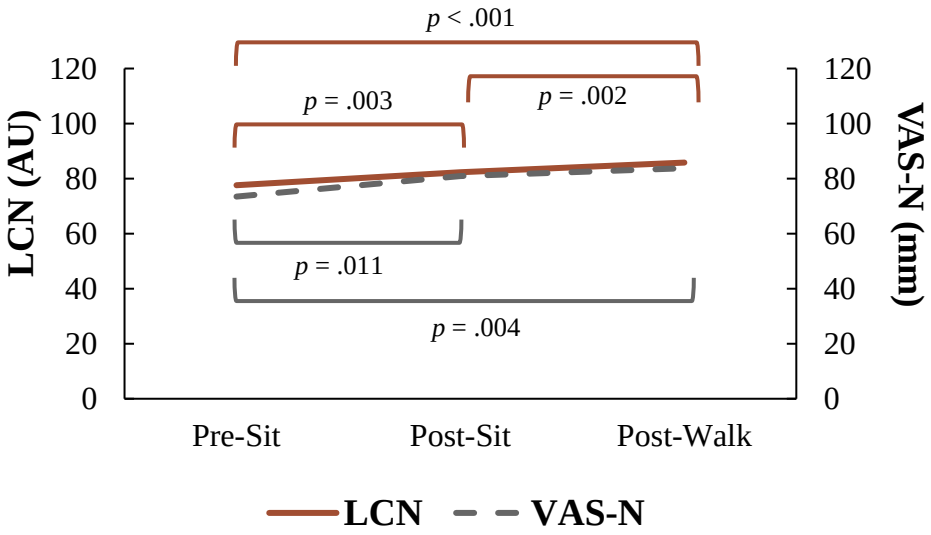

Figure 1). The repeated measures analysis of variance on the VAS-N scores (n = 39) was significant; $F(2, 60) = 9.31$, $p < .001$, $\omega^2_p = .12$). The mean VAS-N score increased from 73.5 ± 23.6 mm to 81.0 ± 16.0 mm from pre-sit to post-sit (+7.5 mm, 95% CI [1.5, 13.6], p = .011, d = 0.37) and 83.8 ± 17.1 mm at post-walk (+10.3 mm [2.8, 17.8], p = .004, d = 0.50). The mean VAS-N score did not increase from post-sit to post-walk (p = .438, d = 0.17). There was a detectable change in connectedness to nature in 17.5% of the participants (called the responders) with complete pre-sit and post-walk data on the criterion scale, the LCN (**Error! Reference source not found.**). Compared to the non-responders (the 82.5% of participants without a detectable change in

connectedness to nature), the responders had a slightly lower mean age than the overall sample (25.1 ± 10.6 years vs. 26.0 ± 9.0 years). Females were 52% of the overall sample but 57% of the responders. Participants of color were 55% of the overall sample but 43% of the responders.

Table 2 Changes in connectedness to nature from pre-sit to post-walk, based on MDC_{95} for LCN and VAS-N

Scale	SEM	MDC_{95}	Below MDC_{95}: (*n*)	No Change (*n*)	Above MDC_{95}: (*n*)
LCN (AU)	6.4	18	0/40 (0%)	33/40 (82.5%)	7/40 (17.5%)
VAS-N (mm)	11.9	33	0/40 (0%)	37/40 (92.5%)	3/40 (7.5%)

MDC_{95}: minimal detectable change based on the 95% confidence interval; LCN: Love and Care for Nature Scale; VAS-N: Visual Analog Scale-Nature; SEM: standard error of measurement; AU: arbitrary units; mm: millimeters. Below MDC_{95} means the participants' scores decreased beyond the MDC_{95}. No Change means the participants' scores did not decrease or increase beyond the MDC_{95}. Above MDC_{95} means the participants' scores increased beyond the MDC_{95}. Each MDC_{95} was calculated from the respective scale's SEM. The SEM was calculated from the pooled standard deviation and the point estimate of the intraclass correlation coefficient at pre-sit at the Wetlands Park. The proportions' denominators are the number of participants from both study sites for whom pre-sit and post-walk data were available.

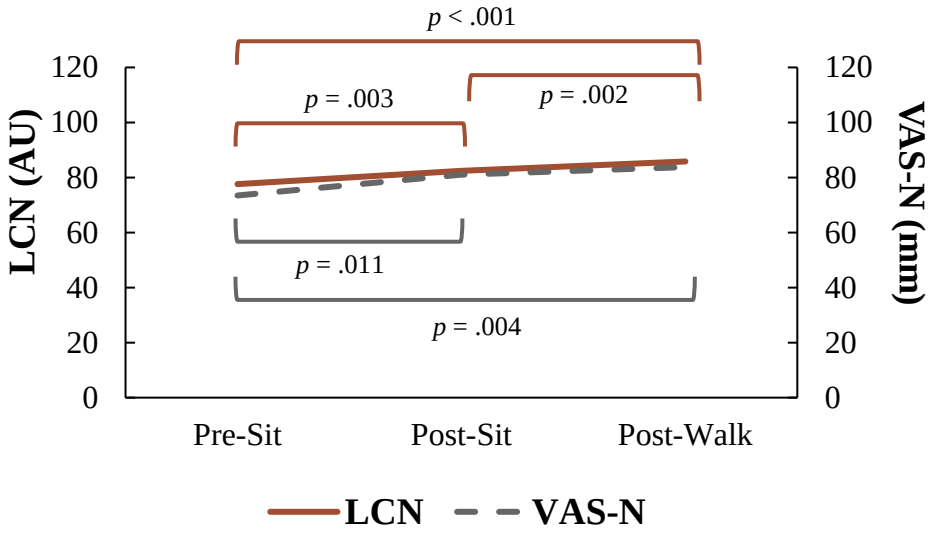

Figure 1. Mean LCN and VAS-N scores across time (both scales: *n* = 39). Standard deviations of LCN and VAS-N scores at each timepoint are provided in the present study's text. LCN: Love and Care for Nature Scale; VAS-N: Visual Analog Scale-Nature; AU: arbitrary units; mm: millimeters.

Secondary Aim: The correlations between the LCN and VAS-N scores were significant, positive, and moderate to very strong at pre-sit and post-sit, and significant, positive, and strong to very strong at post-walk (

Table 3 and Figure 2).

Table 3. Correlations between the LCN and VAS-N scores at pre-sit, post-sit, and post-walk

Timepoint	Coefficient(df) (95% CI)	Direction, Strength	*p* value

Pre-Sit	$\rho(40) = .71$ (.51, .84)	Positive, Moderate–Very Strong	< .001
Post-Sit	$\rho(39) = .73$ (.55, .85)	Positive, Moderate–Very Strong	< .001
Post-Walk	$\rho(38) = .78$ (.61, .88)	Positive, Strong–Very Strong	< .001

LCN: Love and Care for Nature Scale; VAS-N: Visual Analog Scale-Nature; df: degrees of freedom; CI: confidence interval. All correlations were two-tailed Spearman's rank correlations (ρ). The 95% CIs were estimated based on Fisher's *r*-to-*z* transformation. When estimating the 95% CIs for Spearman's ρ, the standard error was estimated by using Fieller, Hartley, and Pearson's formula in IBM SPSS Statistics v28.

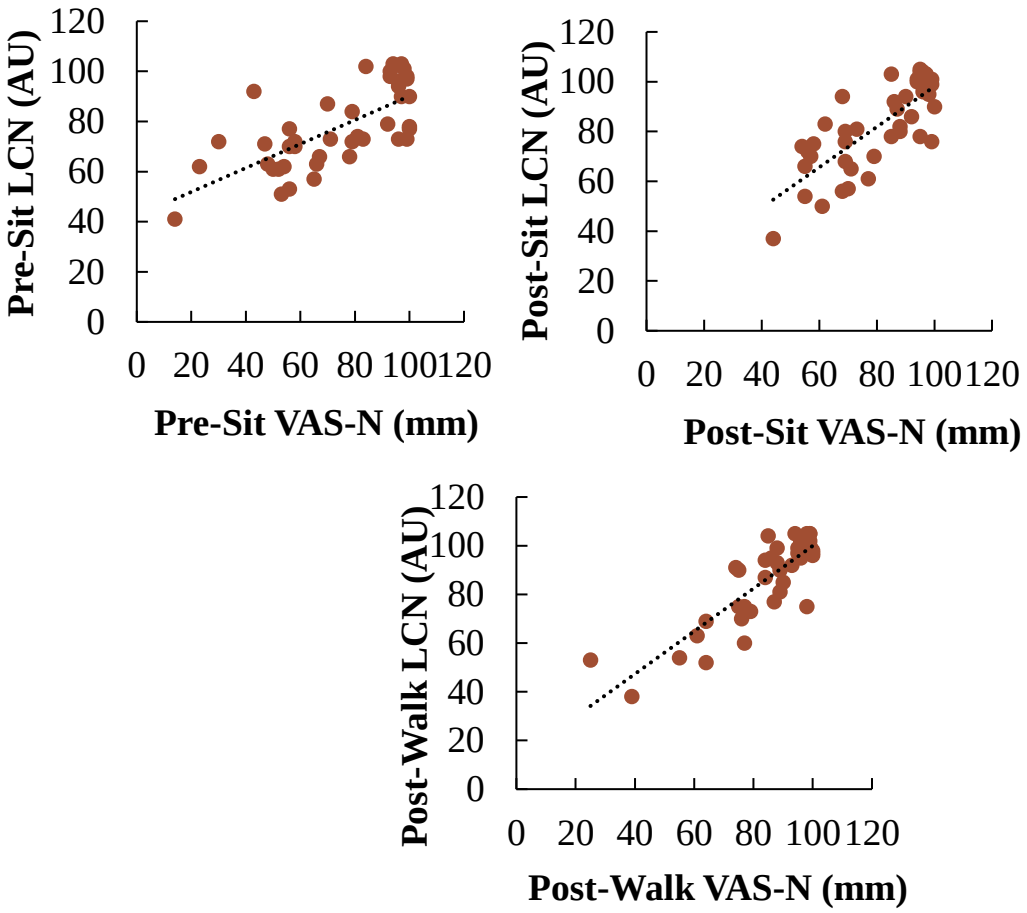

Figure 2. Scatterplots of the LCN and VAS-N scores at pre-sit (N = 42), post-sit (n = 41), and post-walk (n = 40). Maximum LCN and VAS-N scores are 105 AU and 100 mm, respectively. Dotted lines are the linear trendlines. Neither the regression equations nor the coefficients of determination are shown because the data violated at least one assumption of Pearson's correlation. LCN: Love and Care for Nature Scale; VAS-N: Visual Analog Scale-Nature; AU: arbitrary units; mm: millimeters.

Tertiary Aim: For both the LCN and VAS-N, the CVs and ICCs showed good-to-excellent and poor-to-good test-retest reliability, respectively (
Table 4).

Table 4. CVs and ICCs for the LCN and VAS-N across approximately 24 hours.

	Pre-Sit		Post-Sit		Post-Walk	
	CV (%)	ICC	CV (%)	ICC	CV (%)	ICC
LCN	6.1	.84 [.64, .93]	5.5	.85 [.68, .94]	10.1	.73 [.44, .88]

	Excellent	$p < .001$ Moderate to Good	Excellent	$p < .001$ Moderate to Good	Good	$p < .001$ Poor to Moderate
VAS-N	14.0 Good	.67 [.36, .85] $p < .001$ Poor to Moderate	10.9 Good	.59 [.24, .81] $p = .002$ Poor to Moderate	9.3 Excellent	.76 [.50, .90] $p < .001$ Poor to Good

CV: coefficient of variation; ICC: intraclass correlation coefficient and 95% confidence interval; LCN: Love and Care for Nature Scale; VAS-N: Visual Analog Scale-Nature. The CVs and ICCs were calculated from measurements taken approximately 24 hours apart. Interpretation of CVs based on thresholds adapted from those used by Aronhime et al. (2014). Interpretation of ICCs based on 95% CIs and thresholds adapted from those recommended by Koo and Li (2016).

Quaternary Aim: There was no significant correlation between the SMS and LCN scores at pre-sit, but there were significant, positive, and weak-to-strong correlations at post-sit and post-walk (Table 5 and Figure 3).

Table 5. Correlations between the SMS and LCN scores at pre-sit, post-sit, and post-walk.

Timepoint	Coefficient(df) (95% CI)	Direction, Strength	*p* value
Pre-Sit	$\rho(31) = .21$ (−.16, .52)	No Significant Correlation	.246
Post-Sit	$\rho(32) = .53$ (.22, .74)	Positive, Weak–Strong	.001
Post-Walk	$\rho(32) = .59$ (.31, .78)	Positive, Weak–Strong	< .001

LCN: Love and Care for Nature Scale; SMS: State Mindfulness Scale; df: degrees of freedom; CI: confidence interval. All three correlations are two-tailed Spearman's rank correlations (ρ). The 95% CIs were estimated based on Fisher's *r*-to-*z* transformation, and the standard error was estimated by using Fieller, Hartley, and Pearson's formula in IBM SPSS Statistics v28.

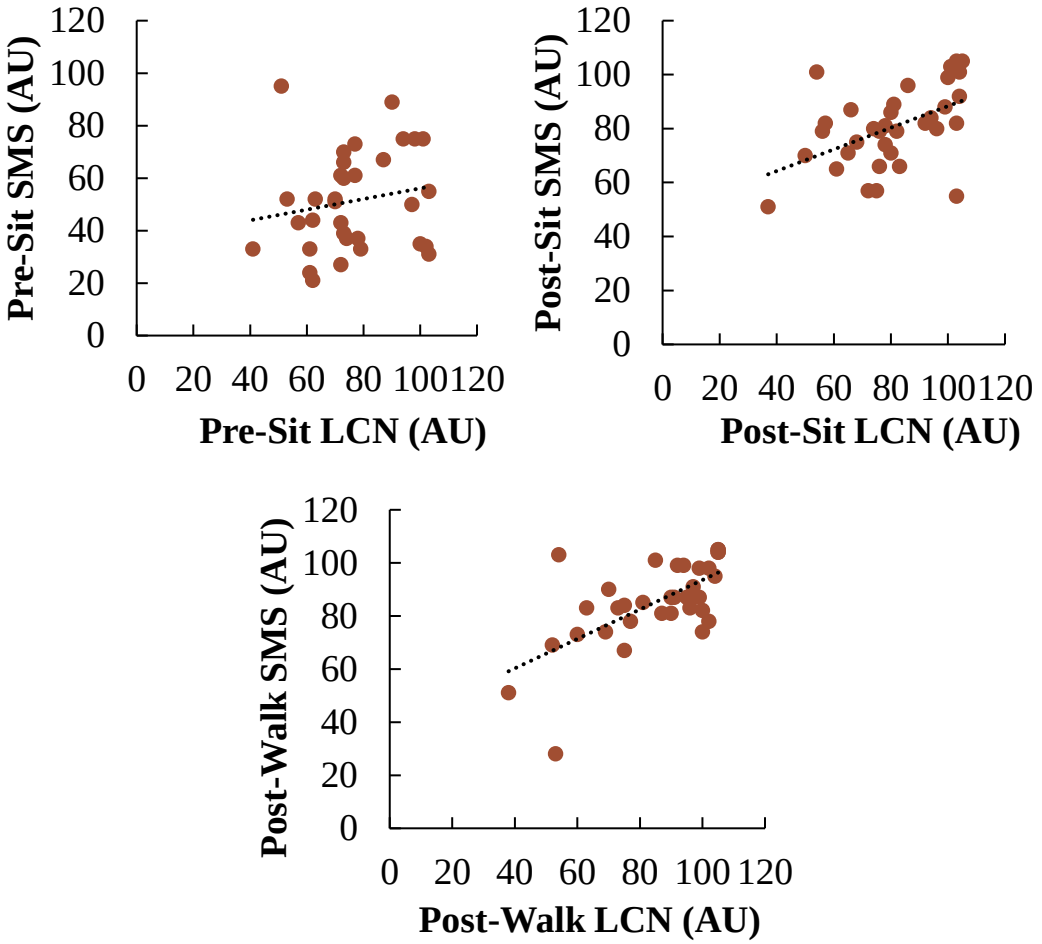

Figure 3. Scatterplots of SMS and LCN scores at pre-sit (n = 33), post-sit (n = 34), and post-walk (n = 34). Maximum score on both scales is 105 AU. Dotted lines are linear trendlines. Neither the regression equation nor the coefficient of determination is shown because the data violated at least one assumption of Pearson's correlation. SMS: State Mindfulness Scale; LCN: Love and Care for Nature Scale; AU: arbitrary units.

DISCUSSION

The present study did not try to establish a cause-and-effect relationship between its intervention and connectedness to nature, as it lacked a control group. Nonetheless, this study advances the literature by connecting two subfields—GE and mindfulness—and evaluating the performance of perceptual scales in a real-world, non-laboratory outdoor setting, such as green space. The study took place on desert trails and had four aims: 1) assess if LCN scores would change after brief sitting and light-to-moderate-intensity walking on desert trails; 2) assess the concurrent validity of the newly developed one-item VAS-N with the LCN; 3) assess the test-retest reliability of both the LCN and VAS-N; and 4) measure and report the relationship between connectedness to nature and state mindfulness.

The results of this study suggest that brief sitting and light-to-moderate intensity walking for 10 min each in green space may increase self-reported connectedness to nature. Again, causal relationships cannot be inferred from an uncontrolled study. Not having control groups is a

recurring limitation that the field must overcome. Salatto et al. (2021), reported that 45 min of sitting and about 8.5 min of moderate-to-vigorous hiking at the Thunderbird Gardens Trailhead significantly increased the mean LCN score from before sitting to after hiking (p = .035, η^2_p = .21). Salatto (2021) reported in a separate study that the mean LCN score significantly increased from 82.3 ± 2.1 AU to 84.2 ± 2.1 AU after two vigorous, out-and-back rides on a mountain bike, separated by 10 min (effect of time: p = .014, η^2_p = .29; pre-to-post change: p = .021, Cohen's d = 0.90). However, neither of those studies had a control group that completed the LCN at the same interval indoors or at the study site without completing GE.

The present study corroborates the tentative finding that acute GE may increase connectedness to nature and adds a new finding: seated immersion may not need to be long, and GE may not need to be moderate-to-vigorous intensity to increase connectedness to nature. Possibly being able to connect to nature quickly via brief seated immersion and light-to-moderate intensity GE is a fresh finding. The tentative finding addresses two misconceptions about GE. The first misconception is that connecting to nature requires grandiose gestures and getting away for long excursions (Loewe, 2022). The second misconception is that connecting to nature via GE requires moderate-to-vigorous activities such as hiking, mountaineering, mountain biking, rock climbing, and trail running. The present study shows that short bouts (10–20 min) and light-to-moderate intensity walking may suffice.

Claims about GE can only be substantiated through randomized controlled trials, a research method notably scarce in the literature but imperative for its advancement. We propose our design as a promising prototype to be improved. One improvement would be incorporating a pre-test control group, where participants complete scales before any intervention, weeks or months before arriving to complete the intervention. A more substantial improvement would be more study arms, such as sitting indoors, sitting in a car in green space, or sitting in green space without engaging in exercise. Our primary aim's greatest value is demonstrating a viable research approach for using the LCN around nature immersion with GE, as well as for conducting repeated measures with short intervals between measurements in green space.

Future studies would benefit from including robust measures of change in scores such as those used in the present study. To the authors' knowledge, this study was the first to report an MDC_{95} for the LCN. The MDC_{95} is valuable because it shows how many and which participants may have benefited from the intervention. Based on the MDC_{95} for the LCN, just 17.5% of participants reported an increase in connectedness to nature that was beyond the expected measurement error. Why some participants responded and others did not is unclear. A diverse sample was a strength of the present study and, moving forward, studies on GE and connectedness to nature should explore the relationships between participants' characteristics and outcomes. Researchers should emphasize recruiting from diverse and underrepresented populations. This need exists because research on how nature affects mental health overrepresents white participants, and many authors fail to report their participants' race and ethnicity (Gallegos-Riofrío et al., 2022). We encourage all researchers to recruit equitably across sex, gender, and race and report these data transparently.

We also encourage researchers to investigate longer immersions in green space. In a recent study of Mexican adults by Garza-Teran et al. (2022), the mean LCN item score significantly increased after a two-day excursion in the Sonoran Desert (p = .035, d = 0.62). This finding is important for two reasons. First, it shows that longer immersions in green space may increase connectedness to nature. Second, the finding suggests that deserts are a biome capable of increasing connectedness to nature. Our study took place within and just north of the Mojave Desert, where the southwestern part of the Great Basin Desert begins. While the Sonoran, Mojave, and Great Basin Deserts differ in climate, ecology, and topography, each desert has brown and green colors. Collectively, the present study and studies by Salatto et al. (2021), Salatto (2021), and Garza-Teran et al. (2022) show that deserts deserve attention in research on GE and connectedness to nature.

Skeptical readers may question the practical value of participants feeling more connected to nature, regardless of the immersion length. The value may be revealed in innovative studies that explore the relationships between connectedness to nature and pro-environmental attitudes and actions. When creating the LCN, Perkins (2010) analyzed whether LCN scores predicted people's willingness to make pro-environmental sacrifices to lifestyle (e.g., "willingness to pay much higher prices for goods and services to protect the environment"). Perkins (2010) also analyzed correlations between LCN scores and the frequency of behaviors (e.g., "How often do you vote for a candidate in an election at least in part because he or she is in favour of strong environmental protection/conservation?"). Scores on the LCN significantly predicted willingness to sacrifice for the environment (p < .001) and were significantly and positively correlated with all seven of the pro-environmental behaviors explored (r = .37–.51, p < .001). Researchers should investigate whether GE over the long-term increases connectedness to nature and promotes pro-environmental attitudes and actions.

Another avenue for finding the practical value of feeling more connected to nature is measuring mental health outcomes. There would be value in measuring stress and state and trait anxiety and depression in people who have non-clinical and clinical levels before and after interventions of nature immersion with GE. While better evidence is needed, early evidence suggests that interacting with nature is a promising therapy for mental health conditions, particularly anxiety (Kotera et al., 2022; Lackey et al., 2021; Pretty et al., 2007; Tillmann et al., 2018). We urge researchers to conduct randomize controlled trials that measure the effects of nature immersion with GE on mental health outcomes. The trials should have follow-up periods and report clear outcomes, ideally alongside each scale's MDC_{95}.

Whatever the aims of their trial, researchers will need valid and reliable scales. While we were encouraged by evidence of the VAS-N's concurrent validity with the LCN, we caution researchers about using either scale. There was not convincing evidence for the test-retest reliability of either scale under the conditions used. This finding was surprising because Salatto (2021) reported a CV of 2.3% and an ICC [95% CI] of .94 [.85, .98] for the LCN across two mountain bike rides in green space separated by 10 min. The CV and ICC were evidence of good-to-excellent test-retest reliability. It is possible the LCN is reliable across repeated

measures within 30–60 min but not approximately 24 hours. In the present study, the LCN scores were not significantly different between days one and two. This fact suggests the lack of test-retest reliability was not caused by carryover effects. As GE research progresses and explores longer interventions (e.g., chronic immersion in nature via GE), studies should assess the test-retest reliability of the LCN and VAS-N across periods lasting 24 hours and longer.

The last finding to discuss is the relationship between connectedness to nature and state mindfulness while sitting and walking in green space. Connectedness to nature and general mindfulness have been described as interconnected (Van Gordon et al., 2018). And a meta-analysis reported the weighted effect size of the relationship between connectedness to nature and trait mindfulness as 0.25 (Schutte & Malouff, 2018). The present study is novel because it focused on state mindfulness during an intervention in green space. Based on the point estimates and 95% CIs for ρ at post-sit and post-walk, the effect size for state mindfulness seems to be at least as big as the effect size for trait mindfulness (Schutte & Malouff, 2018).

Our study suggests value in conducting randomized controlled trials to explore the effects of nature immersion on state mindfulness. We advocate for this inquiry over its inverse (e.g., Does state mindfulness increase connectedness to nature?) because participants in our study engaged in a nature intervention, not a mindfulness intervention. Additionally, throughout the intervention, the LCN and VAS-N scores increased only modestly, whereas the SMS scores increased considerably. However, the absence of a control group precludes confirmation that the intervention was the direct cause of these changes. Our finding aligns with a meta-analysis that reported that the effect of nature-based mindfulness interventions on state mindfulness was medium; Hedges' $g = 0.62$, 95% CI [0.41, 0.83], $p < .001$ (Djernis et al., 2019). The studies in the meta-analysis varied by duration (from one session to weeks) and were mixed bags of solo and group work, various GEs, and informal and formal mindfulness practices. The present study contributes uniquely to the literature by focusing on one delineated bout of acute GE without extra interventions that can confound the relationship between connectedness to nature and state mindfulness. It is worth investigating further if nature immersion with GE is a mindfulness practice. Studies should also examine if or how state mindfulness mediates the relationship between being in nature and feeling connected to it.

Turning to the present study's limitations, the first and most important is the study design. Crucially, we must acknowledge that a repeated measures design without a separate control group cannot establish causality. Future studies need control groups to draw causal conclusions about any observed effects on connectedness to nature and state mindfulness. Suitable control groups may be no intervention, indoor walking, and outdoor sitting without exercise. Additionally, a study with a time and attention control group could clarify if observed increases in repeated measures designs come from heightened attention to one's thoughts and feelings about nature. The present investigation was a proof-of-concept study to assess the suitability of the LCN and VAS-N for test-retest designs in real-world, applied settings like outdoor trails.

Concerns over these scales is the second limitation. The field needs innovative studies to determine the quantity and dimensionality of the constructs that underlie connectedness to nature. Using exploratory and confirmatory factor analyses can help to discover and test potential factor structures, respectively. Additionally, reporting alternative measures of internal consistency beyond Cronbach's α is advisable. In a relevant study, Pasca, Paniagua, and Aragonés (2020) adapted the LCN into a new 10-item scale called the Love for Nature Scale. The authors found that the Love for Nature Scale measures one construct (love for nature) with two interrelated components, connectedness and well-being, which could be treated as a whole. The authors also reported several measures of internal consistency. We propose that researchers explore the suitability of the Love for Nature Scale in acute studies on nature immersion with GE. When using the LCN or Love for Nature Scale in populations distinct from their original development context, researchers may want to assess group variance to validate the scales' measurements in the new population. Researchers may also want to test for temporal invariance to ensure the relationships between the scales' constructs and items remain stable. This concept differs from test-retest reliability.

The present study's third limitation is the risk of bias, specifically selection, recall, and response bias. For response bias, people who volunteered for the study may already have enjoyed nature immersion and been predisposed to report higher scores over time. Future studies may target people without experience being in nature. For recall and response bias, the researchers tried to reduce risk of participants remembering earlier responses or trying to please the researchers; the scales were issued unlabeled in random series, but this may have created an order effect and is not advised. Future studies could issue the scales of interest alongside scales about other constructs. This approach may keep participants from focusing intensely on feelings of love and care for nature, which could independently cause higher scores over time. Issuing the scales digitally could keep participants from viewing earlier responses. However, requiring digital devices may be inequitable for participants, and supplying the devices may be financially impossible for researchers. Even if researchers can supply the devices, the study site may not have a reliable power source or internet connection. Moreover, it is not clear if using digital devices confounds the relationship between nature immersion with GE and connectedness to nature. Aside from these considerations, we recommend that future studies explore whether the relationships are affected by the chosen activity. This might involve testing the effects of various activities on connectedness to nature, such as sitting only, sitting plus walking, walking only, or other activities.

Besides the risk of bias, readers may question the practical value of increases in LCN scores. Understanding this value will require randomized controlled trials that measure how nature immersion with GE affects connectedness and outcomes of mental and physical health. Mixed-methods research designs could allow participants to explain their experience in their own words. Another critique may be that the VAS-N is not needed because almost 100% of participants completed the LCN. The VAS-N is still valuable because completing the LCN several times over a brief intervention is cumbersome. Scoring the LCN potentially hundreds of

times is also cumbersome. Given these considerations, the VAS-N may prove more useful than the LCN in field studies with repeated measures.

In summary, the present study offered evidence that the VAS-N measured the same construct as the LCN, but there was not convincing evidence for either scale's test-retest reliability over approximately 24 hours. Of the two scales, the LCN had the strongest evidence of reliability at pre-sit and post-sit. Researchers planning to conduct GE research should use the LCN and VAS-N cautiously. While the overall sample's connectedness to nature scores increased over 20 minutes of sitting and light-to-moderate intensity walking in green space, causal conclusions cannot be drawn until we see randomized controlled trials with a low risk of bias. Hopefully, the next generation of studies will build on the prototype offered here to further assess the scales' validity and test-retest reliability, the effects of nature immersion with GE on connectedness to nature, and the relationship between connectedness and state mindfulness. These studies should include control groups and detailed methods that can be replicated or reproduced. Evaluating various GEs and green spaces is important, as is prioritizing diversity, equity, and inclusion. Diverse samples that include people from underrepresented groups are essential.

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