Effect of forest bathing integrated with mindfulness-based stress reduction on immune cell populations and quality of life in breast cancer patients: a controlled pilot study

Oh Sook Kwon¹, Keong Sub Shin², Do Bong Kim², He Young Ahn³, Su Jin Park⁴, Chan Woo Park⁴, Beom Seok Yang⁵, Sung Jae Lee⁷

¹Department of Integrative Medicine, Korea University Hospital, 126-1 Anam-Dong, Sungbuk-Gu, Seoul, 136-705, Korea, Tel: 82-2-920-6637
²Sam Medical Center, Anyang 5-Dong, Manan-Gu, Anyang, Gyeonggi-Do, Korea
³Department of Mind-Body Integration, Seoul University of Buddhism, 1038-2 Doksan-Dong, Geumcheon-Gu, Seoul, Korea
⁴Korea Forest Research Institute, 57 Hoegi-Ro, Dongdaemun-Gu, Seoul, Korea
⁵Korea Institute of Science and Technology, 39-1 Hawolgok-Dong, Sungbuk-Gu, Seoul, Korea

*Corresponding author

Keywords: Forest bathing, MBSR, Breast cancer patients, NK cells, Quality of life

Email addresses:
OSK:koswell@daum.net, KSS: bioshin@hotmail.com, DBK: ptrkdb@daum.net, HYA: mbsr1@hanmail.net, SJP: snowshoe@snu.ac.kr, CWP: pcwpcw@forest.go.kr, BSY: bsyang@kist.re.kr, SJL: lee3676@korea.ac.kr
Abstract

**Background:** The therapeutic effects of forest bathing on cancer patients have not yet been evaluated despite the known beneficial effects of this practice on immune function and stress reduction in healthy human subjects. We performed a controlled pilot study to assess the impact of forest bathing and its effects when used in combination with mindfulness-based stress reduction (MBSR) in breast cancer patients.

**Methods:** A total of 22 breast cancer patients from an urban area were randomly divided into 2 groups: group 1 (n = 11) was exposed only to forest bathing for 6 days, and group 2 (n = 11) underwent MBSR for 2 hours daily in addition to forest bathing. Blood samples were collected at the beginning and on the last day of treatment, and the populations of T helper cells and natural killer (NK) cells were counted. The participants’ quality of life was analyzed using the World Health Organization Quality of Life Assessment Instrument-Brief Form (WHOQOL-BREF) criteria.

**Results:** Forest bathing significantly increased the mean number of NK cells by 20.2%, and the scores of certain WHOQOL-BREF domains such as domain 1 (physical health) score by 15.7%, overall quality of life by 25.0%, and general health by 41.1%. The patients exposed to forest bathing in combination with the MBSR program showed significantly enhanced values; the mean NK cell population increased by 40.8%, WHOQOL-BREF score of domain 1 by 41.1%, domain 2 (psychological health) by 30.3%, and overall quality of life by 52.2%, representing 2.0-, 2.6-, 2.5-, and 2.1-fold higher increases respectively, compared with forest bathing alone with statistical significances. The score of general health was also significantly improved by
62.5% with the combination treatment, however, without being significantly different from that of forest bathing alone.

**Conclusion:** Forest bathing improved the immune function and quality of life of the breast cancer patients, and the beneficial effects are enhanced by the concurrent exposure to an MBSR program. Therefore, forest bathing and its integration with an MBSR program should be considered as one of the complementary and alternative medicine options for treating breast cancer patients.
Background

Forest bathing has been increasingly drawing attention for its proposed positive effects on human health [1]. This practice involves visiting a forest to relax while breathing in volatile organic chemicals produced by trees called phytoncides. Phytoncides were originally characterized as chemical agents with antimicrobial activities, and various types with different chemical structures have been indentified [2].

The beneficial psychological and physiological effects of forest bathing on humans have been shown in several studies. The Profile of Mood States (POMS) test was used to evaluate the effects of forest bathing on healthy volunteers, and the results showed significantly increased scores for vigor and decreased scores for anxiety and depression [3]. These results suggest that forest bathing may release stress or help participants manage stress better. The physiological benefits of this practice have been shown in studies demonstrating the enhancement of immune cell function. Healthy male and female volunteers living in urban areas who participated in a forest bathing trip showed significantly increased natural killer (NK) cell numbers and its relative proportions to lymphocytes, as well as enhanced expressions of anticancer proteins, such as perforin, GrA, and GRN synthesized from NK cells [4-6]. Phytoncides have been implicated in the effects of forest bathing on NK cells. Li et al. [7] showed that the phytoncides α-pinene, 1,8-cineole, and d-limonene stimulate the proliferation of NK cells and enhance their biological activities in an in vitro study. The changes in the stress hormone levels could also explain the effect of forest bathing on the modulation of NK cell activity. Forest bathing was reported to decrease the levels of the stress hormone cortisol [8–10], and cortisol level was negatively correlated with NK cell number and activity in human subjects [11]. Citrus fragrance, which is a phytoncide, was
shown to regulate the levels of stress hormones, such as cortisol and dopamine, and this was associated with the induction of NK cell activity [12]. In a study in mice, physical and/or psychological stress decreased NK cell activity and reduced the granzyme and perforin levels [13]. Taken together, these results support the notion that stress reduction may be one of the mechanisms mediating the beneficial effects of forest bathing, that is, increase in NK cell population and activity. It was suggested that forest bathing trips may have a cancer preventive effect because NK cells are involved in immune surveillance against tumor development and they can attack tumors by releasing proteins, such as perforin, GRN, and GrA/B [14]. In addition, the terpenoids in phytoncides, including α-humulene, β-caryophyllene, α-pinene, and β-pinene, were shown to have anticancer activity in animal studies [15].

Therapies based on the fact that the mind interacts with the body and can therefore affect human physical function and health are called “mind-body interventions” [17-18], and they comprise a distinct category of complementary medicine as delineated by the US National Center for Complementary or Alternative Medicine at the National Institutes of Health. This approach is increasingly being considered in medical practice, although its incidence is still low [16]. Cancer patients, in particular, tend to express a higher interest in this method than the general population. A variety of mind-body intervention practices and programs have been developed. They consist of relaxation therapies; meditation; exercise programs combined with meditation, such as yoga and taisi; and art and music therapy among others. Mind-body intervention therapies have been applied effectively to the treatment of cancer patients for the reduction of adverse effects, such as pain and insomnia, and for the improvement of quality of life [18-21]. Mindfulness-based stress reduction (MBSR) is one of the most frequently used mind-body interventions. It is a type of meditation therapy that was
originally established by Kabat-Zinn and colleagues at the Stress Reduction Clinic of the University of Massachusetts Medical Center [22, 23]. Since then, many clinical applications and well-being programs that use MBSR have been adopted in clinical centers around the world. MBSR has a root in the Buddhist spiritual traditions. It uses mindfulness meditation and yoga to alleviate pain and improve the physical and emotional health of patients. Its beneficial effects in the treatment of diseases and disorders, such as cancer, chronic pain, hypertension, and anxiety, have been proposed [24-29].

Although the beneficial effects of forest bathing have been well documented in healthy people, the effects of this practice on cancer patients remain to be evaluated. In addition, cooperative effects between forest bathing and a program based on mind-body intervention are expected for cancer patients. Here, we investigated the effects of forest bathing and its combination with MBSR on breast cancer patients by assessing the changes in the number of immune cell population and in quality of life.

**Results**

**Forest bathing increases NK cell population and certain WHOQOL domain scores in breast cancer patients**

To assess whether forest bathing has beneficial effects on breast cancer patients, the patients in group 1 (n = 11), which are described in table 1, were exposed to forest bathing for 6 days. The proportions of T and NK cells (%) to lymphocytes and the domain scores of the WHOQOL-BREF were obtained before and after the forest bathing treatment program, and the
mean and standard deviation values are listed in table 3. The increase rate in each measurement from before to after the forest bathing periods was calculated and is shown in table 3, including the calculated significance of the differences.

The mean CD 56\(^+\) NK cell population increased significantly by 20.2\% (p = 0.004) after exposure to forest bathing. Contrary to the NK cell population, the number of CD4\(^+\) T helper cells did not change significantly, although its mean value increased by 1.2\%.

The WHOQOL-BREF was used to assess the changes in the quality of life in the group 1 patients after exposure to forest bathing. As shown in table 3-1, forest bathing significantly increased the mean WHOQOL domain 1 (physical health) score by 15.7\% (p = 0.049). In addition, forest bathing significantly increased the mean overall quality of life scores by 25.0\% (p = 0.006) and general health by 41.1\% (p = 0.026). However, the WHOQOL domain 2 (psychological health), 3 (social relationships), and 4 (environment) scores did not change significantly, although the mean score values of domains 2 and 3 showed a slight increase.

Forest bathing in combination with MBSR increases the proportion of NK cells and WHOQOL scores to a greater degree than forest bathing alone

To examine the effect of the combination treatment of forest bathing and MBSR on breast cancer patients, the 11 participants described as group 2 in table 1 underwent an MBSR program concurrent with the 6 days of forest bathing. Similar to group 1, the mean values of the T and NK cell populations (%) in lymphocytes and the WHOQOL-BREF scores were obtained before and after the intervention program and the percent increase and p values were calculated. The results, which are summarized in table 4, show that forest bathing combined with MBSR resulted in a greater enhancement of NK cell population and WHOQOL domain
scores than forest bathing alone. The percent increase of the NK cell population by the combined intervention was 40.8% (p < 0.001) compared with 20.2% by forest bathing alone. However, similar to the results obtained with group 1, the CD4\(^+\) T helper population did not change significantly with the combination treatment and only increased slightly by 3.4%. On the other hand, the WHOQOL domain 1 and 2 scores increased significantly in response to the combination treatment, showing an improvement of 41.1% in domain 1 (p < 0.001) and 30.0% in domain 2 (p < 0.001). In addition, increases of 52.2% and 62.5% in the overall quality of life (p < 0.001) and general health (p = 0.002), respectively, were also observed. The improvements in the WHOQOL scores by the combination treatment were considerably higher than those obtained in group 1 by forest bathing only. No significant changes in quality of life domains 3 and 4 were observed in group 2 (table 4).

**Forest bathing and MBSR show cooperative effects in the enhancement of NK cell population and WHOQOL scores in breast cancer patients**

The considerable increase in NK cell population and WHOQOL scores in the patients exposed to forest bathing combined with MBSR compared with forest bathing alone suggests that forest bathing and MBSR may act in a cooperative manner in breast cancer patients. In fact, the mean increases in NK cell population showed a 2.0-fold higher value in group 2, which was subjected to the combination of MBSR and forest bathing, than in group 1 patients, which were treated with forest bathing alone (p = 0.033). Likewise, the WHOQOL-BREF scores showed an improvement of 2.6-fold in domain 1 (p = 0.037), 2.5-fold in domain 2 (p = 0.045), and 2.1-fold in the overall score (p = 0.026; Figs. 1 and 2). However, no statistically significant differences were observed between the 2 groups in the mean increase in the CD4\(^+\) T helper cell
population and WHOQOL domain 3 and 4 scores or in general health, although more or less higher increases were seen in group 2. This result indicates that forest bathing and MBSR can act cooperatively in breast cancer patients by enhancing immune function through an increase in NK cell population and the improvement of some aspects of quality of life.

Discussion

The present study is the first to evaluate the effects of forest bathing in breast cancer patients, although the beneficial effects of this practice on healthy human subjects, as reflected in the increase in the number and activity of NK cells, have been reported previously [3-10]. Furthermore, we assessed the effect of forest bathing in combination with MBSR. We demonstrated that breast cancer patients showed a positive response to forest bathing by the significant increase in NK cell population. This result is consistent with that of a previous study that showed an increase in NK cells of approximately 36.1% in healthy individuals exposed to forest bathing for 3 days, although the induction level of 20.2% in the present study with breast cancer patients is lower [6]. In addition, we showed that forest bathing and MBSR act in a cooperative manner in increasing the NK cell population and improving quality of life. NK cell population changes have been used before as biomarkers of the response of cancer patients to various complementary and alternative medicinal practices, such as meditation and yoga [32, 33].

NK cells, which play a crucial role in innate immunity, are cytolytic and secrete cytokines against tumor cells and cells infected with bacteria and viruses [34, 35]. A close correlation between a reduction of NK cell activity and the development of cancer has been
observed [36-40], and the preventive effect of NK cells against cancer development has been suggested [41]. Furthermore, the use of NK cells in cancer therapy has been proposed [42]. Therefore, an increase in NK cell population caused by forest bathing is expected to be beneficial for cancer patients.

The mechanism underlying the increase in NK cell population by forest bathing can be explained using physiological and psychological approaches. Physiologically, there is evidence that phytoncides can stimulate NK cell proliferation [7]. Psychologically, the effect of forest bathing on stress reduction can induce an increase in the number of NK cells because NK cell activity is associated with stress in cancer patients. Prior studies have shown that stress level affects immune function by modulating NK cells in cancer patients [43, 44], and psychosocial treatments were shown to significantly improve NK cell levels [45]. As mentioned earlier, the stress hormone cortisol could be one of the biochemical mediators in the inverse relationship between stress and NK cell population growth [8-11]. Therefore, it is possible that forest bathing can suppress cortisol and consequently stimulate NK cells.

The WHOQOL-BREF was used to assess the effect of forest bathing on the quality of life of cancer patients because of the importance of quality of life in the health care of patients with cancer. Patients with cancer who underwent treatment for cancer are prone to experience higher levels of psychological stress and pain than the general public owing to the fear of dying and changes in economic and social status [46]. A diagnosis of breast cancer was shown to alter patients’ emotional, cognitive and social functioning [47]. Therefore, the improvement of quality of life is an important issue in the clinical treatment of cancer patients because poor quality of life can adversely affect therapeutic outcome [48, 49].

Our study showed that forest bathing increased the WHOQOL-BREF domain 1 (physical health) score significantly in breast cancer patients. It is interesting that the
exposure of the patients to the combination treatment of forest bathing and MBSR caused not only an improvement in the score of domain 1 but also in that of domain 2 (psychological health). Furthermore, the increases in these scores were significantly higher than those obtained with forest bathing alone. These results suggest that forest bathing combined with MBSR could potentially result in physical and psychological benefits for breast cancer patients, which would lead to a better therapeutic outcome and enhanced immune function.

Our results showed that forest bathing and the MBSR program acted in a cooperative manner to enhance the NK cell population and WHOQOL-BREF scores. The psychological effects of the MBSR program likely played a key role in this cooperative effect. The importance of psychological factors for predicting a better prognosis in cancer patients has been reported previously [50]. A low stress level in the POMS in breast cancer patients was associated with a longer disease-free interval, whereas a high stress condition was associated with cancer recurrence [51]. Feelings of fear, isolation, and aloneness among breast cancer patients have been reported in prior studies [52]. We believe that forest bathing trips can also contribute to enhancing the quality of life of breast cancer patients because the program provides these patients with an environment in which they can express and share their experiences, feelings, and concerns.

Conclusions

Forest bathing had a beneficial effect on the breast cancer patients by improving immune function and quality of life in physical and psychological aspects. Higher positive outcomes were obtained when the cancer patients were treated with forest bathing.
integrated with an MBSR program. Therefore, we suggest that forest bathing should be considered an effective complementary and alternative treatment for cancer patients. In addition, we recommend its practice in combination with an MBSR program for a better outcome.

Methods

Design and subject

This study was designed as a controlled intervention study. The subjects included 22 Korean women living in an urban area, with a median age of 54 years. They were found to have breast cancer and treated either at the Korea University Hospital, Seoul, South Korea, or at Sam Hospital, Anyang, South Korea. A minimum of 3 months but no longer than 1 year had passed since the last treatment including surgery and chemotherapy and/or radiation therapy for all the subjects. None of the participants had a history of either forest bathing or MBSR treatment. None of them had serious mental or physical problems in managing their daily life, and they did not require nursing care. Their education levels were higher than secondary school, except in 1 subject. All of them were unemployed and staying home at the time of the study. They were randomly divided into 2 subject groups: group 1 consisted of 11 patients who participated in only the forest bathing for 6 days, and group 2, with the remaining 11 patients, was exposed to a combination of forest bathing and an MBSR program. The characteristics of the subjects in each group are listed in table 1.
Intervention procedure

All the participating patients presented at the Korea University Hospital, Seoul, South Korea, on the day they left for the forest, and blood samples were collected. In addition, they spent 1 hour completing the World Health Organization Quality of Life Assessment Instrument-Brief Form (WHOQOL-BREF) questionnaire. The participants were then transported by bus in a 2-hour ride to the Saneum National Forest, located in Kyungkido, South Korea. After arrival at the forest, they were given a short orientation about the schedule and intervention program. The following day, subject group 1 was treated with only forest bathing and group 2 was subjected to forest bathing combined with the MBSR program for 6 consecutive days. All the participants in both groups were recommended to walk through the forest for 1 to 2 hours per day. In addition, all the patients in group 2 attended the MBSR program for 2 hours per day, in the morning, for 6 consecutive days, whereas the group 1 patients had a free schedule while they stayed in the forest. After the completion of the 6-day intervention program, the patients were driven back to the Korea University Hospital, where blood samples were collected and the WHOQOL-BREF questionnaire was completed before they returned home.

Mindfulness-Based Stress Reduction

Significant modifications to the original version of the MBSR program designed by Jon Kabat-Zinn [22, 23] were made in this study to fit the program within the 6-day schedule of this study. The contents of the classes for the 6 days are summarized in table 2. The classes were held each day from 10:00 am to 12:00 noon, for 6 consecutive days. All the classes were run within the Saneum National Forest by a qualified teacher with 6 years of experience.
teaching MBSR. This program, which we call MBSR-informed, used methods such as body scan, sitting, and walking meditation with an emphasis on enhancing the participants’ moment-to-moment awareness. The classes were focused on the cultivation of mindful awareness and designed to help strengthen the participants’ innate ability to be mindfully aware in everyday life. Unlike the standard MBSR programs, no CD-based homework was assigned. Instead, to help the participants maintain mindfulness outside of the class, they were encouraged to practice mindfulness while eating, taking a shower, exercising, walking, and even while talking. The participants were strongly encouraged to pay attention to whatever arises during their waking hours and to remind themselves of questions such as “What am I doing in this moment?” or “What is the current state of my body?” to maintain mindfulness.

**Estimation of the populations of CD4⁺ T helper cells and CD56⁺ NK cells in lymphocytes**

The blood samples that were collected from the participants, using collection tubes with an anticoagulant, were used for the flow cytometric analysis to estimate the percentage of CD4⁺ T helper cells and NK cells in lymphocytes within 4 hours after the sampling. The flow cytometric analysis was performed using the Cytomics FC500 flow cytometer (Beckman Coulter, USA) according to the manufacturer’s protocol as described briefly as follows. All the fluorochrome-conjugated antibody reagents and cell fixing and lysing solutions (Versal Lyse Lysing solution) were purchased from Beckmann Coulter. For the analysis of the CD4⁺ T helper cells, 100 μL of whole blood treated with heparin was mixed with 10 μL of CD45⁺-ECD monoclonal antibody and 20 μL of CD3-FITC/CD4-PE monoclonal antibody. To analyze the CD56⁺ NK cell population, 100 μL of the blood sample was mixed with 10 μL of CD45⁺-ECD
monoclonal antibody and 20 μL of CD3-FITC/CD56-PC5 monoclonal antibody. To eliminate nonspecific staining, 100 μL of the blood sample was mixed with 10 μL of CD45^+^ECD monoclonal antibody and 20 μL of IgG1-FITC/IgG1-PE/IgG1-PC5 monoclonal antibody solution. The 3 mixed blood samples were briefly vortexed and incubated in the dark for 15 minutes at room temperature. Then, 1 mL of Versal Lyse lysing solution (Beckmann Coulter) was added to each sample. The samples were further incubated for 10 minutes at room temperature in the dark before being applied to the flow cytometer. The CD45^+^ECD monoclonal antibody was used to gate the lymphocyte cells in the flow cytometric analysis.

**Assessment with the WHOQOL-BREF**

Quality of life was assessed using the Korean version of the WHOQOL-BREF [30]. WHOQOL-BREF is a concise version of the WHOQOL-100 [31]. The instrument contains a total of 26 questions consisting of 4 domains (24 questions in total): domain 1, physical health (7 questions); domain 2, psychological health (6 questions); domain 3, social relationships (3 questions); and domain 4, environment (8 questions), and 2 separate questions to assess overall quality of life and general health. The questionnaire is self-administered, and the score of each domain stands for the individual’s perception of the quality of life in the domain. The scores for each question were graded from 1 to 5, and these scores were converted to a scale from 0 to 100 by setting score 1 to 0, 2 to 25, 3 to 50, 4 to 75, and 5 to 100. The mean score of the questions in each domain was used to calculate the domain score for each individual.

**Statistical analysis**
All the data are expressed as mean ± SD. The SPSS for Windows version 12.0 was used for the statistical analysis. Comparisons within each group were performed using the paired Student t test. The comparisons between groups 1 and 2 were done by the unpaired Student t test. Statistical significance was set at P < 0.05.

Competing interests

The authors declare that they have no competing interests.

Authors’ contributions

SJL was the principal investigator who participated in the design of the study, data analysis and writing of the manuscript. OSK participated in the overall conduction of experiments, data analysis and writing of the manuscript. KSS and DBK participated in the conduction of experiments and data analysis. HYA participated in the conduction of the MRSA program, data analysis and writing of the manuscript. SJP and CWP participated in coordinating the study. BSY participated in data analysis and writing of the manuscript. All authors have read and approved the final manuscript.

Acknowledgement
This work was supported by a grant from Korea Forest Research Institute (02-01-01-540104).
References


24. Carlson LE, Speca M, Patel KD, Goodey E: Mindfulness-based stress reduction in relation to quality of life, mood, symptoms of stress and levels of cortisol,
dehydroepiandrosterone sulfate (DHEAS) and melatonin in breast and prostate cancer outpatients. *Psychoneuroendocrinology* 2004, **29**:448-474.


and coping in women newly diagnosed with early stage breast cancer. *Brain Behav Immun* 2008, **22**:969-981.


Table 1. Summary of the subject characteristics

<table>
<thead>
<tr>
<th></th>
<th>Group 1 (n = 11)</th>
<th>Group 2 (n = 11)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean ± SD (range)</td>
<td>54.00 ± 9.24 (39–76)</td>
<td>53.00 ± 6.92 (42-69)</td>
</tr>
<tr>
<td>Marital status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>11 100</td>
<td>10 90.9</td>
</tr>
<tr>
<td>Single</td>
<td>0 0</td>
<td>1 9.1</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 or less years</td>
<td>1 9.1</td>
<td>0 0</td>
</tr>
<tr>
<td>More than 9 years</td>
<td>10 90.9</td>
<td>11 100</td>
</tr>
<tr>
<td>Religion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>9 81.8</td>
<td>9 81.8</td>
</tr>
<tr>
<td>No</td>
<td>2 18.2</td>
<td>2 18.2</td>
</tr>
<tr>
<td>Type of surgery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MRM</td>
<td>9 81.8</td>
<td>9 81.8</td>
</tr>
<tr>
<td>Partial mastectomy</td>
<td>2 18.2</td>
<td>2 18.2</td>
</tr>
<tr>
<td>Treatment after surgery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>3 27.3</td>
<td>3 27.3</td>
</tr>
<tr>
<td>Chemotherapy</td>
<td>7 63.6</td>
<td>8 72.7</td>
</tr>
<tr>
<td>Radiotherapy</td>
<td>1 9.1</td>
<td>0 0</td>
</tr>
<tr>
<td>Stage of breast cancer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stage II</td>
<td>2 18.2</td>
<td>3 27.3</td>
</tr>
<tr>
<td>Stage III</td>
<td>7 63.6</td>
<td>6 54.5</td>
</tr>
<tr>
<td>Stage IV</td>
<td>2 18.2</td>
<td>2 18.2</td>
</tr>
<tr>
<td>Sequence</td>
<td>Theme</td>
<td>Content</td>
</tr>
<tr>
<td>------------</td>
<td>--------------------------------------------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td>Class day 1</td>
<td>Introduction and preparation</td>
<td>Introduction to mindfulness</td>
</tr>
<tr>
<td>Class day 2</td>
<td>Opening the 5 senses</td>
<td>Raisin-eating meditation and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>walking meditation</td>
</tr>
<tr>
<td>Class day 3</td>
<td>Familiarization with one's own body</td>
<td>Body scan and mindfulness of</td>
</tr>
<tr>
<td></td>
<td></td>
<td>breathing</td>
</tr>
<tr>
<td>Class day 4</td>
<td>Stress reactivity versus stress response</td>
<td>Understanding of stress and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>mindful communication</td>
</tr>
<tr>
<td>Class day 5</td>
<td>Awareness of nature</td>
<td>Mountain meditation and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>mindfulness of thoughts</td>
</tr>
<tr>
<td>Class day 6</td>
<td>Integration of mindfulness into daily life</td>
<td>Review and plan for using</td>
</tr>
<tr>
<td></td>
<td></td>
<td>mindfulness in one’s daily life</td>
</tr>
</tbody>
</table>
Table 3. Effects of forest bathing on the immune cell populations and WHOQOL-BREF domain scores of the breast cancer patients

<table>
<thead>
<tr>
<th></th>
<th>Pre</th>
<th>Post</th>
<th>% Increase</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>T cell population</td>
<td>36.50 ± 6.88</td>
<td>36.93 ± 8.12</td>
<td>1.2</td>
<td>0.742</td>
</tr>
<tr>
<td>NK cell population</td>
<td>17.08 ± 3.88</td>
<td>20.53 ± 5.39</td>
<td>20.2</td>
<td>0.004</td>
</tr>
<tr>
<td>QOL domain 1</td>
<td>51.63 ± 13.19</td>
<td>59.74 ± 9.46</td>
<td>15.7</td>
<td>0.049</td>
</tr>
<tr>
<td>QOL domain 2</td>
<td>54.17 ± 15.37</td>
<td>60.61 ± 9.01</td>
<td>11.9</td>
<td>0.112</td>
</tr>
<tr>
<td>QOL domain 3</td>
<td>55.97 ± 7.84</td>
<td>59.09 ± 6.62</td>
<td>5.6</td>
<td>0.279</td>
</tr>
<tr>
<td>QOL domain 4</td>
<td>61.36 ± 10.05</td>
<td>58.33 ± 10.54</td>
<td>−4.9</td>
<td>0.221</td>
</tr>
<tr>
<td>QOL overall</td>
<td>54.55 ± 21.85</td>
<td>68.18 ± 11.68</td>
<td>25.0</td>
<td>0.006</td>
</tr>
<tr>
<td>QOL general health</td>
<td>38.64 ± 25.89</td>
<td>54.55 ± 18.77</td>
<td>41.2</td>
<td>0.026</td>
</tr>
</tbody>
</table>

The mean and standard deviation values in group 1 (n = 11) are shown before (pre) and after (post) forest bathing. The percent increase was calculated according to the following formula: \([(\text{post} - \text{pre}) / \text{pre}] \times 100\), and the p values were obtained from the difference between the pre and post values by a paired t test. QOL stands for WHOQOL-BREF.
Table 4. Effect of forest bathing integrated with the MBSR program on the immune cell populations and WHOQOL-BREF domain scores of the breast cancer patients

<table>
<thead>
<tr>
<th></th>
<th>Pre</th>
<th>Post</th>
<th>% Increase</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>T cell population</td>
<td>38.01 ± 5.51</td>
<td>39.31 ± 6.32</td>
<td>3.4</td>
<td>0.425</td>
</tr>
<tr>
<td>NK cell population</td>
<td>16.19 ± 4.85</td>
<td>22.80 ± 6.78</td>
<td>40.8</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>QOL domain 1</td>
<td>49.02 ± 18.36</td>
<td>69.15 ± 18.71</td>
<td>41.1</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>QOL domain 2</td>
<td>56.82 ± 19.74</td>
<td>73.86 ± 15.38</td>
<td>30.0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>QOL domain 3</td>
<td>59.09 ± 11.39</td>
<td>65.63 ± 12.58</td>
<td>11.1</td>
<td>0.105</td>
</tr>
<tr>
<td>QOL domain 4</td>
<td>62.12 ± 16.40</td>
<td>66.67 ± 18.26</td>
<td>7.3</td>
<td>0.140</td>
</tr>
<tr>
<td>QOL overall</td>
<td>52.27 ± 23.60</td>
<td>79.55 ± 15.08</td>
<td>52.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>QOL general health</td>
<td>36.36 ± 17.19</td>
<td>59.09 ± 23.11</td>
<td>62.5</td>
<td>0.002</td>
</tr>
</tbody>
</table>

The mean values, standard deviations, percent increase, and p values for the patients in group 2 (n = 11) were obtained as described in table 3.
Figure legends

Figure 1. Forest bathing and MBSR act in a cooperative manner to induce an increase in NK cell population in breast cancer patients. Black bar: percent increase in the population of each immune cell (NK and T-helper cells) in lymphocytes for the group 1 patients (n = 11) who participated in forest bathing exclusively; white bar: increase for the group 2 patients (n = 11) who were subjected to forest bathing integrated with the MBSR program. The mean increase value for the patients in each group is shown as a bar graph with a standard deviation. *p = 0.033

Figure 2. Forest bathing and MBSR act in a cooperative manner to enhance the WHOQOL-BREF domain scores in the breast cancer patients. Black bar: increase of each WHOQOL-BREF domain score for the group 1 patients (n = 11) exposed to forest bathing alone; white bar: increase in the scores of the group 2 patients (n = 11) who underwent forest bathing integrated with the MBSR program. The mean increase values for the patients in each group are shown as a bar graph with standard deviations. *p = 0.037, **p = 0.045, ***p = 0.026
Figure 1

The figure shows a bar graph comparing the increase in % immune cell population between NK cells and T helper cells. The y-axis represents the increase in % immune cell population, while the x-axis distinguishes between NK cells and T helper cells. The graph includes error bars indicating variability.
Figure 2

Increase in WHOQOL-BREF domain score

**Figure 2**