



Living lab modelling as a pilot study assessing the potential psychological health benefits of forest environment for cancer survivors

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Objective

To evaluate the physiological and psychological changes in cancer survivors who engage in repeated forest therapy in a living environment.

Methods

This study included stay-based forest therapy for female cancer survivors aged ≥ 40 years. The program was conducted in two cycles, each spanning 3 weeks and consisting of a 2-night, 3-day stay, followed by daily life integration. The cycles were repeated from July 2, 2022, to August 18, 2022. Participant assessment included standard physical health parameters and a questionnaire on general characteristics, lifestyle habits, stress levels, and health status.

Results

Thirty-seven female cancer survivors participated in the forest healing program, 56.8% of whom had a history of breast cancer. The median body mass index (BMI) was 23.80 kg/m² (range, 21.00-25.60). More than half of the patients reported mild-to-moderate fatigue, chronic pain, and mild-to-moderate depression (81%, 65%, and 73%, respectively). After two cycles of forest therapy, no significant differences were observed in terms of fatigue, pain, or BMI levels. However, significant improvements were found in quality of life measures, particularly the psychological quality of life (mean score 12.54 at baseline vs. 13.48 after cycle 2; $P=0.007$). Positive improvements were also observed in terms of stress (mean score 17.03 vs. 13.76; $P=0.002$) and depression (mean score 8.35 vs. 6.11; $P=0.002$) levels.

Conclusion

Our forest-healing program demonstrated that nature-based therapies improve the mental health and quality of life of female cancer survivors, suggesting the need for further research on nature-based interventions to better support cancer survivors.

Keywords: Forests; Relaxation therapy; Cancer survivors; Quality of life; Psychological well-being

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Introduction

Cancer is the leading cause of death in South Korea [1]. It imposes a significant medical and economic burden not only in the country but also worldwide [2-4]. However, the field of cancer treatment has advanced significantly in recent years, with both conventional and novel therapies such as targeted therapies, contributing to improved outcomes [5]. Despite the increasing incidence of cancer, in cases of breast cancer, advancements in early detection and treatment methods have notably improved the relative survival rates. Consequently, there has been a significant increase in the number of breast cancer survivors [4].

Improving the quality of life (QOL) of cancer survivors is crucial as they often experience various mental and physical challenges following cancer treatment [6]. They can experience chronic mental and physical health issues that extend beyond the immediate post-treatment period [7]. However, one notable gap in the current research on cancer survivorship is the relatively limited focus on improving QOL compared to that on cancer treatment.

Cancer survivors face various health-related issues and are at a higher metabolic risk than individuals who have not experienced cancer [8,9]; the prevalence of metabolic syndrome is higher among cancer survivors than among individuals with no history of cancer [10]. Breast cancer survivors are up to 1.66 times more likely to develop metabolic syndrome than those who have never had breast cancer [11]. In addition, cancer survivors experience mental health challenges, such as depression, anxiety, and stress related to fear of recurrence or mortality, as well as physical issues, including sleep disturbances and fatigue [12,13]. Studies and interventions that focus on meditation and nature-based therapies have been conducted to address these chronic issues and improve patients' QOL, and have demonstrated positive impacts on their physical, mental, and social well-being [14].

Nature-based interventions such as forest therapy offer an alternative way for cancer survivors to improve and maintain their overall health status after cancer treatment [15]. The health benefits of nature and therapeutic effects of forests have garnered increasing attention worldwide, as supported by evidence-based data [16,17]. Forest environments have been identified as favorable restorative settings that positively affect human physiological and psychological functions [16]. Research has demonstrated the beneficial effects of

forests on various health conditions including allergies, respiratory diseases, and cardiovascular disorders. Additionally, spending time in forests promotes stress recovery, enhances concentration and productivity, improves psychological well-being, encourages positive social interactions, and reduces aggressive behavior [18]. These findings substantiate the scholarly understanding of the positive effects of forests on human health and wellbeing.

If a forest healing program is implemented repeatedly over a certain period, it is likely to yield favorable health outcomes. By assessing cancer survivors' health outcomes in the context of early-life health factors, we aimed to determine how nature-based treatments can reduce post-treatment complications among cancer survivors. We also aimed to understand the physical and psychological changes experienced by female cancer survivors who repeatedly participated in forest-based healing programs within a living environment, and to what extent they experienced these changes.

Materials and methods

This study was conducted at the forest healing center, which encompasses 2,889 ha in Yeongju City and Yecheon County, Gyeongsangbuk-do, South Korea (Supplementary Fig. 1). This study involved a stay-based forest healing program integrated into daily life. It was conducted in two cycles, each consisting of a 3-week program with a 2-night, 3-day stay, followed by daily life integration. The cycles were repeated from July 2, 2022, to August 18, 2022 (Fig. 1).

1. The experimental site for healing

The forest healing center features various facilities and gardens, including a health promotion center covering an area of 142 ha, which offers health assessments and indoor healing equipment experiences; accommodation facilities for short- and long-term visitors; a water healing center providing water-based healing programs utilizing various water pressure massages and spa facilities; nine representative forest trails spanning approximately 45 km, including a universally designed deck road for convenient use by people with disabilities and older people; an anion healing garden for anion therapy adjacent to a valley; an aromatic healing garden with over 100,000 plants from 64 native Korean species for aromatherapy; and a barefoot healing garden for

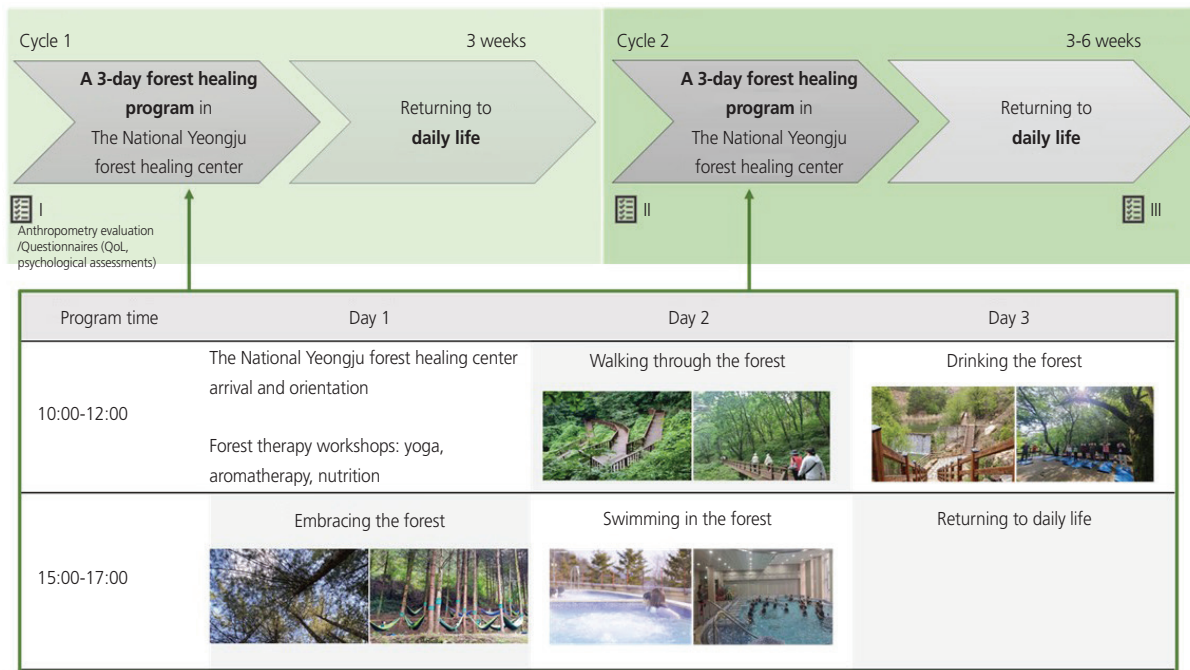


Fig. 1. A 3-day forest healing program in the forest healing center.

feet stimulation while walking with natural materials such as wood chips and gravel.

2. Study population

Study participants were recruited via a public notice that targeted female cancer survivors aged ≥ 40 years who met one or more of the following criteria for metabolic syndrome: waist circumference ≥ 85 cm; triglyceride levels ≥ 150 mg/dL; low high-density lipoprotein cholesterol levels < 50 mg/dL; blood pressure $\geq 130/85$ mmHg or currently taking medication for hypertension; and fasting blood glucose levels ≥ 100 mg/dL or currently taking medication for blood glucose regulation. The study did not differentiate participants according to the cancer type. Individuals provided written informed consent to participate in the study and to share their information. The participants were committed for the entire duration of the study. They were willing to respond to various surveys for effect verification, and other reasons.

Participants were ineligible for the study if they had mobility limitations necessitating assistance from another individual, were deemed vulnerable to the study, had cardiovascular diseases other than hypertension, or had specific medical conditions other than cancer.

3. Research design for forest healing program cycles

The program consisted of two repetitions: a 3-day greenspace exposure phase, followed by an 18-day reintegration into daily life (a stay-based forest healing program integrated with daily life). Fig. 1 illustrates the composition of the 3-day forest healing program at the forest healing center. The itinerary for the 3-day forest healing program was as follows.

Day 1: an orientation session introduced the participants to the forest healing program, including a tour of the facility and an explanation of the guidelines. The program featured forest therapy workshops aimed at promoting holistic well-being through activities such as yoga, aromatherapy, and nutritional guidance. Participants also engaged in forest immersion activities such as barefoot walking in pine forests and sunbathing.

Day 2: walking in the forest. The forest trail consisted of a gradual uphill path with an average incline of 15.2° and maximum incline of 52.6° . The concentration of non-volatile organic compounds (phytoncides) is approximately 431.03 parts per trillion by volume. The participants also engaged in swimming in the forest. The facilities consisted of a swimming pool, fitness pool, and bathtub, covering areas of 257 m^2 , 63 m^2 , and 36 m^2 , respectively. All are maintained to meet the potential groundwater quality standards.

Day 3: drinking in the forest. The participants embarked on a serene forest path adorned with stairs and varying slopes ranging from 46.1° to 0.0°, with an average slope of 15.2°. The path was adorned with 12.1% broad-leaved trees, 76.1% class three trees, and 23.9% class four trees. The participants experienced the anion healing garden, which was located at a lower elevation and encircled by a dam, and the sounds of flowing water-aided relaxation. Subsequently, participants returned to their daily lives.

4. A forest healing program integrated with daily life

As illustrated in Fig. 1, a 3-week cycle of an overnight forest therapy program integrated with daily life was conducted. The identical program was replicated in two sessions, resulting in a total duration of 6 weeks.

5. Demographic and psychological approach of the participants

The current study aimed to assess the effect of forest therapy on physical and psychological outcomes in female cancer survivors. To assess the participants' physical indicators, we utilized a body composition analyzer (InBody device: ACCU-NIQ BC720, and SELVAS; Healthcare Inc., Daejeon, Korea) to obtain information on body fat percentage, basal metabolic rate, and obesity indicators. Body mass index (BMI) was calculated as weight (kg) divided by height squared (m^2). The waist-hip ratio is the ratio of the waist circumference to the hip circumference and is automatically obtained using a body composition analyzer. The skeletal muscle index was determined by dividing the limb skeletal muscle mass (kg) by the height squared (m^2). Psychosocial assessments were conducted using questions commonly used in health check-ups and national health and nutrition surveys. The questionnaire assessed general characteristics, lifestyle, stress levels, health status, and sleep duration. Sleep-time efficiency is defined as the ratio of the total sleep time to the time spent in bed, representing the actual duration of sleep [19]. The specific scales utilized comprised the quick inventory of depressive symptomatology (QIDS) for measuring depression [20], beck anxiety inventory (BAI) for assessing anxiety [21], beck hopelessness scale for gauging feelings of hopelessness [22], and the Korean version of the World Health Organization quality of life scale-brief to evaluate social impact [23].

Measurements in this clinical study were performed at the outset, at the commencement of the second cycle, and at

the end of the study period. The 83-item survey typically requires approximately 15-25 minutes to complete.

6. Data analysis

Statistical analyses were performed using R language version 4.2.2 (R Foundation for Statistical Computing, Vienna, Austria) and the T&F program ver. 4.0 (Yoolin BioSoft, Goyang, Korea). Continuous variables are presented as the median (interquartile range) or mean \pm standard deviation, as appropriate, while categorical variables are expressed as the sample number (%). A generalized estimating equation (GEE) analysis was conducted to examine the population effects of the forest healing program. GEE was used to control for variances in the dependent variables, which were measured three times: before the program, after the first cycle, and after the second cycle. GEE analysis was adjusted for covariates including age, BMI, and cancer type. The dependent variables used in the GEE analysis were the survey scores related to stress, health, sleep quality, depression, anxiety, hopelessness, and QOL. Paired comparisons of continuous responses between repeated measures were analyzed using the Wilcoxon signed-rank test. The *P*-values were adjusted using the Bonferroni method to account for multiple comparisons. McNemar's test was used to compare categorical responses between different program sessions. Statistical significance was defined as $P < 0.05$.

7. Ethics approval and consent to participate

This study was approved by the Institutional Review Board of Korea University (KUIRB-2022-0145-01) and adhered to the principles of the Declaration of Helsinki. Prior to their participation, all participants were provided with a comprehensive explanation of the study titled 'forest healing program integrated with daily life' in both verbal and written forms. We detailed the study objectives, experimental procedures, measurements of physical and psychological conditions, and potential adverse effects. Written informed consent was obtained from each participant and permission to conduct the experiment at the forest healing center was granted.

Results

A total of 37 female cancer survivors participated in the forest healing program. The baseline characteristics of the study

population are summarized in Table 1. Approximately half (56.80%) of the participants had a history of breast cancer. The median time since the last treatment was 36 months (range, 17.00-59.00). The median BMI was 23.80 kg/m² (range, 21.00-25.60). Type 2 diabetes and hypertension were present in seven (18.90%) and 14 (37.80%) patients, respectively.

Most participants (30/37) reported mild-to-moderate fatigue before the program. In addition, 24 of the 37 patients experienced mild to moderate chronic pain. Sleep disturbances

were identified (20/37). The median sleep time efficiency was 86.61% (range, 71.10-100.00).

There were no significant differences in anthropometric indices, including body weight, body fat percentage, skeletal muscle index, or blood pressure before and after the two program cycles (Table 2). Complaints of fatigue and pain did not decrease after the program relative to before the program (fatigue, 81% vs. 86%; pain, 65% vs. 68%). However, there was a moderate improvement in sleep disturbance after the forest therapy (54% before vs. 33% after the program).

Notably, there were significant improvements in physical and psychological QOL (Fig. 2). Although there was a significant improvement in all QOL domains except social QOL, the difference was most significant in psychological QOL (Table 3). When changes in QOL scores were delineated for individual participants, most of the participants showed an increasing trend, and although some women showed the opposite (lattice plot of psychological QOL, Supplementary Fig. 2).

Similar to the increase in psychological QOL scores, there were improvements in related psychological measures, including stress, depression, and anxiety, after the forest therapy (Table 3). The mean total stress score decreased significantly from 17.03 to 13.76 ($P=0.002$). The lattice plot of the stress index for individual participants showed a global decrease in scores with a few exceptions. The depression score (QIDS score) also significantly decreased (8.35 vs. 6.11; $P=0.002$), as did the proportion of participants with mild-to-moderate depression (QIDS score ≥ 6 ; 73.0% vs. 48.6%; $P=0.027$). Although the anxiety score (BAI) was initially below the cutoff of diagnosing anxiety (mean, 8.32 ± 6.31 ; cut-

Table 1. Characteristics of the participants (n=37)

Variable	Value
Age (yr)	61.00 (51.50-69.50)
Height (cm)	157.00 (151.80-162.05)
Weight (kg)	57.10 (53.70-65.05)
BMI (kg/m ²)	23.80 (21.00-25.60)
Waist-hip ratio	0.85 (0.80-0.86)
Skeletal muscle index (kg/m ²)	7.41 (7.16-8.05)
Cancer diagnosis	
Breast cancer	21 (56.80)
Other cancer	16 (43.20)
Time from last treatments (months)	36.00 (17.00-59.00)
Type 2 diabetes	7 (18.90)
Hypertension	14 (37.80)
Dyslipidemia	9 (24.30)
Total sleep time (hours)	6.00 (5.00-7.00)
Sleep time efficacy	86.61 (71.10-100.00)

Values are presented as median (interquartile range) or number (%). BMI, body mass index.

Table 2. Anthropometric indices measured before, after cycle 1, and after cycle 2 of the forest healing program

Variable	Baseline	After cycle 1	After cycle 2
Weight (kg)	57.10 (53.70-65.05)	57.30 (53.15-65.20)	57.25 (54.65-62.73)
BMI (kg/m ²)	23.80 (21.00-25.60)	23.80 (20.80-25.80)	23.50 (21.30-25.70)
Body fat percent	32.90 (28.20-34.85)	31.60 (28.90-34.65)	33.35 (28.62-37.75)
Visceral fat area (cm ²)	84.00 (52.00-101.50)	76.00 (56.00-102.00)	87.70 (61.73-110.80)
Skeletal muscle mass (kg)	22.00 (20.15-23.30)	22.10 (20.10-23.35)	21.20 (18.85-22.80)
Skeletal muscle index	7.41 (7.16-8.05)	7.51 (7.08-8.00)	6.12 (5.82-6.82)
SBP (mmHg)	131.00 (120.50-143.50)	128.50 (113.80-143.50)	125.00 (115.80-130.00)
DBP (mmHg)	77.00 (72.00-87.00)	75.50 (68.00-88.00)	75.00 (71.80-79.30)

Values are presented as median (interquartile range) or number (%).

BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure.

off score ≥ 22), there was a statistically significant decrease in the score (8.32 vs. 5.05; $P < 0.001$).

Discussion

Our study revealed that two cycles of the forest-based healing program were associated with improvements in the psychological QOL of cancer survivors. Among mental health problems, significant improvements in stress, depression, and anxiety were observed. However, regarding the participants' anthropometric indices, no significant improvements in their metabolic and physical status were observed from before to after repeat cycles of the forest-based healing program. This study represents the first holistic model of cancer survivor care in a natural setting, and its findings emphasize the importance of considering patients' needs, practical daily life support, and health promotion programs.

With the exception of the social domain, the participants' QOL significantly improved in all areas, especially in the psychological domain. Forest visits, which involve spending time in natural settings, have a positive impact on psychological and physiological health [16,17]. These effects reduce the incidence of stress- and lifestyle-related diseases [17]. In particular, psychological symptoms (anxiety, depression, anger, fatigue, confusion, and vigor) were reported to have significantly improved in the forest-exposed group with high heterogeneity compared to those in the non-exposed group [16]. However, uncontrolled potential biases or confounding factors, such as social interactions of patients, physical activities, and environmental factors in the forest, limit the ability to draw definitive conclusions and assess the long-term ef-

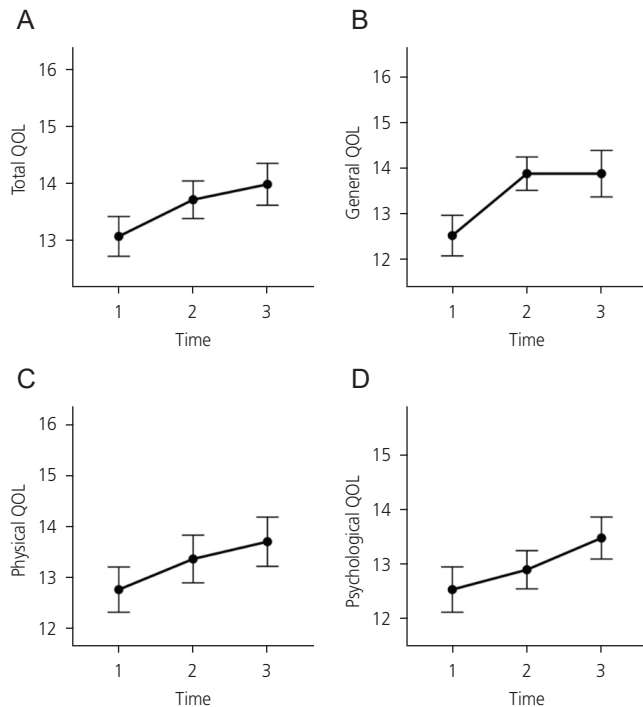


Fig. 2. Trends of quality of life (QOL) scores as the forest healing program progressed. (A) Total; (B) general; (C) physical; and (D) psychological QOL scores (mean \pm standard error).

Table 3. Questionnaire assessments on quality of life and psychosocial well-being before and after the forest healing program

Variable	Baseline	After cycle 1	After cycle 2	P-value ^{a)}
Quality of life				
Total	13.05 \pm 2.12	13.70 \pm 2.01	13.97 \pm 2.24	0.008
General	12.54 \pm 2.69	13.89 \pm 2.21	13.89 \pm 3.09	0.002
Physical	12.77 \pm 2.70	13.37 \pm 2.85	13.71 \pm 2.95	0.040
Psychological	12.54 \pm 2.50	12.90 \pm 2.11	13.48 \pm 2.33	0.007
Social	14.81 \pm 2.70	15.57 \pm 2.25	15.35 \pm 2.39	0.173
Lifestyle	13.15 \pm 2.50	13.82 \pm 2.33	14.05 \pm 2.41	0.033
Stress	17.03 \pm 7.29	14.84 \pm 7.33	13.76 \pm 6.65	0.002
Depression	8.35 \pm 5.09	6.54 \pm 4.18	6.11 \pm 5.34	0.002
Anxiety	8.32 \pm 6.31	6.41 \pm 6.35	5.05 \pm 6.60	<0.001
Hopelessness	5.08 \pm 4.88	4.78 \pm 4.83	4.30 \pm 4.34	0.080

Values are presented as mean \pm standard deviation.

^{a)}Generalized estimating equation analysis adjusted for age, body mass index, and cancer type (breast cancer vs. other cancers).

fects of forest interventions [16].

This study had a small sample size, which did not meet the statistical power required to detect significant therapeutic effects. Nevertheless, we noted improvements in the psychological health and QOL of the participants, which have been attributed to several proposed mechanisms. First, our findings indicate a significant reduction in average stress scores, consistent with previous research indicating that nature-based treatments for cancer survivors can effectively alleviate stress [24,25]. Individuals living with cancer for at least 5 years after diagnosis reportedly experienced significantly higher levels of moderate (23% vs. 17%) and severe (8% vs. 3%) mental distress than controls [26]. Therefore, it is widely recognized that cancer survivors often experience considerable stress and anxiety long after completing their cancer treatment. They may experience various stressors, including the late effects of cancer and its treatment, physical symptoms (such as pain, insomnia, and fatigue), fear of cancer recurrence, and emotional trauma (such as anxiety and depression). Given the negative effects of these stressors on the mental and overall health of cancer survivors, it is essential to provide appropriate stress-relief methods specifically designed for them [12,27]. Previous studies have also indicated that forest-based therapy is associated with reduced blood cortisol levels [16]. Cortisol, often referred to as a stress hormone, is produced by the adrenal glands and plays a crucial role in regulating several important functions in the body, including how the body responds to stress [28]. Therefore, our results show that the stay-based forest healing program has a positive effect on the mental health of cancer survivors by reducing stress levels and relieving depression and anxiety.

Second, the stay-based forest healing program included various physical activities, such as forest walking and swimming. Our findings revealed a significant improvement in the participants' physical QOL. This aligns with previous research indicating that physical activity, particularly in older individuals, can effectively alleviate symptoms of anxiety and depression, enhance mood, contribute to overall well-being, and serve as a preventive measure against depression [29]. Another study has reported an association between outdoor physical activity and reduced anxiety [30]. These studies consistently demonstrated the positive impact of physical activity on mental health. In a previous study, active cancer survivors, defined as those engaging in regular physical activity for 7.5-13.3 hours per week, exhibited a 47% lower risk of all-

cause mortality than inactive cancer survivors [31]. In another study, high levels of physical activity after cancer diagnosis were associated with 37% and 39% lower risks of cancer-related mortality and all-cause mortality, respectively, compared to cancer survivors with low levels of physical activity after diagnosis [32]. Physical activity can also aid in coping with the side effects of treatment and possibly even lower the risk of developing new cancers in the future [33]. Given the findings of previous studies, our results indicate that our stay-based forest healing program, which incorporates physical activity, is associated with improved mental health among cancer survivors. Although the participants' physical parameters, such as body weight and BMI, did not improve as a result of our stay-based forest healing program, they were not negatively affected. To confirm the positive effects of our forest program on the body composition of cancer survivors, it is necessary to continuously implement our healing program over a longer period.

Third, our study participants gathered to participate in a stay-based forest-healing program. A previous study found that participating in a group activity could help cancer survivors feel less lonely by getting them in contact with other cancer survivors who could share their experiences related to cancer and its treatment [34]. Usually, they are aware of each other's experiences without explicitly saying so and they are also aware of how to respond to each other's worries [35]. In our study, we provided opportunities for cancer survivors to spend time with each other through a stay-based forest healing program. The participants' social QOL improved, although the results were not statistically significant. To investigate social support in cancer survivors by creating social connections through our forest healing program, it is necessary to consider additional indicators of psychological health that can assess loneliness or social connections [36].

Our stay-based forest healing program, as a living lab approach, was positively associated with the mental health and QOL of cancer survivors. However, there was no improvement in body composition or anthropometric indices, which could be considered a marked reduction in metabolic risk [37]. We deduce that this result is because long-term regular intervention is needed to effectively change body composition and anthropometric characteristics [38]. Furthermore, given that our study program involved phases in which participants reintegrated into their regular daily lives, assessing the reduction in post-treatment complications related to their

initial daily life-related health factors is challenging, but crucial for enhancing the efficacy of nature-based treatments. Therefore, it is necessary to modify stay-based forest healing programs such that cancer survivors can continuously incorporate forest healing activities into their daily lives, thereby reducing their metabolic risks.

Throughout the study period, the dropout rate of the participants at the midpoint was 0%. Previous studies have reported that cancer survivors can drop out of clinical trials involving supportive or palliative treatment [39]. Dropout occurred in longer trials, with a rate of up to 50% [40]. The reasons cancer survivors abandon supportive or palliative treatment midway include social or environmental factors and symptoms experienced [39]. Although our forest therapy lasted 6 weeks, including a 3-day forest healing program and reintegration into the participants' daily lives, we infer that the program did not represent a burden large enough to prompt the participants to drop out of the trial.

Our study has some limitations. First, we only studied the changes over time before and after the stay-based forest healing program, as the program was repeated. Future research is needed to confirm the effects of our forest healing program by including a control group. Another limitation is the small sample size. Our forest-healing program was conducted with participants staying in designated forest-surrounded areas, making it challenging to include a large number of individuals simultaneously. Third, because a questionnaire was used to evaluate the QOL, stress, and mental health status of cancer survivors, there could have been a response bias regarding the results. Finally, the physical effects of the stay-based forest healing program were assessed based only on body composition analysis without blood testing to detect physical changes. Individuals using integrative medicine are aware of invasive testing. Hence, there is a need to generate evidence through non-invasive outcome measurements for such healing practices.

In conclusion, our study on a forest-based healing program implementing repetitive cycles showed a positive impact on the psychological well-being and QOL of cancer survivors. This outcome strongly indicates that nature-based therapies such as those conducted in forest environments can function as complementary treatments for cancer survivors by augmenting their mental health. Further research with a specific focus on cyclic nature-based interventions is warranted to enhance both physiological and psychological markers

among cancer survivors, particularly those at risk for metabolic issues.

Conflict of interest

None.

Ethical approval

This study was approved by the Institutional Review Board of Korea University (KUIRB-2022-0145-01) and adhered to the principles of the Declaration of Helsinki.

Patient consent

Written informed consent was obtained from each participant, and permission to conduct the experiment at the forest healing center was granted.

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References

1. Yun BS, Park EH, Ha J, Lee JY, Lee KH, Lee TS, et al. Incidence and survival of gynecologic cancer including cervical, uterine, ovarian, vaginal, vulvar cancer and gestational trophoblastic neoplasia in Korea, 1999-

- 2019: Korea Central Cancer Registry. *Obstet Gynecol Sci* 2023;66:545-61.
2. Kanjak J, Likitdee N, Kietpeerakool C, Temtanakitpaisan A. Evaluation of mobile health applications for cervical cancer in the digital marketplace. *Obstet Gynecol Sci* 2022;65:244-55.
3. GBD 2019 Cancer Risk Factors Collaborators. The global burden of cancer attributable to risk factors, 2010-19: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet* 2022;400:563-91.
4. Oh CM, Won YJ, Jung KW, Kong HJ, Cho H, Lee JK, et al. Cancer statistics in Korea: incidence, mortality, survival, and prevalence in 2013. *Cancer Res Treat* 2016;48:436-50.
5. Debela DT, Muzazu SG, Heraro KD, Ndalama MT, Mesele BW, Haile DC, et al. New approaches and procedures for cancer treatment: current perspectives. *SAGE Open Med* 2021;9:20503121211034366.
6. Miller KD, Nogueira L, Devasia T, Mariotto AB, Yabroff KR, Jemal A, et al. Cancer treatment and survivorship statistics, 2022. *CA Cancer J Clin* 2022;72:409-36.
7. Liu ZY, Wang C, Zhang YJ, Zhu HL. Combined lifestyle, mental health, and mortality in US cancer survivors: a national cohort study. *J Transl Med* 2022;20:376.
8. Park S, Lee S, Kim Y, Lee Y, Kang MW, Han K, et al. Altered risk for cardiovascular events with changes in the metabolic syndrome status: a nationwide population-based study of approximately 10 million persons. *Ann Intern Med* 2019;171:875-84.
9. Jung HS, Myung SK, Kim BS, Seo HG. Metabolic syndrome in adult cancer survivors: a meta-analysis. *Diabetes Res Clin Pract* 2012;95:275-82.
10. Kim M, Kim IH, Lim MK, Kim Y, Park B. Increased prevalence of metabolic syndrome in adult cancer survivors: Asian first report in community setting. *Cancer Epidemiol* 2019;58:130-6.
11. Buttros Dde A, Nahas EA, Vespoli Hde L, Uemura G, de Almeida Bda R, Nahas-Neto J. Risk of metabolic syndrome in postmenopausal breast cancer survivors. *Menopause* 2013;20:448-54.
12. Andrykowski MA, Lykins E, Floyd A. Psychological health in cancer survivors. *Semin Oncol Nurs* 2008;24:193-201.
13. van Leeuwen M, Husson O, Alberti P, Arraras JL, Chinot OL, Costantini A, et al. Understanding the quality of life (QOL) issues in survivors of cancer: towards the development of an EORTC QOL cancer survivorship questionnaire. *Health Qual Life Outcomes* 2018;16:114.
14. Baydoun M, Moran C, McLennan A, Piedalue KL, Oberoi D, Carlson LE. Mindfulness-based interventions in cancer survivors: a systematic review of participants' adherence to home practice. *Patient Prefer Adherence* 2021;15:1225-42.
15. Anundi H, Dolling A, Palsdottir AM. Forest therapy for women with gynaecological cancer-a feasibility study to find new alternatives in cancer rehabilitation. *Forests* 2023;14:333.
16. Oh B, Lee KJ, Zaslawski C, Yeung A, Rosenthal D, Larkey L, et al. Health and well-being benefits of spending time in forests: systematic review. *Environ Health Prev Med* 2017;22:71.
17. Shim SR, Chang J, Lee J, Byeon W, Lee J, Lee KJ. Perspectives on the psychological and physiological effects of forest therapy: a systematic review with a meta-analysis and meta-regression. *Forests* 2022;13:2029.
18. Piva G, Caruso L, Gómez AC, Calzolari M, Visintin EP, Davoli P, et al. Effects of forest walking on physical and mental health in elderly populations: a systematic review. *Rev Environ Health* 2022;39:121-36.
19. Reed DL, Sacco WP. Measuring sleep efficiency: what should the denominator be? *J Clin Sleep Med* 2016;12:263-6.
20. Hong JP, Park SJ, Park S, Lim A, Jeon D. Reliability and validity study of the Korean self rating version of quick inventory of depressive symptomatology (K-QIDS-SR). *Mood Emot* 2013;11:44-50.
21. Oh H, Park K, Yoon S, Kim Y, Lee SH, Choi YY, et al. Clinical utility of beck anxiety inventory in clinical and nonclinical Korean samples. *Front Psychiatry* 2018;9:666.
22. Kim S, Lee EH, Hwang ST, Hong SH, Lee K, Kim JH. Reliability and validity of the Korean version of the beck hopelessness scale. *J Korean Neuropsychiatr Assoc* 2015;54:84-90.
23. Min SK, Kim KI, Lee CI, Jung YC, Suh SY, Kim DK. Development of the Korean versions of WHO quality of life scale and WHOQOL-BREF. *Qual Life Res* 2002;11:593-600.
24. Timko Olson ER, Olson AA, Driscoll M, Vermeesch AL. Nature-based interventions and exposure among cancer survivors: a scoping review. *Int J Environ Res Public Health* 2023;20:2376.

25. Blaschke S. The role of nature in cancer patients' lives: a systematic review and qualitative meta-synthesis. *BMC Cancer* 2017;17:370.
26. Niedzwiedz CL, Knifton L, Robb KA, Katikireddi SV, Smith DJ. Depression and anxiety among people living with and beyond cancer: a growing clinical and research priority. *BMC Cancer* 2019;19:943.
27. Salvador C, Mark P, Hoenemeyer T, McDonald V. Prospective feasibility study of a mindfulness-based program for breast cancer patients in the southeastern US. *Complement Ther Clin Pract* 2022;49:101639.
28. Kim H, Kim J, Ju HJ, Jang BJ, Wang TK, Kim YI. Effect of forest therapy for menopausal women with insomnia. *Int J Environ Res Public Health* 2020;17:6548.
29. Park SH, Han KS, Kang CB. Effects of exercise programs on depressive symptoms, quality of life, and self-esteem in older people: a systematic review of randomized controlled trials. *Appl Nurs Res* 2014;27:219-26.
30. Lawton E, Brymer E, Clough P, Denovan A. The relationship between the physical activity environment, nature relatedness, anxiety, and the psychological well-being benefits of regular exercisers. *Front Psychol* 2017;8:1058.
31. Li Q, Pan X, Li X, Huang W. Association of physical activity intensity with all-cause mortality in cancer survivors: a national prospective cohort study. *Cancers (Basel)* 2022;14:5760.
32. Friedenreich CM, Stone CR, Cheung WY, Hayes SC. Physical activity and mortality in cancer survivors: a systematic review and meta-analysis. *JNCI Cancer Spectr* 2019;4:pkz080.
33. Tong CKW, Lau B, Davis MK. Exercise training for cancer survivors. *Curr Treat Options Oncol* 2020;21:53.
34. Tabrizi FM, Radfar M, Taei Z. Effects of supportive-expressive discussion groups on loneliness, hope and quality of life in breast cancer survivors: a randomized control trial. *Psychooncology* 2016;25:1057-63.
35. McDonough MH, Beselt LJ, Kronlund LJ, Albinati NK, Daun JT, Trudeau MS, et al. Social support and physical activity for cancer survivors: a qualitative review and meta-study. *J Cancer Surviv* 2021;15:713-28.
36. Wang JW, Zhang TR, Shen Q, Yang ZQ, Liu C, Chen SJ, et al. The experience of cancer survivors in community-based psycho-social support activities in Shanghai, China: a qualitative study. *Qual Life Res* 2015;24:2815-22.
37. Lee BJ, Yim MH. Comparison of anthropometric and body composition indices in the identification of metabolic risk factors. *Sci Rep* 2021;11:9931.
38. Dunskey A, Zach S, Zeev A, Goldbourt U, Shimony T, Goldsmith R, et al. Level of physical activity and anthropometric characteristics in old age—results from a national health survey. *Eur Rev Aging Phys Act* 2014;11:149-57.
39. Hui D, Glitza I, Chisholm G, Yennu S, Bruera E. Attrition rates, reasons, and predictive factors in supportive care and palliative oncology clinical trials. *Cancer* 2013;119:1098-105.
40. Gebert P, Schindel D, Frick J, Schenk L, Grittner U. Characteristics and patient-reported outcomes associated with dropout in severely affected oncological patients: an exploratory study. *BMC Med Res Methodol* 2021;21:77.