

Research Article

# Phytoncides (Wood Essential Oils) Induce Human Natural Killer Cell Activity

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To explore the effect of forest bathing on the human immune system, we investigated the effect of phytoncides (wood essential oils) on natural killer (NK) activity and the expression of perforin, granzyme A and granulysin in human NK cells. We used NK-92MI cell, an interleukin-2 independent human NK cell line derived from the NK-92 cell, in the present study. NK-92MI cells express the CD56 surface marker, perforin, granzyme A, and granulysin by flow cytometry and are highly cytotoxic to K562 cells in chromium release assay. Phytoncides significantly increase cytolytic activity of NK-92MI cells in a dose-dependent manner and significantly increase the expression of perforin, granzyme A, and granulysin in the NK-92MI cells. Phytoncides also partially, but significantly, restore the decreased human NK activity and the decreased perforin, granzyme A, and granulysin expression in NK-92MI cells induced by dimethyl 2,2-dichlorovinyl phosphate (DDVP), an organophosphorus pesticide. Pretreatment with phytoncides partially prevents DDVP-induced inhibition of NK activity. Taken together, these data indicate that phytoncides significantly enhance human NK activity and this effect is at least partially mediated by induction of intracellular perforin, granzyme A, and granulysin.

Read More: <http://informahealthcare.com/doi/abs/10.1080/08923970600809439%20>

## Benefits-Based Analysis of Visitor Use of Sorak-San National Park in Korea

- [WON SOP SHIN,](#)
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## Abstract

Benefits-based management seeks to provide recreation benefits for recreation participants by managing the physical environments in which recreation occurs. This study investigates the relationship between benefits desired by visitors and the physical, social, and managerial characteristics of settings that facilitate realization of recreation benefits. Data such as perceived benefits from recreation experiences, setting attributes that significantly influenced perceived benefits, and sociodemographic variables were collected from 376 visitors to Sorak-san National Park in the eastern part of the Korean peninsula. Cluster analysis was used to group visitors' desired benefits into 12 domains: relationship with nature/scenery, escaping pressure, learning about nature, family togetherness, introspection, exploration, autonomy/achievement, being with friends, leading others, skills/learning, risk taking, and meeting/observing new people. Multiple regression was used to link benefit domains with the characteristics of settings. The social attribute of recreation settings was linked to eight of the ten benefit domains. There were two statistically strong multiple regression correlations: (1) between domain of "relationship with nature /scenery" and the attributes "forest/water," "attractive nature," and "facility/maintenance" and (2) between the domain of "escaping pressure" and the attributes "attractive nature" and "social." The results of this study are useful to managers in their efforts to provide recreation opportunities for visitors to achieve beneficial outcomes.

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### Urban forest park use and psychosocial outcomes: A case study in six cities across South Korea

[Preview](#)

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[Won Sop Shin<sup>a</sup>](#), [Hon Gyo Kwon<sup>a</sup>](#), [William E. Hammitt<sup>b</sup>](#) & [Bum Soo Kim<sup>c</sup>](#)

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**[Publishing models and article dates explained](#)**

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**Abstract**

Urban forest parks provide a wide range of experience outcomes to visitors. However, there is too little scientifically documented knowledge of the outcomes of the use. This study was conducted to identify visitors' psychosocial outcomes from urban forest park use, and to examine whether or not the visitors' psychosocial outcomes were related to some personal variables. Structured surveys were conducted with 2292 urban forest park visitors in six cities across South Korea during the summer and autumn of 2003. Examination of park experience outcomes revealed that there were three factors of outcomes: "learning and self/other relations", "social and self-development" and "enjoying nature". The results also indicated that older and more highly educated visitors were more likely to rate the outcomes as important than those who were younger and less educated. There were no significant differences in the outcomes between male and female visitors.

[J Int Med Res.](#) 2006 Mar-Apr;34(2):152-9.

## **The effects of exercise in forest and urban environments on sympathetic nervous activity of normal young adults.**

[Yamaguchi M](#), [Deguchi M](#), [Miyazaki Y](#).

### **Source**

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### **Abstract**

In Japan, forest-air bathing and walking (shinrin-yoku) has been proposed as a health-facilitating activity in which people spend a short period of time in a forest environment. Initially, we examined the usefulness of salivary amylase activity as an indicator of an individual's stress levels in a forest environment. The circadian rhythm of salivary amylase activity was measured in healthy young male subjects under stress-free conditions. The salivary amylase activity remained relatively constant throughout the day. Salivary amylase activity was then measured before and after walking in both urban and forest environments using a hand-held monitor. Our results indicated that (i) the circadian rhythm fluctuations in salivary amylase activity were much smaller than the stressor-induced variations; (ii) salivary amylase activity was an excellent indicator of the changes in sympathetic nervous activity; and (iii) the forest was a good environment in which people could experience much less environment-derived stress.

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16749410

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### The influence of forest view through a window on job satisfaction and job stress

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[Won Sop Shin](#)\*

pages 248-253

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**Abstract**

Windows have been found to be a particularly salient feature of the workplace, not only as a matter of preference but also for health and well-being. Depending on what is in the view, looking out of the window may provide numerous opportunities for restoration. This study investigated the effect of window views on job satisfaction and stress. The impact of two specific influencing mechanisms was examined: existence of forest views through windows in workplaces, and absence of forest views through windows in workplaces. The sample consisted of 931 office workers in Seoul, South Korea, 481 who could see forest views from their workplaces and 450 who could not see forest views. A set of self-administered questionnaires including job satisfaction and job stress measures was distributed to the sample from April to September 2004. The results showed a significant direct effect of forest views from windows on job satisfaction and stress. Respondents' personal information such as gender, age and job category did not influence on the window view effects. As expected, employees' job satisfaction and job stress were highly and negatively correlated.

[Int J Immunopathol Pharmacol](#). 2007 Apr-Jun;20(2 Suppl 2):3-8.

## Forest bathing enhances human natural killer activity and expression of anti-cancer proteins.

[Li Q](#), [Morimoto K](#), [Nakadai A](#), [Inagaki H](#), [Katsumata M](#), [Shimizu T](#), [Hirata Y](#), [Hirata K](#), [Suzuki H](#), [Miyazaki Y](#), [Kagawa T](#), [Koyama Y](#), [Ohira T](#), [Takayama N](#), [Krensky AM](#), [Kawada T](#).

### Source

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### Abstract

In order to explore the effect of forest bathing on human immune function, we investigated natural killer (NK) activity; the number of NK cells, and perforin, granzymes and granulysin-expression in peripheral blood lymphocytes (PBL) during a visit to forest fields. Twelve healthy male subjects, age 37-55 years, were selected with informed consent from three large companies in Tokyo, Japan. The subjects experienced a three-day/two-night trip in three different forest fields. On the first day, subjects walked for two hours in the afternoon in a forest field; and on the second day, they walked for two hours in the morning and afternoon, respectively, in two different forest fields. Blood was sampled on the second and third days, and NK activity; proportions of NK, T cells, granulysin, perforin, and granzymes A/B-expressing cells in PBL were measured. Similar measurements were made before the trip on a normal working day as the control. Almost all of the subjects (11/12) showed higher NK activity after the trip (about 50 percent increased) compared with before. There are significant differences both before and after the trip and between days 1 and 2 in NK activity. The forest bathing trip also significantly increased the numbers of NK, perforin, granulysin, and granzymes A/B-expressing cells. Taken together, these findings indicate that a forest bathing trip can increase NK activity, and that this effect at least partially mediated by increasing the number of NK cells and by the induction of intracellular anti-cancer proteins.

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17903349

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[J Physiol Anthropol](#). 2007 Mar;26(2):123-8.

## Physiological effects of Shinrin-yoku (taking in the atmosphere of the forest)--using salivary cortisol and cerebral activity as indicators.

[Park BJ](#), [Tsunetsugu Y](#), [Kasetani T](#), [Hirano H](#), [Kagawa T](#), [Sato M](#), [Miyazaki Y](#).

### Source

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### Abstract

The purpose of this study is to examine the physiological effects of Shinrin-yoku (taking in the atmosphere of the forest). The subjects were 12 male students (22.8 $\pm$ 1.4 yr). On the first day of the experiments, one group of 6 subjects was sent to a forest area, and the other group of 6 subjects was sent to a city area. On

the second day, each group was sent to the opposite area for a cross check. In the forenoon, the subjects were asked to walk around their given area for 20 minutes. In the afternoon, they were asked to sit on chairs and watch the landscapes of their given area for 20 minutes. Cerebral activity in the prefrontal area and salivary cortisol were measured as physiological indices in the morning at the place of accommodation, before and after walking in the forest or city areas during the forenoon, and before and after watching the landscapes in the afternoon in the forest and city areas, and in the evening at the place of accommodation. The results indicated that cerebral activity in the prefrontal area of the forest area group was significantly lower than that of the group in the city area after walking; the concentration of salivary cortisol in the forest area group was significantly lower than that of the group in the city area before and after watching each landscape. The results of the physiological measurements show that Shinrin-yoku can effectively relax both people's body and spirit.

[J Physiol Anthropol](#). 2007 Mar;26(2):135-42.

## **Physiological effects of Shinrin-yoku (taking in the atmosphere of the forest) in an old-growth broadleaf forest in Yamagata Prefecture, Japan.**

[Tsunetsugu Y](#), [Park BJ](#), [Ishii H](#), [Hirano H](#), [Kagawa T](#), [Miyazaki Y](#).

### **Source**

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### **Abstract**

The physiological effects of "Shinrin-yoku" (taking in the atmosphere of the forest) were examined by investigating blood pressure, pulse rate, heart rate variability (HRV), salivary cortisol concentration, and immunoglobulin A concentration in saliva. Subjective feelings of being "comfortable", "calm", and "refreshed" were also assessed by questionnaire. The subjects were 12 male university students aged from 21 to 23 (mean $\pm$ -SD: 22.0 $\pm$ -1.0). The physiological measurements were conducted six times, i.e., in the morning and evening before meals at the place of accommodation, before and after the subjects walked a predetermined course in the forest and city areas for 15 minutes, and before and after they sat still on a chair watching the scenery in the respective areas for 15 minutes. The findings were as follows. In the forest area compared to the city area, 1) blood pressure and pulse rate were significantly lower, and 2) the power of the HF component of the HRV tended to be higher and LF/(LF+HF) tended to be lower. Also, 3) salivary cortisol concentration was significantly lower in the forest area. These physiological responses suggest that sympathetic nervous activity was suppressed and parasympathetic nervous activity was enhanced in the forest area, and that "Shinrin-yoku" reduced stress levels. In the subjective evaluation, 4) "comfortable", "calm", and "refreshed" feelings were significantly higher in the forest area. The present study has, by conducting physiological investigations with subjective evaluations as supporting evidence, demonstrated the relaxing and stress-relieving effects of "Shinrin-yoku".

[Int J Immunopathol Pharmacol](#). 2008 Jan-Mar;21(1):117-27.

## **Visiting a forest, but not a city, increases human natural killer activity and expression of anti-cancer proteins.**

[Li Q](#), [Morimoto K](#), [Kobayashi M](#), [Inagaki H](#), [Katsumata M](#), [Hirata Y](#), [Hirata K](#), [Suzuki H](#), [Li YJ](#), [Wakayama Y](#), [Kawada T](#), [Park BJ](#), [Ohira T](#), [Matsui N](#), [Kagawa T](#), [Miyazaki Y](#), [Krensky AM](#).

## Source

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## Abstract

We previously reported that a forest bathing trip enhanced human NK activity, number of NK cells, and intracellular anti-cancer proteins in lymphocytes. In the present study, we investigated how long the increased NK activity lasts and compared the effect of a forest bathing trip on NK activity with a trip to places in a city without forests. Twelve healthy male subjects, age 35-56 years, were selected with informed consent. The subjects experienced a three-day/two-night trip to forest fields and to a city, in which activity levels during both trips were matched. On day 1, subjects walked for two hours in the afternoon in a forest field; and on day 2, they walked for two hours in the morning and afternoon, respectively, in two different forest fields; and on day 3, the subjects finished the trip and returned to Tokyo after drawing blood samples and completing the questionnaire. Blood and urine were sampled on the second and third days during the trips, and on days 7 and 30 after the trip, and NK activity, numbers of NK and T cells, and granulysin, perforin, and granzymes A/B-expressing lymphocytes in the blood samples, and the concentration of adrenaline in urine were measured. Similar measurements were made before the trips on a normal working day as the control. Phytoncide concentrations in forest and city air were measured. The forest bathing trip significantly increased NK activity and the numbers of NK, perforin, granulysin, and granzyme A/B-expressing cells and significantly decreased the concentration of adrenaline in urine. The increased NK activity lasted for more than 7 days after the trip. In contrast, a city tourist visit did not increase NK activity, numbers of NK cells, nor the expression of selected intracellular anti-cancer proteins, and did not decrease the concentration of adrenaline in urine. Phytoncides, such as alpha-pinene and beta-pinene were detected in forest air, but almost not in city air. These findings indicate that a forest bathing trip increased NK activity, number of NK cells, and levels of intracellular anti-cancer proteins, and that this effect lasted at least 7 days after the trip. Phytoncides released from trees and decreased stress hormone may partially contribute to the increased NK activity.

[J Biol Regul Homeost Agents](#). 2008 Jan-Mar;22(1):45-55.

## **A forest bathing trip increases human natural killer activity and expression of anti-cancer proteins in female subjects.**

[Li Q](#), [Morimoto K](#), [Kobayashi M](#), [Inagaki H](#), [Katsumata M](#), [Hirata Y](#), [Hirata K](#), [Shimizu T](#), [Li YJ](#), [Wakayama Y](#), [Kawada T](#), [Ohira T](#), [Takayama N](#), [Kagawa T](#), [Miyazaki Y](#).

## Source

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## Abstract

We previously reported that forest bathing trips enhanced human NK activity, number of NK cells, and intracellular anti-cancer proteins in lymphocytes, and that the increased NK activity lasted for more than 7 days after the trip in male subjects. In the present study, we investigated the effect of forest bathing trip on human NK activity in female subjects. Thirteen healthy nurses, age 25-43 years, professional career 4-18 years, were selected with informed consent. The subjects experienced a three-day/two-night trip to forest fields. On day 1, the subjects walked for two hours in the afternoon in a forest field; on day 2, they walked for two hours each in the morning and afternoon in two different forest fields; and on day 3, the subjects finished the trip and returned to Tokyo after drawing blood and completing a questionnaire. Blood and urine were sampled on the second and third days during the trip, and on days 7 and 30 after the trip. NK activity, numbers of NK and T cells, and granulysin, perforin, and granzymes A/B-expressing lymphocytes in the blood samples, the concentrations of estradiol and progesterone in serum, and the concentrations of

adrenaline and noradrenaline in urine were measured. Similar control measurements were made before the trip on a normal working day. The concentrations of phytoncides in the forests were measured. The forest bathing trip significantly increased NK activity and the numbers of NK, perforin, granulysin, and granzymes A/B-expressing cells and significantly decreased the percentage of T cells, and the concentrations of adrenaline and noradrenaline in urine. The increased NK activity lasted for more than 7 days after the trip. Phytoncides, such as alpha-pinene and beta-pinene were detected in forest air. These findings indicate that a forest bathing trip also increased NK activity, number of NK cells, and levels of intracellular anti-cancer proteins in female subjects, and that this effect lasted at least 7 days after the trip. Phytoncides released from trees and decreased stress hormone levels may partially contribute to the increased NK activity.

## **Effect of phytoncide from trees on human natural killer cell function.**

[Li Q](#), [Kobayashi M](#), [Wakayama Y](#), [Inagaki H](#), [Katsumata M](#), [Hirata Y](#), [Hirata K](#), [Shimizu T](#), [Kawada T](#), [Park BJ](#), [Ohira T](#), [Kagawa T](#), [Miyazaki Y](#).

### **Source**

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### **Abstract**

We previously reported that the forest environment enhanced human natural killer (NK) cell activity, the number of NK cells, and intracellular anti-cancer proteins in lymphocytes, and that the increased NK activity lasted for more than 7 days after trips to forests both in male and female subjects. To explore the factors in the forest environment that activated human NK cells, in the present study we investigate the effect of essential oils from trees on human immune function in twelve healthy male subjects, age 37-60 years, who stayed at an urban hotel for 3 nights from 7.00 p.m. to 8.00 a.m. Aromatic volatile substances (phytoncides) were produced by vaporizing *Chamaecyparis obtusa* (hinoki cypress) stem oil with a humidifier in the hotel room during the night stay. Blood samples were taken on the last day and urine samples were analysed every day during the stay. NK activity, the percentages of NK and T cells, and granulysin, perforin, granzyme A/B-expressing lymphocytes in blood, and the concentrations of adrenaline and noradrenaline in urine were measured. Similar control measurements were made before the stay on a normal working day. The concentrations of phytoncides in the hotel room air were measured. Phytoncide exposure significantly increased NK activity and the percentages of NK, perforin, granulysin, and granzyme A/B-expressing cells, and significantly decreased the percentage of T cells, and the concentrations of adrenaline and noradrenaline in urine. Phytoncides, such as alpha-pinene and beta-pinene, were detected in the hotel room air. These findings indicate that phytoncide exposure and decreased stress hormone levels may partially contribute to increased NK activity.

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[PubMed - indexed for MEDLINE]

[Environ Health Prev Med](#). 2010 Jan;15(1):1-8. doi: 10.1007/s12199-008-0069-2.

## Promoting human health through forests: overview and major challenges.

[Karjalainen E](#), [Sarjala T](#), [Raitio H](#).

### Source

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### Abstract

This review aims to contribute to the ongoing discussion about human health, global change, and biodiversity by concentrating on the relationships between forests and human health. This review gives a short overview of the most important health benefits that forests provide to humans, and the risks that forests may pose to human health. Furthermore, it discusses the future challenges for the research on the links between forests and human health, and for delivering health through forests in practice. Forests provide enormous possibilities to improve human health conditions. The results of a vast amount of research show that forest visits promote both physical and mental health by reducing stress. Forests represent rich natural pharmacies by virtue of being enormous sources of plant and microbial material with known or potential medicinal or nutritional value. Forest food offers a safety net for the most vulnerable population groups in developing countries, and healthy forest ecosystems may also help in regulation of infectious diseases. Utilizing forests effectively in health promotion could reduce public health care budgets and create new sources of income. Main challenges to delivering health through forests are due to ecosystem and biodiversity degradation, deforestation, and climate change. In addition, major implementation of research results into practice is still lacking. Inadequate implementation is partly caused by insufficient evidence base and partly due to the lack of policy-makers' and practitioners' awareness of the potential of forests for improving human health. This calls for strong cooperation among researchers, policy-makers, and practitioners as well as between different sectors, especially between health and environmental professionals.

[J Biol Regul Homeost Agents](#). 2010 Apr-Jun;24(2):157-65.

## A day trip to a forest park increases human natural killer activity and the expression of anti-cancer proteins in male subjects.

[Li Q](#), [Kobayashi M](#), [Inagaki H](#), [Hirata Y](#), [Li YJ](#), [Hirata K](#), [Shimizu T](#), [Suzuki H](#), [Katsumata M](#), [Wakayama Y](#), [Kawada T](#), [Ohira T](#), [Matsui N](#), [Kagawa T](#).

### Source

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### Abstract

We previously reported that 2-night/3-day trips to forest parks enhanced human NK activity, the number of NK cells, and intracellular anti-cancer proteins in lymphocytes, and that this increased NK activity lasted for more than 7 days after the trip in both male and female subjects. In the present study, we investigated the effect of a day trip to a forest park on human NK activity in male subjects. Twelve healthy male subjects, aged 35-53 years, were selected after giving informed consent. The subjects experienced a day trip to a forest park in the suburbs of Tokyo. They walked for two hours in the morning and afternoon, respectively, in the forest park on Sunday. Blood and urine were sampled in the morning of the following day and 7 days after the trip, and the NK activity, numbers of NK and T cells, and granulysin, perforin, and granzyme A/B-expressing lymphocytes, the concentration of cortisol in blood samples, and the concentration of adrenaline in urine were measured. Similar measurements were made before the trip on a weekend day as

the control. Phytoncide concentrations in the forest were measured. The day trip to the forest park significantly increased NK activity and the numbers of CD16(+) and CD56(+) NK cells, perforin, granulysin, and granzyme A/B-expressing NK cells and significantly decreased CD4(+) T cells, the concentrations of cortisol in the blood and adrenaline in urine. The increased NK activity lasted for 7 days after the trip. Phytoncides, such as isoprene, alpha-pinene, and beta-pinene, were detected in the forest air. These findings indicate that the day trip to the forest park also increased the NK activity, number of NK cells, and levels of intracellular anti-cancer proteins, and that this effect lasted for at least 7 days after the trip. Phytoncides released from trees and decreased stress hormone levels may partially contribute to the increased NK activity.

[Environ Health Prev Med.](#) 2010 Jan;15(1):18-26. doi: 10.1007/s12199-009-0086-9.

## **The physiological effects of Shinrin-yoku (taking in the forest atmosphere or forest bathing): evidence from field experiments in 24 forests across Japan.**

[Park BJ](#), [Tsunetsugu Y](#), [Kasetani T](#), [Kagawa T](#), [Miyazaki Y](#).

### **Source**

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### **Abstract**

This paper reviews previous research on the physiological effects of Shinrin-yoku (taking in the forest atmosphere or forest bathing), and presents new results from field experiments conducted in 24 forests across Japan. The term Shinrin-yoku was coined by the Japanese Ministry of Agriculture, Forestry, and Fisheries in 1982, and can be defined as making contact with and taking in the atmosphere of the forest. In order to clarify the physiological effects of Shinrin-yoku, we conducted field experiments in 24 forests across Japan. In each experiment, 12 subjects (280 total; ages 21.7 +/- 1.5 year) walked in and viewed a forest or city area. On the first day, six subjects were sent to a forest area, and the others to a city area. On the second day, each group was sent to the other area as a cross-check. Salivary cortisol, blood pressure, pulse rate, and heart rate variability were used as indices. These indices were measured in the morning at the accommodation facility before breakfast and also both before and after the walking (for 16 +/- 5 min) and viewing (for 14 +/- 2 min). The R-R interval was also measured during the walking and viewing periods. The results show that forest environments promote lower concentrations of cortisol, lower pulse rate, lower blood pressure, greater parasympathetic nerve activity, and lower sympathetic nerve activity than do city environments. These results will contribute to the development of a research field dedicated to forest medicine, which may be used as a strategy for preventive medicine.

## **Trends in research related to “Shinrin-yoku” (taking in the forest atmosphere or forest bathing) in Japan**

[Yuko Tsunetsugu](#),<sup>1</sup> [Bum-Jin Park](#),<sup>2</sup> and [Yoshifumi Miyazaki](#)<sup>2</sup>

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## Abstract

“Shinrin-yoku”, which can be defined as “taking in the forest atmosphere or forest bathing”, has been receiving increasing attention in Japan in recent years for its capacity to provide relaxation and reduce stress. Since 2004, the authors of this paper have been involved in an investigation designed to ascertain the physiological effects of “Shinrin-yoku” within the framework of the “Therapeutic Effects of Forests” project. We have conducted physiological experiments, both in actual forests and in the laboratory, to elucidate the physiological effects on individuals of exposure to the total environment of forests or to only certain elements of this environment, such as the odor of wood, the sound of running stream water, and the scenery of the forest. We have obtained physiological measurements of central nervous activity, autonomic nervous activity, and biomarkers reflecting stress response that can be applied in this line of approach. Using these measurements, we have summarized the separate elements of forests in terms of the five senses. We have also reviewed a selection of field studies and introduced a number of results from ongoing projects as well as those from early studies. Future perspectives are also discussed.

**Keywords:** Field study, Forest bathing, Heart rate variability (HRV), Near-infrared spectroscopy (NIRS), Salivary cortisol

[Environ Health Prev Med](#). 2010 Jan;15(1):38-47. doi: 10.1007/s12199-009-0114-9. Epub 2009 Oct 21.

## Forest experience and psychological health benefits: the state of the art and future prospect in Korea.

[Shin WS](#), [Yeoun PS](#), [Yoo RW](#), [Shin CS](#).

### Source

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### Abstract

The aims of this study were twofold: to examine the empirical evidence supporting the positive contribution that a forest environment can make on human psychological health and well-being and to describe the theoretical framework within which the forest environment has this effect. Our review of the literature provides empirical evidence that a forest experience can contribute to improved emotional and cognitive health. This experience can be through a forest activity program and by experiencing the social and physical conditions of the forest environment and the therapeutic elements of the forest. Visiting or viewing a forest scene has been documented to have a positive effect on psychological healing and well-being in terms of recovering from stress, improving concentration and productivity, improving the psychological state, particularly for people from urban environments. Wilderness and related studies clearly demonstrate that being in a forest environment has a positive effect on people, while results from other studies indicate that contacts with forest environments provide multiple positive physiological and psychological effects on human health that included decreasing the blood pressure and heart rate and reducing anxiety and stress. There are several theories explaining the healing effects of the forest on human beings. Most hypothesize that restorative environments are settings in which recovery is associated with the reduction of stress and that the benefits of contact with nature include a wide range of positive physiological and psychological responses. These theories are based on an evolutionary perspective and share a number of similarities and differences. This

article summarizes a number of these theories of restorative environments as well as addresses the current status of forest therapy and the challenges and opportunities for therapeutic effects of the forest in Korea.

[Eur J Appl Physiol](#). 2011 Nov;111(11):2845-53. doi: 10.1007/s00421-011-1918-z. Epub 2011 Mar 23.

## **Acute effects of walking in forest environments on cardiovascular and metabolic parameters.**

[Li Q](#), [Otsuka T](#), [Kobayashi M](#), [Wakayama Y](#), [Inagaki H](#), [Katsumata M](#), [Hirata Y](#), [Li Y](#), [Hirata K](#), [Shimizu T](#), [Suzuki H](#), [Kawada T](#), [Kagawa T](#).

### **Source**

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### **Abstract**

We previously found that forest environments reduced stress hormones such as adrenaline and noradrenaline and showed the relaxing effect both in male and female subjects. In the present study, we investigated the effects of walking under forest environments on cardiovascular and metabolic parameters. Sixteen healthy male subjects (mean age  $57.4 \pm 11.6$  years) were selected after obtaining informed consent. The subjects took day trips to a forest park in the suburbs of Tokyo and to an urban area of Tokyo as a control in September 2010. On both trips, they walked for 2 h in the morning and afternoon on a Sunday. Blood and urine were sampled on the morning before each trip and after each trip. Blood pressure was measured on the morning (0800) before each trip, at noon (1300), in the afternoon (1600) during each trip, and on the morning (0800) after each trip. The day trip to the forest park significantly reduced blood pressure and urinary noradrenaline and dopamine levels and significantly increased serum adiponectin and dehydroepiandrosterone sulfate (DHEA-S) levels. Walking exercise also reduced the levels of serum N-terminal pro-B-type natriuretic peptide (NT-proBNP) and urinary dopamine. Taken together, habitual walking in forest environments may lower blood pressure by reducing sympathetic nerve activity and have beneficial effects on blood adiponectin and DHEA-S levels, and habitual walking exercise may have beneficial effects on blood NT-proBNP levels.

[Public Health](#). 2011 Feb;125(2):93-100. doi: 10.1016/j.puhe.2010.09.005. Epub 2011 Feb 1.

## **Effect of forest bathing on physiological and psychological responses in young Japanese male subjects.**

[Lee J](#), [Park BJ](#), [Tsunetsugu Y](#), [Ohira T](#), [Kagawa T](#), [Miyazaki Y](#).

### **Source**

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### **Abstract**

#### **OBJECTIVE:**

To provide scientific evidence supporting the efficacy of forest bathing as a natural therapy by investigating its physiological benefits using biological indicators in outdoor settings.

#### **STUDY DESIGN:**

Within-group comparisons were used to examine psychological and physiological responses to exposure to real forest and urban environments.

**METHODS:**

Young Japanese male adults participated in a 3-day, 2-night field experiment. Physiological responses as well as self-reported psychological responses to forest and urban environmental stimuli were measured in real settings. The results of each indicator were compared against each environmental stimulus.

**RESULTS:**

Heart rate variability analysis indicated that the forest environment significantly increased parasympathetic nervous activity and significantly suppressed sympathetic activity of participants compared with the urban environment. Salivary cortisol level and pulse rate decreased markedly in the forest setting compared with the urban setting. In psychological tests, forest bathing significantly increased scores of positive feelings and significantly decreased scores of negative feelings after stimuli compared with the urban stimuli.

**CONCLUSION:**

Physiological data from this field experiment provide important scientific evidence on the health benefits of forest bathing. The results support the concept that forest bathing has positive effects on physical and mental health, indicating that it can be effective for health promotion. Despite the small sample size in this study, a very clear tendency towards positive physiological and psychological outcomes in forests was observed.

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[Am J Prev Med](#). 2009 May;36(5):435-8. doi: 10.1016/j.amepre.2009.01.022. Epub 2009 Mar 6.

## Effectiveness of favorite-place prescriptions: a field experiment.

[Korpela KM](#), [Ylén MP](#).

**Source**

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**Abstract****BACKGROUND:**

Previous studies suggest that favorite places provide stress-alleviating experiences and serve emotion regulation. This study used a prospective, experimental design to investigate the hypothesis that a group of adults instructed to regularly visit their local favorite places will experience greater daily restoration and fewer self-reported physical symptoms than a group instructed to avoid all favorite-place visits.

**METHODS:**

Members of the favorite-place group were asked to visit their local favorite places at least once per day on 5 weekdays. They visited five times, on average, and also reported all other place visits in a structured place diary. Members of the not-visiting group visited their favorite place 0-1 times and daily reported all place visits outside the home. The control group, which was given instructions that did not mention favorite places, reported all place visits outside the home. Restorative experiences (assessed on the Restoration Outcome Scale and including attentiveness, relaxation, clearing one's mind, subjective vitality, and self-confidence) and self-reported physical symptoms (headache, backache, muscle tension and pain) were measured with structured health diaries using Likert scales. Data were collected in 2006 and analyzed in 2007 and 2008.

**RESULTS:**

Every day the group visiting favorite places experienced significantly stronger restorative experiences than the not-visiting and control groups. The groups did not differ in the amount of self-rated physical symptoms reported at the end of each day. In all groups such symptoms decreased toward the end of the week.

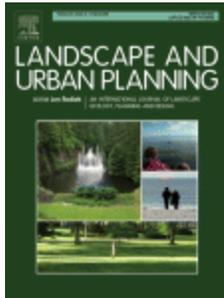
**CONCLUSIONS:**

Favorite-place prescriptions and visits affect subjective well-being. Health counseling and research on coping strategies should not ignore the use of sociophysical environments for self- and emotion-regulation.



## Landscape and Urban Planning

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### Psychophysiological responses and restorative values of natural environments in Taiwan

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- <http://dx.doi.org/10.1016/j.landurbplan.2007.09.010>, [How to Cite or Link Using DOI](#)
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#### Abstract

Scenes of natural areas were used as stimuli to analyze the psychological and physiological responses of subjects while viewing wildland scenes. Attention Restoration Theory [Kaplan, S., 1995. The restorative benefits of nature: toward an integrative framework, *J. Environ. Psychol.*15, 241–248.] and theorized components of restorative environments were used as an orientation for selection of the visual stimuli.

Conducted in Taiwan, the studies recorded the psychophysiological responses of 110 laboratory participants while viewing 12 images that hypothetically represented the Being Away, Extent or Coherence, Fascination, and Compatibility components of restorative environments. Psychological responses were measured using the perceived restorativeness scale and physiological responses were recorded by electromyography (EMG), electroencephalography (EEG), and blood volume pulse (BVP) measurements. Results revealed a large degree of congruency between the psychological measures of restorativeness and the three physiological responses. Improved scores on the perceived restorativeness scale corresponded to increased EMG and EEG readings and lower BVP measurements. These findings provide some objective evidence toward the psychophysiological values; and perhaps benefits, of wildland-wilderness environments. The potential importance of wildland-wilderness environments for the restoration of human well-being is discussed.

[Health Place](#). 2008 Dec;14(4):636-52. Epub 2007 Oct 23.

## **Determinants of restorative experiences in everyday favorite places.**

[Korpela KM](#), [Ylén M](#), [Tyrväinen L](#), [Silvennoinen H](#).

### **Source**

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### **Abstract**

The study was based on the answers to a mailed questionnaire of a simple random sample of respondents from two cities (Helsinki, Tampere) in Finland. Ten determinants of restorative experiences in favorite places (<or = 15 km from home; n=1089) were effective. These determinants included "immediate" use of the favorite place (duration and frequency), personal background of nature experiences (nature orientedness, nature hobbies, childhood nature experiences), and situational factors in life, which were related to stress (hassles at work and with money, satisfaction with life) and to social relations (uplifts of social relations, visiting alone vs. in company). Different variables were associated with restorative experiences in different favorite settings (extensively managed nature areas, built-up green spaces, waterside environments, exercise and activity/hobby areas, and indoor and outdoor urban areas). The concept of "favorite place prescriptions" is introduced as an analogy to "exercise prescriptions" in primary healthcare.

[Lancet](#). 2008 Nov 8;372(9650):1655-60. doi: 10.1016/S0140-6736(08)61689-X.

## **Effect of exposure to natural environment on health inequalities: an observational population study.**

[Mitchell R](#), [Popham F](#).

### **Source**

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### **Abstract**

#### **BACKGROUND:**

Studies have shown that exposure to the natural environment, or so-called green space, has an independent effect on health and health-related behaviours. We postulated that income-related inequality in health would

be less pronounced in populations with greater exposure to green space, since access to such areas can modify pathways through which low socioeconomic position can lead to disease.

***METHODS:***

We classified the population of England at younger than retirement age (n=40 813 236) into groups on the basis of income deprivation and exposure to green space. We obtained individual mortality records (n=366 348) to establish whether the association between income deprivation, all-cause mortality, and cause-specific mortality (circulatory disease, lung cancer, and intentional self-harm) in 2001-05, varied by exposure to green space measured in 2001, with control for potential confounding factors. We used stratified models to identify the nature of this variation.

***FINDINGS:***

The association between income deprivation and mortality differed significantly across the groups of exposure to green space for mortality from all causes ( $p < 0.0001$ ) and circulatory disease ( $p = 0.0212$ ), but not from lung cancer or intentional self-harm. Health inequalities related to income deprivation in all-cause mortality and mortality from circulatory diseases were lower in populations living in the greenest areas. The incidence rate ratio (IRR) for all-cause mortality for the most income deprived quartile compared with the least deprived was 1.93 (95% CI 1.86-2.01) in the least green areas, whereas it was 1.43 (1.34-1.53) in the most green. For circulatory diseases, the IRR was 2.19 (2.04-2.34) in the least green areas and 1.54 (1.38-1.73) in the most green. There was no effect for causes of death unlikely to be affected by green space, such as lung cancer and intentional self-harm.

***INTERPRETATION:***

Populations that are exposed to the greenest environments also have lowest levels of health inequality related to income deprivation. Physical environments that promote good health might be important to reduce socioeconomic health inequalities.