Cumulative Frequency of Nature Dose: How Continuous and Regular Forest Walking Improves Nature Relatedness, Restorativeness, and Learning Engagement in College Students

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Abstract: Forest is a natural resource that provides natural walking as a popular leisure activity for urban residents. From the perspective of “dose of nature”, continuous contact with natural environments and engagement in natural activities can gradually promote positive health benefits. This study aims to explore the “cumulative frequency of nature dose” through regular forest walking. Ten college students were recruited to walk once a week for 30 min in the campus forest. Eight weeks of forest walking experiences were collected by administering questionnaires on nature relatedness, mental health, restorativeness, and learning engagement before the first walk, as well as after the fourth and the eighth walks. The findings of this study revealed that regular forest activities can induce accumulated natural benefits. By taking at least 30 min of forest walks once a week continuously for eight weeks, the subjects improved their mental health, increased learning engagement in school, gained more attention recovery and reflection experiences, and re-established a relationship with nature. In addition, different doses of natural benefits were observed for different cumulative processes.

Keywords: college student; cumulative frequency; exposure to nature; forest walking; human-nature experience; natural benefits; nature dose; nature relatedness

1. Introduction

The UNFPA reported that by 2030, more than five billion of the world’s population will live in urban areas. Evidence has shown that urban life can contribute negatively to mental health and wellbeing. Living in cities is associated with a greater risk of most mental health illnesses, such as mood and anxiety disorders and schizophrenia, as well as loneliness, isolation, and increased stress levels [1–3]. Urbanization has aggravated mental illnesses, such as depression and anxiety, in our society [4,5]. Exposure to the natural environment stimulates multiple health benefits, such as restoring attention and reflection [6–8], impacting cognitive performance [9], enhancing positive emotions [10,11], and reducing stress [9,12,13] and anxiety [11,14]. The annual outpatient report from the Taiwan Ministry of Health and Welfare in 2019 highlighted a critical problem in Taiwan: approximately 2,827,000 (12%) citizens suffer from mental disorders, particularly the younger generation, such as college students. Studies have revealed that college students suffer from increased mental health disorders, such as depression, anxiety, suicidal thoughts, and other neurotic traits [15–17]. For example, in Chen et al.’s study conducted in Taiwan [18], over 25% of students were under poor mental health status and more than 60% experienced stressful incidents. Therefore, it is critical to encourage college students’ contact with nature to improve their mental health and wellbeing.

According to the preventive medical effect, forest therapy—as a natural therapy, shinrin-yoku, which is a Japanese style of forest bathing—can increase positive physical and
psychological health benefits to prevent illness [19,20]. However, the following questions arose: “What is the nature dose to reduce stress”? and “What kinds of activities, such as walking in the forest or urban park, are more beneficial to humans”? [19]. Therefore, facing such a real problem of alienation between humans and nature, can the relationship between human and natural experiences be reconstructed through the frequency of the nature dose within the accumulation of natural activities, especially in the forest”? “Do the natural benefits increase from continuously regular contact with the forest”?

The biophilia hypothesis proposed by Wilson [21] states that the natural closeness of human beings is based on the process of evolution. As humans have been hunter-gatherers in nature in the process of evolution for a long time, they have genetically established an emotional connection with the natural environment and creatures. This emotional connection is attributed to the fact that nature provides resources for human survival [22]. Through the learning experience from the survival process, human beings respond positively to an environment of positive psychological perceptions, such as preference and restorativeness [23,24]. Through a strong sense of connectedness to nature [25], humans can obtain higher natural benefits [26] and show more positive attitudes and behaviors toward the environment [27,28]. That is, people with a stronger natural connection show more vitality, positive emotions, and life satisfaction than those who are alienated from nature [29]. Meanwhile, a study stated that the more frequently a human being is connected to nearby natural activities (e.g., comparing walking in wildness to walking in urban areas), the more increases are observed in happiness, health, and natural behavior [31].

Combining the concept of contact with nature and natural activities that provide doses of natural benefits, the “Dose of Nature” and “Green Exercise” proposed by Barton and Pretty [32] state that the dose responses, including duration, intensity, or landscape types, can influence individual health benefits (e.g., emotion). Shanahan et al. [33] proposed a nature-dose-response model that considers the following three key components of nature dose for health benefits: intensity of exposure (how much), frequency of exposure (how often), and duration of exposure (how long). Cox et al. [34] demonstrated that intensity (staying at a place with over 25% vegetation cover), frequency (visiting green space once a week), and duration (spending 10 min or more in nature) are associated with lower levels of depression. Shanahan et al. [35] reported that visiting green spaces at least once a week for 30 min or more can help urban residents reduce levels of depression and high blood pressure. In addition, Yeh et al. [36] defined the framework of green physical activity as contact with nearby nature, such as walking in a garden or park to release energy while gaining physical, psychological, and emotional health benefits [37]. Moreover, several researchers have related walking in nature to doses of natural benefits. Walking for 50 min in a natural environment can reduce anxiety and rumination and increase performance on working memory [38]. Similarly, walking 30 min in urban nature compared to urban areas can reduce rumination and negative emotions and enhance positive emotions [39]. Above all, green space experiences with physical activities ranging between 10 and 50 min can increase positive emotional states, working performance, and physical health. Therefore, how about exposure to forest areas?

Engaging in walking in the forest [40,41] or viewing the forest landscape [42] can induce a positive mood, reduce depression, and improve physiological responses, such as lower blood pressure and heart rate, higher parasympathetic nervous activity, and lower sympathetic nervous activity. For instance, Kim et al. [41] examined the impact of forest activities on college students’ psychological responses. They reported that the forest activity group demonstrated positive increases in their mood, stress response, and subjective wellbeing compared to the control group, which was not involved in any forest activities. In addition, research in learning institutions has demonstrated an improvement in activity level, balance and coordination abilities, health conditions, and learning concentration when students regularly spend time in the natural environment [43,44]. The feasibility
of engagement with nature also plays an important role in promoting students’ abilities, such as academic achievement and social behaviors [45]. The more high-school students are exposed to natural environments, the better performance they achieve in terms of, for example, test scores, graduation rates, and enrollment in tertiary education [46]. Student motivation, enjoyment, and engagement are better in natural settings [47] and promote intrinsic motivation for learning engagement and the longevity of learning interest [48].

Most previous studies have focused on the comparison of various landscape environments, such as urban, natural, or nearby nature, and the duration of contact with nature to evoke psychological health benefits and wellbeing [49]. However, only a few studies have explored the cumulative effects of the nature doses (i.e., indicated the doses of natural benefits of walking in the forest). This study focuses on the cumulative frequency of nature dose in the nature-dose-response model proposed by Shanahan et al. [33]. Frequency of nature dose is the number of times a person is exposed to nature during a particular time frame and in a pattern of exposure, such as regular, consistent, or intermittent. An individual’s health responses to the frequency of nature exposure are likely to be important in different patterns and across different time frames. We address the following question: “If college students increase their cumulative frequency of contact with nature and continually engage in natural activities, can they benefit from this connection and obtain more natural health benefits?” The core hypothesis of this research lies in the expectation that a continuous natural contact experience can enhance the positive relationship with nature, gain restorativeness experience, and improve the learning experience.

2. Materials and Methods

This study was designed to explore the effects of continuously regular forest walking on nature relatedness and natural benefits. A survey that included nature relatedness, mental health, restorativeness, and learning engagement was conducted to identify the factors that support the concept of interest here.

2.1. Participants and Research Site

College students of Huafan University were recruited for the eight-week field experiment. The recruitment information was posted on a student social networking site for Huafan University. The inclusion criteria required the participants to be over 20 years of age and to be currently enrolled college students who do not spend their daily life in the forest, including not having habits of forest walking and engaging in natural activities. Every participant who completed the eight-week walking experiment was provided with an incentive of 500 NT. The experiment was conducted from March to May 2017. Before starting the experiment, the researchers explained the study’s purpose and procedures, and the subjects’ willingness were confirmed to meet the research ethics statement by signing the informed consent form. During the spring semester, when the weather was warmer for forest walking, we encountered difficulties in recruiting and keeping subjects who were willing to participate in a long-term onsite experiment. Subjects might have been involved in other campus activities, which meant that they could not continue their forest walking once a week. When subjects missed one walking for personal reasons during the experiment, they dropped out of the study and did not receive the compensation. At the beginning of the experiment, 14 subjects participated (six males, eight females; mean age 22.2 ± 0.8 years); however, only 10 subjects (three males, seven females; mean age 22.3 ± 0.8 years) completed the eight-consecutive-week forest walking and related survey.

A post hoc power analysis was conducted using the software GPower. The sample size of 10 was used for the statistical power analyses. The recommended effect sizes used for this assessment were as follows: small ($f = 0.10$), medium ($f = 0.25$), and large ($f = 0.40$) [50]. The alpha level used for this analysis was $p < 0.05$. The post hoc analyses revealed the statistical power for this study was 0.87 for detecting a large effect, whereas the power below 0.43 for the detection of a moderate to small effect size. Thus, there was more than
adequate power (i.e., power $\geq 0.80$) at the large effect size level but less than adequate statistical power at the medium to small effect size level.

The field experiment was conducted on the campus of Huafan University in north Taiwan. Huafan University is situated at an altitude of approximately 500 m on Dalun Mountain in Shiding District, New Taipei City; it is known as a Forest University. There are several forest trails on campus, including White Bird Trail, Enthusiasm Trail, Sanyou Road, and Water Road, for forest walking. However, due to restrictions on the hillside development, school buildings are in a clustered development in Huafan University. Students’ activity and living areas were mainly artificially constructed environments. Forest and trails surrounded the area but were out of students’ ordinary life environments (Figure 1; also see Figures 2 and 3). Therefore, the subjects were asked to regularly choose one campus forest trail to start their forest walking and stay on the trail environment at least 30 min per week for eight weeks.

Figure 1. Map of trails at Huafan University.

Figure 2. Photographs of the Water Road trail taken by Subject A03.
2.2. Research Procedure

As shown in Figure 4, one week before the forest walking, the subjects were asked to sign the informed consent form, were explained the research process, and undertook a pre-test of nature relatedness, mental health, learning engagement, and attention recovery and reflection. After the fourth and the eighth forest walking, the subjects completed a post-test of these questionnaires. Data were collected through online surveys. The questions in the survey were shown in a random order to reduce the retest effects. The forest walking was carried out once a week, for at least 30 min each, for eight weeks. The subjects chose their free time to participate in the forest walking. After forest walking, they were asked to upload information on their walk (location, date, and time), at least one forest photograph of their walk (See Figures 2 and 3), and a brief note about their walking experience.

The study assigned an assistant to regularly remind subjects to have their walks and upload the reports. The assistant also examined the uploaded data to track the participation of subjects. Acceding to the data subjects uploaded, subjects’ walking periods were between 30 and 45 min.

2.3. Doses of Natural Benefits Measured by Questionnaires

2.3.1. Nature Relatedness

We used the Nature Relatedness (NR) scale developed by Nisbet et al. [51] to evaluate the personal natural connection characteristics. The NR scale, which contains 21 items, measures the three dimensions of the connection between an individual and nature: NR-Self, NR-Perspective, and NR-Experience. In this study, the value of Cronbach’s alpha for the full NR scale was evaluated as 0.73. The subjects answered on a 5-level Likert scale (1 = strongly disagree, 5 = strongly agree).
2.3.2. Mental Health

The Mental Health Continuum Short Form (MHC-SF) is a tool used to evaluate the mental health benefits of participants. It comprises 14 items, mainly measuring three aspects of psychological wellbeing: emotional, social, and psychological [52]. Emotional wellbeing measures positive emotions and overall life satisfaction; social wellbeing measures social acceptance, social realization, social contribution, social cohesion, and social integration; and psychological wellbeing measures self-acceptance and positive relationships with others, personal growth, life purpose, environmental control, and autonomy. The Cronbach’s alpha for this tool was evaluated as 0.86 in this study. The subjects answered on a 5-level Likert scale (1 = strongly disagree, 5 = strongly agree).

2.3.3. Attention Recovery and Reflection

The attention recovery and reflection scale was developed by the authors of [53]. Attention recovery mainly measures the mental recovery state of the subject in the environment, such as relaxation, rejuvenation, release of stress, and regain concentration, within seven items. Reflection indicates whether the subject thinks more deeply about their own problems and goals or reflects on their own attitudes and ways of dealing with things. It contains six items. In this study, the Cronbach’s alpha values were 0.89 for the recovery experience and 0.73 for the reflection experience. The subjects answered on a 5-level Likert scale (1 = strongly disagree, 5 = strongly agree).

2.3.4. Learning Engagement

The Learning Engagement Scale for College Students was developed by Lin and Huang [54]. It contains 20 items and evaluates college students’ learning engagement behavior from five dimensions: performance (e.g., I rarely skip or miss classes), interaction (e.g., During class, I will ask questions), emotion (e.g., School is one of my favorite places), skills (e.g., During class, I will use the methods and knowledge I have learned to complete the homework), and attitude (e.g., Before learning a new chapter, I will preview in advance). The Cronbach’s alpha for this scale was 0.82. The subjects answered on a 5-level Likert scale (1 = strongly disagree, 5 = strongly agree).

3. Results

Friedman and Wilcoxon signed-rank tests were conducted to test whether the participants exhibited significant differences in terms of each measurement variable after the pre-test, the four-week forest walking, and the eight-week forest walking to compare the doses of natural cumulative benefits gained through participation in the three stages.

3.1. Doses of Nature Relatedness in Forest Walking

In this study, 10 college students participated in the entire eight weeks of forest walking. Table 1 presented the experimental results. The Friedman test results showed significant differences in nature relatedness in the three stages ($\chi^2 = 15.765, p < 0.001$) through a dose of continuous in-forest walking. The different stages were examined in pairs using the Wilcoxon signed-rank test. The results showed that after four weeks of forest walking, no significant difference was observed in nature relatedness in the pre-test ($Z = -1.667, p = 0.096$), but after walking in the forest for eight weeks, it increased significantly ($Z = -2.555, p < 0.05$). These data were also graphed, as shown in Figure 5, using a scatter plot.
Table 1. Frequency doses of natural benefits among pre-test, four weeks of forest walking, and eight weeks of forest walking.

| Frequency of Forest Walking | (1) Pre-Test | (2) 4th Forest Walking | (3) 8th Forest Walking | Chi-Square $\chi^2$ | Asymp. Sig. p-Value | Wilcoxon Signed-Ranked Test (Post-Hoc) |
|-----------------------------|--------------|------------------------|------------------------|----------------------|---------------------|--------------------------------------|
| Natural connection          | 73.6±5.06    | 74.1±5.30              | 77.8±7.05              | 15.765               | 0.000 ***           | 1 < 2 < 3                            |
| Mental Health               | 47.5±11.09   | 53.2±9.32              | 55.6±7.12              | 7.154                | 0.023 *             | 1 < 2, 3                             |
| Attention Recovery          | 20.4±2.01    | 29.7±4.00              | 31.2±3.05              | 18.885               | 0.000 ***           | 1 < 2 < 3                            |
| Reflection                  | 18.2±2.20    | 23.4±3.72              | 24.9±2.77              | 16.722               | 0.000 ***           | 1 < 2 < 3                            |
| Learning Engagement         | 70.4±11.32   | 76.4±10.21             | 78.5±8.81              | 8.539                | 0.015 *             | 1 < 2, 3                             |

*p < 0.05; *** p < 0.001.

Figure 5. Scatterplot of nature relatedness vs. frequency of forest walking.

3.2. Dose of Natural Benefits in Forest Walking

Table 1 presents a detailed understanding of the results obtained at different stages of testing the doses of natural benefits in the forest. In terms of detecting natural benefit doses, the Friedman test results showed that continuous forest walking was associated with mental health ($\chi^2 = 7.154, p < 0.05$), attention recovery ($\chi^2 = 18.885, p < 0.001$) and reflection ($\chi^2 = 16.772, p < 0.001$), and learning engagement ($\chi^2 = 8.539, p < 0.05$). The results of the Wilcoxon signed-ranked test indicated that the doses of natural benefits, such as mental health ($Z = -1.962, p < 0.05$), attention recovery ($Z = -2.812, p < 0.01$) and reflection ($Z = -2.670, p < 0.01$), and learning engagement ($Z = -1.993, p < 0.05$), were significantly better than those in the pre-test. Moreover, after continuous forest walking for eight weeks, the doses of natural benefits in attention recovery ($Z = -2.388, p < 0.05$) and reflection ($Z = -2.058, p < 0.05$) were significantly better than those in four weeks; however, no significant effects were observed for mental health ($Z = -1.474, p = 0.141$) and learning input ($Z = -1.547, p = 0.122$) between four and eight weeks.

Figure 6 shows that mental health and learning engagement share the same pattern with continuous forest walking once a week. Students reported that their mental health and learning engagement improved in the fourth week, but the accumulated improvement did not continue into the eighth week. However, the attention recovery and reflection exhibited accumulated effects (Figure 7) when the students continuously walked in the forest every week.
How to convince humans to continually experience nature is an important topic in the landscape of human health. What is the pre-requisite of the dose of nature and natural benefits? This study shows that taking 30 min of forest walking can influence the doses of natural benefits in our daily life. These statements are in accordance with the results of previous studies that have tested engagement in nearby natural activities, such as gardening, walking, sightseeing, and other physical activities. At least 60 min per week of forest walking provides subjective health, wellbeing, and positive emotion\(^{[55–57]}\).

4.1. Cumulative Frequency Doses of Natural Benefits in Different Cumulative Processes

The results provide insight into how humans are deeply affiliated with nature\(^{[21]}\). They indicated that continuous exposure exhibits natural cumulative health benefits in forest walking. The findings of natural benefit doses can be summarized as follows: by taking at least 30-min forest walking once a week for eight weeks continuously, the subjects improved their mental health, increased learning engagement in school, gained more attention recovery and reflection experiences, and re-established a relationship with nature and felt a stronger resonant nature relatedness. A closer connection with nature leads to better health benefits (e.g., attentional recovery and reflection)\(^{[58]}\). In contrast, individuals who have frequent contact with nature can obtain more restorative experiences in natural

**Figure 6.** Scatterplot on mental health and learning engagement vs. frequency of forest walking.

**Figure 7.** Scatterplot of attention recovery and reflection vs. frequency of forest walking.
environments and have a strong connectedness with nature [25,51]. The “dose-response” research conducted for public health yielded similar results [35], indicating that visiting an urban green space for at least 30 min a week can prevent 7% of depression and 9% of high blood pressure cases. However, the study found different doses of natural benefits in different cumulative processes.

First, according to the results, forest walking can provide great restorative benefits. These results are consistent with the previously obtained result that forest landscapes help people recover better from attentional fatigue incurred than viewing urban streets [53]. As they were involved in more weeks of forest walking, the subjects gained more restorative benefits. After four and eight weeks of forest walking, the attention recovery and reflection experiences were significantly increased continually. This result agrees with that obtained by the authors in [55], who stated that a forest is a more restorative environment with fascination and being-away characteristics that can improve an individual’s physical and psychological conditions. It was found that more frequent contact with nature, even if the time of each contact is not long, results in the accumulation of more doses of restorative benefits.

Second, in terms of personal mental health state and learning engagement, the results showed a significant improvement after four weeks of forest walking; however, after eight weeks of walking, the results showed a level of a slight increase. Moreover, subjects reported a reduction in stress after connecting to nature. This is consistent with the results obtained by previous research, according to which forest activities can improve mental health [40], reduce depression [41], and promote learning motivation and learning engagement [47,48]. These findings imply that regular exposure to nature for four weeks can improve an individual’s mental wellbeing and learning attitude. However, it may take more than eight weeks or more profound natural experiences to obtain a continued improvement. Future research is required to explore this issue further.

In addition, the dose of natural connection slightly improved after four weeks of forest walking but did not show a significant level of difference in natural connection until eight weeks. The results indicate that it is necessary to accumulate more experiences regarding contact with nature to enhance an individual’s doses of nature connectedness. By increasing the experience of nature, we can improve the alienated relationship between humans and nature.

4.2. How Can College Students Be Encouraged to Continuously Contact Nature and Accumulate Benefits?

The findings of this study revealed that regular forest activities could induce accumulated natural benefits. This statement echoes previous research [59] that the “dose-response” of nature can be a guideline for humans to understand the issue of human-nature relationships. To improve college students’ relationships with nature, as well as their health conditions, more nature-based leisure or learning activities should be planned or promoted on college campuses. In addition, regular and short (30 min) natural experiences should be provided in students’ school lives.

Accounting for the nature-dose-response model proposed by Shanahan et al. [33], intensity (how much), frequency (how often), and duration (how long) are the main elements of the nature dose for health benefits. This study indicates that a higher intensity of nature (in the forest), cumulative frequency (once a week for 8 weeks), and short duration (30 min) lead to greater natural benefits. This concept can have implications for urban green infrastructure. One is to improve the accessibility of highly natural areas, such as improving the public transportation and suburban trail system, to make it easier for urban residents to continuously and regularly visit suburban forest areas to engage in leisure activities. Another aspect concerns ecology and human health, that is, planning more nearby urban natural environments, such as urban parks, urban forests, and gardening, to motivate individuals to continuously and regularly engage in natural activities for at least 30 min.
4.3. Limitation and Recommendations for Future Research

To examine the long-term frequency effects on the nature dose, the study conducted an 8-week onsite experiment. Thus, we also encountered difficulties in recruiting and keeping subjects who were willing to participate in a long-term onsite experiment. The small sample size of 10 may be considered to reduce the power of the study and increases the risk of the type II error, i.e., the null hypothesis is incorrectly accepted, and no difference between the study groups is reported. Although, significant differences were observed in the results, and the post hoc power analysis revealed that they met adequate statistical power at the large effect size level. This study has the undeniable exploratory merit of offering valuable insights into the frequency dose of nature and natural benefits. The comparison among the pre-test and two post-tests reveal the accumulated effects on frequency dose, i.e., more regular forest walking will lead to more natural benefits. The qualitative descriptions of natural experiences provided by the subjects can be further analyzed in detail. Further studies with a larger sample size and control group experiment are suggested to investigate the different doses of natural benefits further.

5. Conclusions

The cumulative frequency of nature doses that promote health benefits has received little research attention. This study verifies that humans-regular and continuous exposure to the natural environment can impact the natural benefits and improve the human-nature relationships. The results demonstrated cumulative benefits obtained through continuous exposure to 30-min forest walking once a week for a given time period. We can reasonably conclude that forest walking is full of natural features, such as primary forest, tree-covered landscape, rocks, and animals, which provide scenery completely different from the urban environment that leads humans to immerse in and become attracted by that scenery. Therefore, through continually engaging in forest walks, they could not only improve their mental health and learning engagement but also experience attention recovery and reflection through connection with nature by themselves. Overall, the empirical research presents the cumulative benefits of the dose of nature to promote regular natural activities and to improve the relationship between the natural environment and humans more comprehensively. In addition, the study encourages individuals who are alienated from nature to interact regularly with nature, which can increase their health benefits and mental wellbeing.

Author Contributions: Conceptualization, W.-Y.C. and S.-H.H.; methodology, W.-Y.C.; formal analysis, W.-Y.C.; investigation, W.-Y.C.; writing—original draft preparation, W.-Y.C. and S.-H.H.; supervision, W.-Y.C. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Ethical review and approval were waived for this study, the research funding from the Ministry of Education was not expected to apply for the research ethics committee (REC) during that time.

Informed Consent Statement: Although the ethical review and approval were waived for this study, informed consent was still obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to privacy concern.

Acknowledgments: The authors thank the subjects who joined our study.

Conflicts of Interest: The authors declare no conflict of interest.

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