

Effects of forest environment (Shinrin-yoku/Forest bathing) on health promotion and disease prevention - the Establishment of "Forest Medicine"

Qing Li (*Environmental Health and Preventive Medicine*, 2022)

Abstract

Humans have enjoyed forest environments for ages because of the quiet atmosphere, beautiful scenery, mild climate, pleasant aromas, and fresh, clean air. In Japan, since 2004, serial studies have been conducted to investigate the effects of forest environments (Forest bathing/Shinrin-yoku) on human health. My research team has established a new medical science called Forest Medicine. The Forest Medicine is a new interdisciplinary science, belonging to the categories of alternative medicine, environmental medicine and preventive medicine, which studies the effects of forest environments (Forest bathing/Shinrin-yoku) on human health. It has been reported that Forest bathing/Shinrin-yoku has the following beneficial effects on human health:

1. Shinrin-yoku increases human natural killer (NK) activity, the number of NK cells, and the intracellular levels of anti-cancer proteins, suggesting a preventive effect on cancers.
2. Shinrin-yoku reduces blood pressure and heart rate showing preventive effect on hypertension and heart diseases.
3. Shinrin-yoku reduces stress hormones, such as urinary adrenaline and noradrenaline and salivary/serum cortisol contributing to stress management.
4. Shinrin-yoku increases the activity of parasympathetic nerves and reduces the activity of sympathetic nerves to stabilize the balance of autonomic nervous system.
5. Shinrin-yoku improves sleep.
6. Shinrin-yoku increases the levels of serum adiponectin and dehydroepiandrosterone sulfate.
7. In the Profile of Mood States (POMS) test, Shinrin-yoku reduces the scores for anxiety, depression, anger, fatigue, and confusion, and increases the score for vigor, showing preventive effects on depression.
8. Shinrin-yoku may apply to rehabilitation medicine.
9. Shinrin-yoku in city parks also has benefits on human health.
10. Shinrin-yoku may have preventive effect on COVID-19 by boosting immune function and by reducing mental stress.

Taken together, these findings suggest that Shinrin-yoku may have potential preventive effects on non-communicable diseases.

Blood pressure-lowering effect of Shinrin-yoku (Forest bathing): a systematic review and meta-analysis

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(BMC Complementary and Alternative Medicine, 2017)

Abstract

Background: Shinrin-yoku (experiencing the forest atmosphere or forest bathing) has received increasing attention from the perspective of preventive medicine in recent years. Some studies have reported that the forest environment decreases blood pressure. However, little is known about the possibility of anti-hypertensive applications of Shinrin-yoku. This study aimed to evaluate preventive or therapeutic effects of the forest environment on blood pressure.

Methods: We systematically reviewed the medical literature and performed a meta-analysis. Four electronic databases were systematically searched for the period before May 2016 with language restriction of English and Japanese. The review considered all published, randomized, controlled trials, cohort studies, and comparative studies that evaluated the effects of the forest environment on changes in systolic blood pressure. A subsequent meta-analysis was performed.

Results: Twenty trials involving 732 participants were reviewed. Systolic blood pressure of the forest environment was significantly lower than that of the non-forest environment. Additionally, diastolic blood pressure of the forest environment was significantly lower than that of the non-forest environment.

Conclusions: This systematic review shows a significant effect of Shinrin-yoku on reduction of blood pressure.

Effects of forest bathing (shinrin-yoku) on levels of cortisol as a stress biomarker: a systematic review and meta-analysis

Michele Antonelli, Grazia Barbieri, Davide Donelli
(*International Journal of Biometeorology*, 2019)

Abstract

Forest bathing is a traditional practice characterized by visiting a forest and breathing its air. This review aims to investigate the effects of forest bathing on levels of salivary or serum cortisol as a stress biomarker in order to understand whether forest bathing can reduce stress. Medline/PubMed, Embase, Scopus, Web of Science, Cochrane Library, and Google Scholar were systematically searched for relevant articles. The quality of included trials was assessed following the criteria of the NIH dedicated tools. Afterwards, a qualitative and quantitative synthesis of retrieved evidence was performed. A total of 971 articles were screened; 22 of them were included in the systematic review and 8 in the meta-analysis. In all but two included studies, cortisol levels were significantly lower after intervention in forest groups if compared with control/comparison groups, or a significant pre-post reduction of cortisol levels was reported in the forest groups. The main results of the meta-analysis showed that salivary cortisol levels were significantly lower in the forest groups compared with the urban groups both before (MD = - 0.08 $\mu\text{g/dl}$ [95% CI - 0.11 to - 0.05 $\mu\text{g/dl}$]; $p < 0.01$; $I^2 = 46\%$) and after intervention (MD = - 0.05 $\mu\text{g/dl}$ [95% CI - 0.06 to - 0.04 $\mu\text{g/dl}$]; $p < 0.01$; $I^2 = 88\%$). Overall, forest bathing can significantly influence cortisol levels on a short term in such a way as to reduce stress.

Psychological effects of forest environments on healthy adults: Shinrin-yoku (forest-air bathing, walking) as a possible method of stress reduction

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(*Public Health*, 2007)

Abstract

Objectives: Shinrin-yoku (walking and/or staying in forests in order to promote health) is a major form of relaxation in Japan. The aims of this study were: (1) to evaluate the psychological effects of shinrin-yoku in a large number of participants; and (2) to identify the factors related to these effects.

Methods: Four hundred and ninety-eight healthy volunteers took part in the study. Surveys were conducted twice in a forest on the same day (forest day) and twice on a control day. Outcome measures were evaluated using the Multiple Mood Scale-Short Form (hostility, depression, boredom, friendliness, wellbeing and liveliness) and the State-Trait Anxiety Inventory A-State Scale. Statistical analyses were conducted using analysis of variance and multiple regression analyses.

Results: Hostility ($P < 0.001$) and depression ($P < 0.001$) scores decreased significantly, and liveliness ($P = 0.001$) scores increased significantly on the forest day compared with the control day. The main effect of environment was also observed with all outcomes except for hostility, and the forest environment was advantageous. Stress levels were shown to be related to the magnitude of the shinrin-yoku effect; the higher the stress level, the greater the effect.

Conclusions: This study revealed that forest environments are advantageous with respect to acute emotions, especially among those experiencing chronic stress. Accordingly, shinrin-yoku may be employed as a stress reduction method, and forest environments can be viewed as therapeutic landscapes. Therefore, customary shinrin-yoku may help to decrease the risk of psychosocial stress-related diseases, and evaluation of the long-term effects of shinrin-yoku is warranted.

Exploring the Physiological and Psychological Effects of Digital Shinrin-Yoku and Its Characteristics as a Restorative Environment

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(International Journal of Environmental Research and Public Health, 2022)

Abstract

This study investigated the physiological and psychological therapeutic effects of a digital Shinrin-yoku environment constructed indoors in an urban facility as well as the characteristics of the environment that contribute to restorativeness (restorative traits). We measured the fluctuations in the physical and mental states of 25 subjects by obtaining both before-after measurements and continuous measurements while exposed to a digital Shinrin-yoku environment that reproduced visual, auditory, and olfactory elements. The results demonstrated that the parasympathetic nerve activity was significantly increased and that the heart rate was significantly decreased during the exposure compared with that during the resting state. As for mood, five of the six Profile of Mood States (POMS) scales ("Tension-Anxiety," "Depression," "Anger-Hostility," "Fatigue," and "Confusion") were significantly decreased after the experience. In addition, psychological restorative effects were also confirmed, with a significant decrease in "negative affect" (measured using the Positive and Negative Affect Schedule (PANAS)) and a significant increase in the sense of restorativeness (Restorative Outcome Scale (ROS)) after the experience. In contrast, comparing the digital Shinrin-yoku environment with the actual forest environment and the urban environment using POMS, PANAS, ROS, and Perceived Restorativeness Scale (PRS), the psychological effects and environmental traits of the digital Shinrin-yoku were found to be considerably similar to those of the actual forest environment.

Physiological Effects of Visual Stimulation with Forest Imagery

Chorong Song, Harumi Ikei, Yoshifumi Miyazaki

(International Journal of Environmental Research and Public Health, 2018)

Abstract

This study was aimed to clarify the physiological effects of visual stimulation using forest imagery on activity of the brain and autonomic nervous system. Seventeen female university students (mean age, 21.1 ± 1.0 years) participated in the study. As an indicator of brain activity, oxyhemoglobin (oxy-Hb) concentrations were measured in the left and right prefrontal cortex using near-infrared time-resolved spectroscopy. Heart rate variability (HRV) was used as an indicator of autonomic nervous activity. The high-frequency (HF) component of HRV, which reflected parasympathetic nervous activity, and the ratio of low-frequency (LF) and high-frequency components (LF/HF), which reflected sympathetic nervous activity, were measured. Forest and city (control) images were used as visual stimuli using a large plasma display window. After sitting at rest viewing a gray background for 60 s, participants viewed two images for 90 s. During rest and visual stimulation, HRV and oxy-Hb concentration in the prefrontal cortex were continuously measured. Immediately thereafter, subjective evaluation of feelings was performed using a modified semantic differential (SD) method. The results showed that visual stimulation with forest imagery induced (1) a significant decrease in oxy-Hb concentrations in the right prefrontal cortex and (2) a significant increase in perceptions of feeling "comfortable," "relaxed," and "natural."

Impact of viewing vs. not viewing a real forest on physiological and psychological responses in the same setting

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(*International Journal of Environmental Research and Public Health*, 2014)

Abstract

We investigated the impact of viewing versus not viewing a real forest on human subjects' physiological and psychological responses in the same setting. Fifteen healthy volunteers (11 males, four females, mean age 36 years) participated. Each participant was asked to view a forest while seated in a comfortable chair for 15 min (Forest condition) vs. sitting the same length of time with a curtain obscuring the forest view (Enclosed condition). Both conditions significantly decreased blood pressure (BP) variables, i.e., systolic BP, diastolic BP, and mean arterial pressure between pre and post experimental stimuli, but these reductions showed no difference between conditions. Interestingly, the Forest viewing reduced cerebral oxygenated hemoglobin (HbO₂) assessed by near-infrared spectroscopy (NIRS) and improved the subjects' Profile of Mood States (POMS) scores, whereas the Enclosed condition increased the HbO₂ and did not affect the POMS scores. There were no significant differences in saliva amylase or heart rate variability (HRV) between the two conditions. Collectively, these results suggest that viewing a real forest may have a positive effect on cerebral activity and psychological responses. However, both viewing and not viewing the forest had similar effects on cardiovascular responses such as BP variables and HRV.

View through a Window May Influence Recovery from Surgery

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View Through a Window May Influence Recovery from Surgery

Abstract. Records on recovery after cholecystectomy of patients in a suburban Pennsylvania hospital between 1972 and 1981 were examined to determine whether assignment to a room with a window view of a natural setting might have restorative influences. Twenty-three surgical patients assigned to rooms with windows looking out on a natural scene had shorter postoperative hospital stays, received fewer negative evaluative comments in nurses' notes, and took fewer potent analgesics than 23 matched patients in similar rooms with windows facing a brick building wall.

Investigations of aesthetic and affective responses to outdoor visual environments have shown a strong tendency for American and European groups to prefer natural scenes more than urban views that lack natural elements (1, 2). Views of vegetation, and especially water, appear to sustain interest and attention more effectively than urban views of equivalent information rate (2). Because most natural views apparently elicit positive feelings, reduce fear in stressed subjects, hold interest, and may block or reduce stressful thoughts, they might also foster restoration from anxiety or stress (3).

The restorative effect of natural views on surgical patients was examined in a suburban Pennsylvania hospital (200 beds). Such patients often experience considerable anxiety (4, 5), and hospital confinement limits their access to outdoor environments almost entirely to views through windows. Views to the outside may be especially important to individuals who have unvarying schedules and spend a great deal of time in the same room (6), such as surgical patients. It is possible that a hospital window view could influence a patient's emotional

state and might accordingly affect recovery.

Records of patients assigned to rooms on the second and third floors of a three-story wing of the hospital between 1972 and 1981 were obtained. Windows on one side of the wing look out on either a small stand of deciduous trees or a brown brick wall (Fig. 1). The same nurses are assigned to the rooms on a given floor; the nurses' stations are lo-

cated somewhat closer to the wall-view rooms on both floors. The rooms are all for double occupancy and are nearly identical in terms of dimensions, window size, arrangement of beds, furniture, and other major physical characteristics. Each room has a single window 1.83 m high and 1.22 m wide with the lower edge 74 cm above the floor. The size and placement of the window allow an unobstructed view out for a patient lying in bed on either side of the room. The rooms differ, therefore, essentially only in what is seen through the window. Patients are assigned to rooms as they become vacant.

The sample consisted exclusively of patients who had undergone cholecystectomy, a common type of gall bladder surgery. This is a comparatively standardized procedure with similar postoperative management in the uncomplicated cases. Only cholecystectomies performed between 1 May and 20 October (1972 through 1981) were identified because the trees have foliage during those months. Patients younger than 20 years or older than 69, patients who developed serious complications, and those with a history of psychological disturbances

were excluded. Patients were then matched so that one member of each pair had a view of the trees and the other, the brick wall. The criteria for matching were sex, age (within 5 years), being a smoker or nonsmoker, being obese or within normal weight limits, general nature of previous hospitalization, year of surgery (within 6 years), and floor level. Patients on the second floor, a surgical floor, were also matched by the color of

their room (rooms on that floor alternate between blue and green). The 6-year interval for year of surgery was established on the basis of inquiries concerning possible changes in procedures. There was no statistically significant difference in the sampling distributions by year of surgery between the wall-view and tree-view groups. The final data base consisted of records of 46 patients grouped into 23 pairs (15 female and 8 male). An attempt was made to match patients by physician, but this was possible for only seven pairs because the number of doctors was large. However, for the remaining pairs the distribution of different physicians was similar in the two groups. There was no instance, for example, when patients of the same doctor all had rooms with same view.

Recovery data were extracted from the records by a nurse with extensive surgical floor experience. The nurse did not know which scene was visible from a patient's window. Five types of information were taken from each record: number of days of hospitalization; number and strength of analgesics each day (7); number and strength of doses for anxiety, including tranquilizers and barbiturates, each day (8); minor complications, such as persistent headache and nausea requiring medication—symptoms which are considered to result frequently from conversion reactions (9); and all nurses' notes relating to a patient's condition or course of recovery.

Length of hospitalization was defined as day of surgery to day of discharge. These data were assumed to be only ordinal because surgery was performed at different times of day and discharge times were somewhat different. The rec-

ords showed that patients with window views of the trees spent less time in the hospital than those with views of the brick wall: 7.96 days compared with 8.70 days per patient [Wilcoxon matched-pairs signed-ranks analysis, $T(17) = 35$, $z = 1.965$, $P = 0.025$].

Nurses' notes consisted of comments about the patient's condition written during the postsurgical period ending at midnight of the seventh recovery day after the day of surgery. Notes were classified as negative or positive—for example, negative notes included "upset and crying" or "needs much encouragement," and positive notes included "in good spirits" and "moving well." More negative notes were made on patients with the brick wall view: 3.96 per patient compared to 1.13 per patient with the tree view [Wilcoxon matched-pairs signed-ranks analysis, $T(21) = 15$, $z = 3.49$, $P < 0.001$]. Although more

Table 1. Comparison of analgesic doses per patient for wall-view and tree-view groups.

Analgesic strength	Number of doses					
	Days 0-1		Days 2-5		Days 6-7	
	Wall group	Tree group	Wall group	Tree group	Wall group	Tree group
Strong	2.56	2.40	2.48	0.96	0.22	0.17
Moderate	4.00	5.00	3.65	1.74	0.35	0.17
Weak	0.23	0.30	2.57	5.39	0.96	1.09

positive comments were recorded for the tree-view patients, the difference was not statistically significant.

The multivariate two-sample Hotelling test was used to compare the groups for analgesic intake (10). The average number of doses per patient, within each strength level, was computed for (i) the day of surgery and first recovery day, (ii) days 2 through 5 after surgery, and (iii) days 6 and 7 after surgery. It was expected that for the first period no differences in analgesic intake would be found between the two groups, because patients would have been too drugged or too absorbed by intense pain to attend to the windows (5). It was also expected that there would be no significant variation across groups in the final two days. In fact, only 45 percent of the patients took any analgesics after the fifth day. The data are summarized in Table 1.

For the period of primary interest, days 2 through 5, there were statistically significant variation between the tree-view and wall-view patients in the mean number of analgesic doses ($T^2 = 13.52$, $F = 4.30$, $P < 0.01$). In the other two periods there were no significant differences. In days 2 through 5 patients with the tree view took fewer moderate and strong pain doses than did the wall-view group and more doses in the weak category. The wall group, therefore, was given many more doses of potent narcotics, whereas the tree group more frequently received such drugs as aspirin and acetaminophen.

With respect to doses of anti-anxiety drugs, there was no significant variation between the groups. Wall-view patients were given more doses of narcotic anal-

gesics, which produce drowsiness or sedation as side-effects, possibly reducing their need for sleeping pills or tranquilizers. To test this inverse relation, anti-anxiety dose frequencies were compared when patients took either no or one strong or moderate analgesic dose or at least two strong or moderate analgesic doses. The observed frequency of doses was lower than the expected frequency when two or more strong or moderate analgesics were taken on the same day [$\chi^2(1) = 10.45$, $P < 0.01$]. The intake of narcotic analgesics by patients with the wall view may have lowered their use of anti-anxiety drugs to that of patients with the tree view.

A weighted score of minor postsurgi-

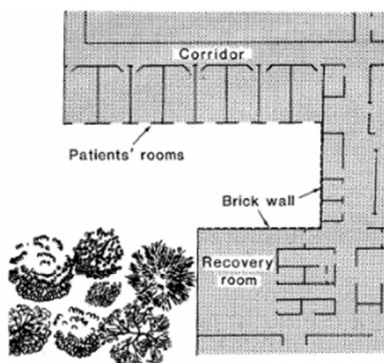


Fig. 1. Plan of the second floor of the study hospital showing the trees versus wall window views of patients. Data were also collected for patients assigned to third-floor rooms. One room on each floor was excluded because portions of both the trees and wall were visible from the windows. Architectural dimensions are not precisely to scale.

cal complications (excluding routine postanesthetic occurrences such as nausea) was computed for each patient, with criteria and procedures similar to those used by Cohen and Lazarus (9, 11). Although tree-view patients had lower scores, the difference was not statistically significant. This small difference found may be due to the greater intake of potent analgesics by the wall-view group rather than to a possibly higher frequency of conversion reactions.

In summary, in comparison with the wall-view group, the patients with the tree view had shorter postoperative hospital stays, had fewer negative evaluative comments from nurses, took fewer moderate and strong analgesic doses,

and had slightly lower scores for minor postsurgical complications. Although the findings suggest that the natural scene had comparatively therapeutic influences, it should be recognized that the "built" view in this study was a comparatively monotonous one, a largely featureless brick wall. The conclusions cannot be extended to all built views, nor to other patient groups, such as long-term patients, who may suffer from low arousal or boredom rather than from the anxiety problems typically associated with surgeries. Perhaps to a chronically understimulated patient, a built view such as a lively city street might be more stimulating and hence more therapeutic than many natural views. These cautions

notwithstanding, the results imply that hospital design and siting decisions should take into account the quality of patient window views.

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7. Analgesic doses were classified as weak, moderate, or strong on the basis of the drug, dosage, patient's weight, and whether the drug was administered orally or by injection. Examples in the weak category include acetaminophen and acetaminophen with small amounts of codeine. Examples in the moderate strength class are injections of meperidine hydrochloride (Demerol) in doses up to 50 mg, and tablets of oxycodone hydrochloride-oxycodone terephthalate (Percodan); strong analgesics include hydromorphone hydrochloride (Dilaudid) and large doses of meperidine hydrochloride.
8. Tranquilizers and barbiturates doses were classified as weak, moderate, or strong according to similar criteria used for analgesics. The anti-anxiety drugs in the weak category were tranquilizers; the moderate class was dominated by tranquilizers; and the vast majority in the strong category were large dosages of barbiturates. No distinction was made between tranquilizers and barbiturates in terms of function because tranquilizers were often prescribed as sleeping medications.
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11. Minor complications were scored as follows: nausea (1 point); nausea requiring medication (2 points); antacids given (1 point); rectal tube for gas (1 point); inability to move bowels, enema given (2 points); inability to void, catheterization required (2 points); medication for diarrhea, gut irritability, or both (1 point); medication for constipation or for urine stimulation (1 point); and antibiotics given for postoperative fever and infection (3 points).
12. The collection of data was facilitated by the full cooperation of W. M. Tomlinson and A. King, president and director of medical records, respectively, of Paoli Memorial Hospital, Paoli, Pa. I thank M. Mozzani for reading patient records, A. E. Hoerl for statistical consultation, and several physicians for their helpful comments on research methods. I also thank S. M. Parnes, L. P. Herrington, M. Zuckerman, and T. C. Meierding. Supported by grant 23170 from the Consortium for Environmental Forestry Studies, U.S. Department of Agriculture Forest Service.

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