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Nature Therapy and Preventive Medicine

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1. Introduction

Five million years passed before humans evolved into what we are today. Therefore, more than 99.99% of our evolutionary history was spent in natural environments, assuming that urbanization can be defined as a postindustrial revolution development. We have become the species we are today, living in a modern civilization, through a process of evolution within a natural environment. Human bodies are made so as to adapt to nature. However, terms that we hear today, such as "technostress (Brod, 1984)," indicate that artificialization, which is the process of society and our lives being intruded by technologies of different types, is occurring so rapidly that we now experience stressful situations and are forced to deal with the resultant pressures.

If, under such circumstances, we receive a nature-based stimulus through nature therapy, we may become aware of what we really are. We may have the chance to relax and be very comfortable. This is accomplished without logical thought. Instead, we intuitively perceive the world through the five senses. Because this process cannot be described in words, physiological indicators play an important role.

Although we are now living in a society characterized by urbanization and artificialization, our physiological functions are still adapted to to nature (Miyazaki et al., 2011). Because of this discrepancy between our body requirements and our manner of living, our stress levels are always very high and our sympathetic nervous system is excessively stimulated. In many cases, lowering elevated stress levels to a point where the body can function properly is an immediate necessity. This is exactly where nature therapy comes in. As the body approaches the "expected" natural state of well-being, immune functions are enhanced and disease resistance improves. In modern medicine, for example, we treat ourselves with antibiotics when we contract pneumonia, expecting them to relieve symptoms. In contrast, nature therapy causes a "nonspecific effect" whereby our bodies become resistant to pneumonia as a result of increased immune function induced by relief of body stress.

Our recent field research investigating immune responses to natural environments demonstrated that immune functions are enhanced by contact with forest environments. Middle-aged employees who had no subjective symptoms but who complained of lack of energy and decreased immune functionvolunteered to participate in our study. We examined natural killer cell activity (NK activity) as an indicator of immune function, particularly as an indicator of anticancer activity. After the second day walk in the local forest, NK activity was enhanced by 56% in these subjects, and normal immune functions were restored. A statistically significant increase of 23% was maintained for 1 month even after these volunteers had returned to urban life, clearly illustrating the preventive medical effect of nature therapy (Li et al., 2007a, 2008a, 2008b, 2010).

A great deal of attention is now being paid to nature therapy to scientifically identify synchronizations between humans and nature using data on the physiological effects of relaxation. In this chapter, based on human physiological data, we outline the present state of research on nature therapy and its scientific evidence from the viewpoint of preventive medicine. In addition, individual differences in the physiological effects of nature therapy and current initiatives on the relationship between nature and human health are discussed.

2. Nature therapy and well-being

2.1 Health and well-being

People have a growing interest in ways to improve their own health, which perhaps reflects the stresses of modern society. How can we achieve a sense of well-being? Obviously, being healthy does not simply mean freedom from disease.

Various definitions of well-being can be found nowadays; one understanding of the word “healthy” is “the state in which an individual fully displays the abilities he or she has or is born with.” Because it differs from one individual to another, a healthy state can be maintained even when living with a physical disability. Thus, well-being is relative rather than absolute. Even more important is the conviction that being healthy is not just an ideal “picture” in itself but rather a process through which a positive and constructive life can be led. In other words, health should be a “means” not a “goal.”

2.2 Nature and comfort

“Comfort” is a common term in daily life, yet no set definition is available in the academic community. One understanding of comfort is the “harmonization of rhythm between human beings and the environment.” During everyday life, a feeling of comfort can be experienced if our rhythms are synchronized with those of the environment. This comfort is sometimes reflected in phrases such as “We hit it off immediately,” “We get on well with each other,” or “I like the atmosphere.” For example, when I feel that the audience is listening to my lecture and that our intentions are synchronized, I feel comfortable with the idea of talking some more. Humans can achieve peace in natural surroundings, gaining comfort as a result of synchronization between us and Mother Nature.

Masao Inui categorized comfort using the terms “passive comfort” and “active comfort.” “Passive comfort” is rooted in the desire for safety and the elimination of discomfort. When assessing this category of comfort, it should not be difficult to reach consensus because individual preferences are not involved. In contrast, "active comfort" is rooted in the desire for personal growth and the urge to achieve something extra. Of course, personal aims can change and it can be difficult to reach consensus even within oneself. Active comfort is needed most in today's society. Although passive comfort is the basic minimum that must be achieved, in future research on comfort, active comfort will be the main subject of study as its assessment is already attracting the interest of many researchers.

2.3 Forest therapy

Based on these effects of nature on human well-being, Japan's Forestry Agency startedand provided the blueprint for the "forest therapy stations" project in 2005. The term "forest therapy" was coined during the process of developing this project, and the underlying idea was borrowed from the term "aromatherapy."

The blueprint for forest therapy was prepared as a result of rapid advances made over the last 3 years in assessment of physiological techniques to achieve relaxation (Lee et al., 2011a; Tsunetsugu et al., 2010). From 2005–2011, the team organized for the study [primarily from the Center for Environment, Health and Field Sciences, Chiba University and the Forestry and Forest Products Research Institute (FFPRI)] performed experiments over a period of about 1 week in 48 different forests at various locations throughout Japan, ranging from the large northern island of Hokkaido to Okinawa in the south. Measured variables (endpoints) included stress hormone (cortisol) levels in saliva and autonomic nervous activity (sympathetic and parasympathetic) monitored by heart rate fluctuation, blood pressure, and heart rate. In addition, for the first time in the world, a method was developed to monitor prefrontal cortex activity in the brain using near-infrared spectroscopy in the field. Measurements of forest phytoncides, urban exhaust fumes, temperature and humidity, illuminance, wind velocity, and negative (minus) and positive (plus) ions were also performed. By conducting these studies with human volunteers at forest sites throughout Japan, we were able to confirm the physiological effects of relaxation and provide scientific evidence for the benefits of forest therapy.

3. Methodology for evaluating health-related effects

3.1 Physiological relaxation

To investigate the physiological effects of actual natural environments, all measurement and sampling was performed in the field. Physiological data were collected through measurements of salivary cortisol concentration, blood pressure (systolic and diastolic), pulse rate, and heart rate variability.

Salivary cortisol, a stress hormone, was analyzed to determine stress responses to natural environments. Cortisol is released by the hypothalamic–pituitary–adrenal (HPA) axis in response to stress (Seplaki et al., 2004) and is a reliable indicator of endocrine stress responses (Kirschbaum & Hellhammer, 1989). Its release in response to stress is immediate and is highly associated with the free cortisol fraction in blood (Kirschbaum & Hellhammer, 1994). The sampling procedure is very simple and does not affect the cortisol values (Kirschbaum & Hellhammer, 1989). In response to a stressor, the excretion of cortisol (Pruessner et al., 1999), blood pressure, and pulse rate generally increases (Sluiter et al., 2000). In this study, saliva samples were obtained using a salivette device (No. 51.1534; Sarstedt, Numbrecht, Germany), immediately frozen, and transported to the laboratory (SRL, Inc., Tsukuba, Japan) for analysis of cortisol concentrations.

Pulse rate and blood pressure (systolic and diastolic blood pressures) as indices of autonomic nervous system activity were measured by the oscillometric method using a digital blood pressure monitor (HEM1000; Omron, Japan). Heart rate variability (HRV), an indicator of human autonomic activity (Kobayashi et al., 1999), was measured using a portable electrocardiograph (Activtracer AC-301A, GMS, Tokyo, Japan). HRV data were obtained at various frequencies using an HRV software tool (MemCalc/win, GMS). For real-time analysis of HRV, interbeat (R–R) intervals were obtained in 1-min segments using the maximum entropy method. Variance of the two major spectral components of HRV was calculated: the low-frequency (LF; 0.04–0.15 Hz) band and the high-frequency (HF; 0.15–0.4 Hz) band (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996). The LF/HF ratio in R–R interval variability was also assessed. We used the HF data as an index of parasympathetic nervous activity (Cacioppo et al., 1994) and the LF/HF ratio as an index of sympathetic nervous activity (Weise & Heydenreich, 1989).

3.2 Immune function

Effects of nature therapy on human immune function were evaluated by measurement of NK activity, the number of NK cells, and intracellular levels of anticancer proteins, including perforin, granulysin (GRN), granzyme A (GrA), and GrB in peripheral blood (Li et al., 2007a, 2008a, 2008b, 2010; Li, 2010a; Li & Kawada, 2011).

3.2.1 NK activity

Peripheral blood lymphocytes (PBLs) were separated from peripheral blood using a BD Vacutainer CPT tube, and adjusted to 4×10^6 cells/ml. NK activity was assayed according to a standard method (Li et al., 2007a, 2008a, 2008b, 2010; Li, 2010b). In brief, K-562 target cells were labeled with a sodium ^{51}Cr-chromate solution for 60 min at 37°C in 5% CO_2 and washed 4 times in RPMI-1640 containing 10% fetal bovine serum (FBS). The target cells were placed in round-bottomed 96-well microplates. Effector cells (PBLs) at 4×10^6, 2×10^6, and 1×10^6 cells/ml in 100 µl were then added to the wells in triplicate at E:T ratios of 40:1, 20:1, and 10:1, respectively. Following a 4-h incubation period at 37°C in 5% CO_2, the microplates were centrifuged and 100 µl of supernatant from each well was collected and measured in a gamma counter. NK activity was then calculated as described previously (Li et al., 2007a, 2008a, 2008b, 2010; Li, 2010b).

3.2.2 NK cells and perforin-, GRN- and GrA/B-expressing lymphocytes by flow cytometry

NK cells in PBLs were stained with phycoerythrin (PE)–CD16 monoclonal antibody and PE–mouse IgG1 as a negative control for 30 min in the dark. The cells were then fixed/permeabilized with Cytofix/Cytoperm solution for 20 min at 4°C. Intracellular perforin and GrA/B were stained with fluorescein isothiocynate (FITC)–antihuman perforin and FITC–GrA/B antibodies. As negative controls, FITC–IgG2b was used for perforin and

FITC–IgG1 for GrA/B for 30 min at 4°C according to the manufacturer's instructions. Intracellular GRN was stained with a rabbit anti-human GRN polyclonal antibody using rabbit serum as the negative control after fixation/permeabilization with Cytofix/Cytoperm solution, and then stained with FITC–goat antirabbit IgG for 30 min at 4°C in the dark (Li et al., 2007a, 2007b, 2008a, 2008b, 2010; Li, 2010b). After staining, the cells were washed twice with fixative solution and once with PBS containing 1% FBS. Flow cytometric analysis was performed with a FACScan flow cytometer as described previously (Li et al., 2007a, 2007b, 2008a, 2008b, 2010; Li, 2010b).

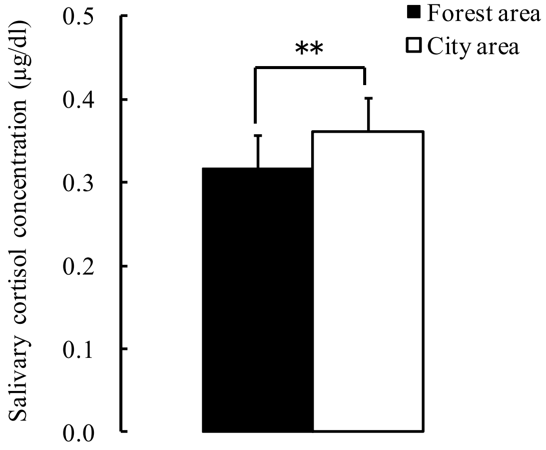
4. Evidence-based approach to health benefits of natural environments

4.1 Field experiments

4.1.1 Nature and physiological relaxation

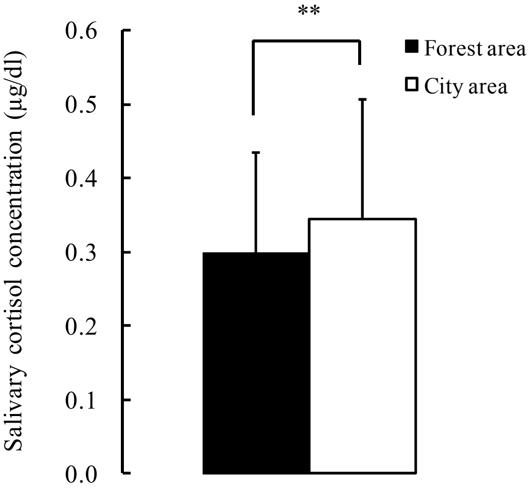
Investigation of human physiological responses in actual field sites is extremely valuable because it can reveal the total effects of the surrounding environment (Lee et al., 2009, 2011b, 2011c; Matsunaga et al., 2011; Park et al., 2007, 2008a, 2008b, 2009; Tsunetsugu et al. 2007b). A field study provides more important information regarding the effects of real environments than an indoor study. From 2005, scientific field data on physiological responses to natural environments have been accumulated and compared with responses in artificial city environments. Here, we present some of this physiological data from experiments conducted in Japanese forest sites. Subjects were assessed after viewing and walking in the forest area.

The concentration of salivary cortisol was significantly decreased when subjects were in the forest area (12.4% decrease after viewing; 15.8% decrease after walking) compared with when they were in the city area (Figs. 1 and 2, respectively).



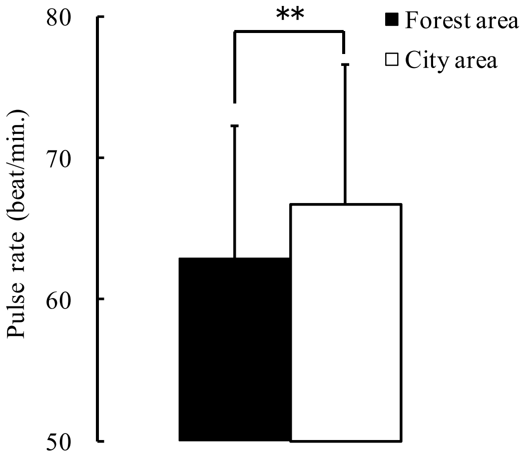
N = 385; Mean ± SD; ** p < 0.01; p-value by t-test. (Source: Park et al., 2011)

Fig. 1. Change in salivary cortisol concentration after forest viewing.



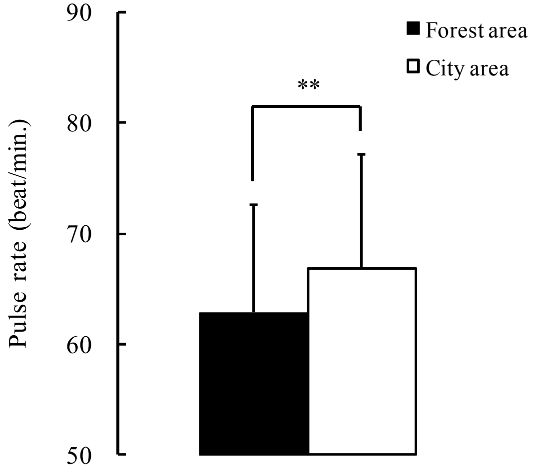
N = 74; Mean ± SD; ** $p < 0.01$; p-value by t-test. (Source: Park et al., 2010)

Fig. 2. Change in salivary cortisol concentration after forest walking.



N = 397; Mean ± SD; ** $p < 0.01$; p-value by t-test. (Source: Park et al., 2011)

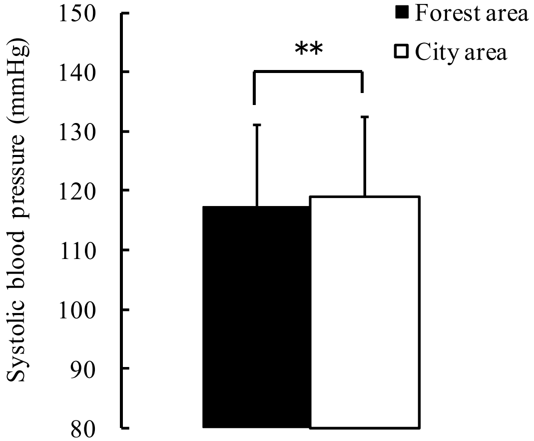
Fig. 3. Change in pulse rate after forest viewing.



N = 75; Mean ± SD; ** p < 0.01; p-value by t-test. (Source: Park et al., 2011)

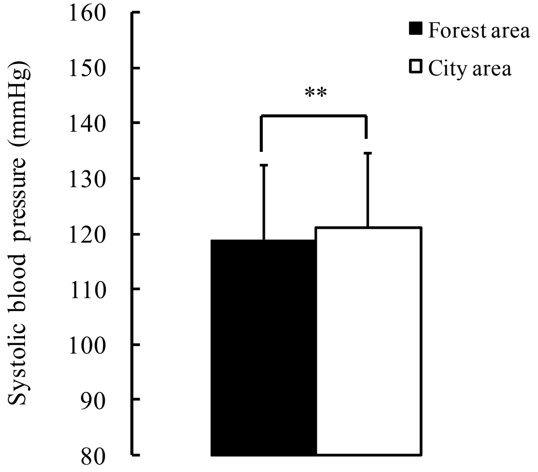
Fig. 4. Change in pulse rate after forest walking.

Figures 3 and 4 show that the average pulse rate was significantly reduced when subjects were in forest environments compared to that when they were in city environments (5.8% decrease after viewing; 3.9% decrease after walking). Similar characteristics in response to the two different modes of environmental stimulation were observed in systolic blood pressure. The average systolic blood pressure was significantly lower in the forest environment than in the city environment (1.4% decrease after viewing; 1.9% decrease after walking; Figs. 5 and 6).



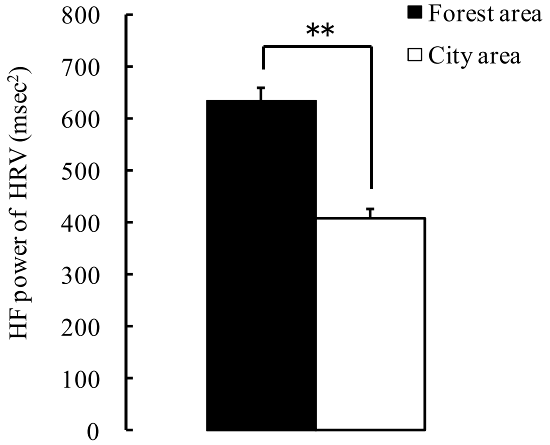
N = 397; Mean ± SD; ** p < 0.01; p-value by t-test. (Source: Park et al., in press)

Fig. 5. Change in systolic blood pressure after forest viewing.



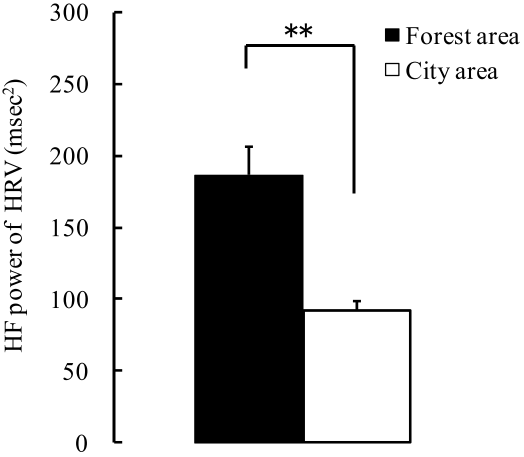
N = 75; Mean ± SD; * $p < 0.05$; p-value by t-test. (Source: Park et al., 2010)

Fig. 6. Change in systolic blood pressure after forest walking.



N = 387; Mean ± SE; ** $p < 0.01$; p-value by t-test. (Source: Park et al., 2011)

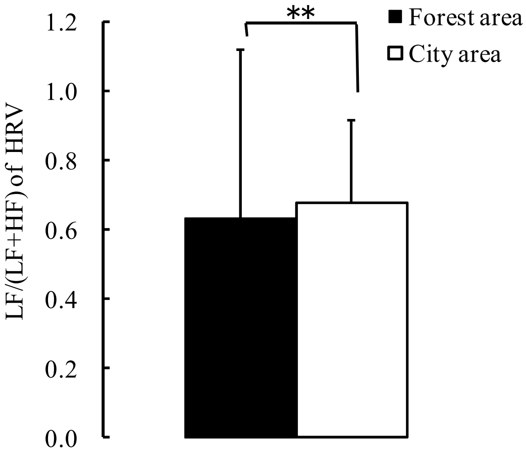
Fig. 7. Change in HF power of HRV on forest viewing.



N = 322; Mean ± SE; ** $p < 0.01$; p-value by t-test. (Source: Park et al., 2011)

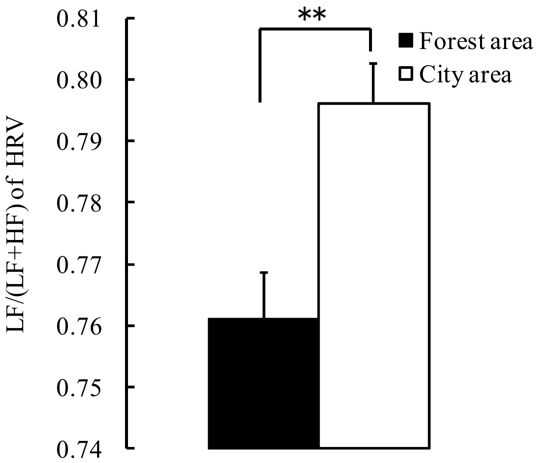
Fig. 8. Change in HF power of HRV on forest walking.

In the results of the HRV analysis, the average power of the HF components increased significantly in the forest environment (viewing and walking) compared with the city environment (Figs. 7 and 8). HF power can be a general indication of parasympathetic nervous activity, which increases when the body is relaxed.



N = 387; Mean ± SE; ** $p < 0.01$; p-value by t-test. (Source: Park et al., 2011)

Fig. 9. Change in LF/(LF + HF) of HRV on forest viewing.



N = 322; Mean ± SE; ** $p < 0.01$; p-value by t-test. (Source: Park et al., 2011)

Fig. 10. Change in LF/(LF + HF) of HRV on forest walking.

In addition, the average LF/(LF + HF) ratio of HRV, which increases during stress, showed significant differences between the forest and city environments. The average LF/(LF + HF) ratio decreased 7.0% when subjects were viewing the forest landscape and 4.4% when they were walking forest paths, compared with the ratio in the city environment (Figs. 9 and 10). This ratio is an index of sympathetic nervous activity associated with lower stress levels. These results indicate that exposure to the forest environment can reduce stress and induce relaxation.

All indices were generally in excellent agreement. They imply that the forest environment has relaxing and stress-relieving effects on humans. The results also accord with the belief of many people–that forest environments enhance physical relaxation.

Our physiological data are important: because they help explain the mechanism of the relaxation effects of the natural environment. The stress response is mediated by two broad components: the sympathetic–adrenal–medullary (SAM) axis and the HPA axis (Dinan, 2004). The SAM axis is involved in immediate sympathetic activation, which prepares an individual to deal with a stressor and results in changes such as increased heart rate and blood pressure (Vente et al., 2003). Cortisol is released by the HPA axis in response to stress (Seplaki et al., 2004). In our study, while people watched forest landscapes or walked around in the forest, their pulse rate, blood pressure, and cortisol concentration decreased. This supports the idea that the forest environment affects both the main components of the stress response system.

4.1.2 Nature and human immune function

Cortisol concentration also has great significance for human immunological activity (DeAmici et al., 2000). Our previous studies demonstrate the response characteristics of immune function and how immunity can be improved by contact with forest environments. It is well known that the immune system including NK cells plays an important role in defense against bacteria, viruses, and tumors and that stress inhibits immune function (Li et al., 2005ab). Forest environments may reduce stress (Park et al., 2010). Therefore, we speculate that forest environments may have beneficial effects on immune function by reducing stress.

4.1.2.1 Effect of forest environments on NK activity in male subjects

As mentioned above, since 2005, a series of investigations to study the effect of forest environments on human immune function have been conducted in Japan (Li et al., 2007a, 2008a, 2008b, 2010). In the first study (Li et al., 2007a), 12 healthy male subjects aged 37–55 years participated in a 3-day/2-night trip to forest areas at Iiyama, Nagano Prefecture, in northwest Japan in early September 2005. Blood was sampled on the second and third days. NK activity, NK cells, and the expression of GRN, perforin, and GrA/B in lymphocyte were measured. As a control, the same measurements were performed before the trip on a normal working day as a control.

Walking in forests significantly increased NK activity and the number of NK cells (Li et al., 2007a). It has been reported that NK cells kill tumor or virus-infected cells by releasing perforin, granzymes, and GRN via the granule exocytosis pathway (Okada et al., 2003; Li et al., 2004, 2005b). To explore the mechanism of enhancement of NK activity, the effect of being in the forest environment on intracellular levels of perforin, GRN, and GrA/B in PBL was investigated. It was found that forest environments also significantly increased the numbers of intracellular perforin, GRN, and GrA/B-expressing lymphocytes. Taken together, these findings indicate that forest environments can increase NK activity and that this effect might be at least partially mediated by an increased number of NK cells and by induction of intracellular perforin, GRN, and GrA/B (Li et al., 2007a).

However, will a trip to an unforested area (e.g., a city) also increase NK activity? To determine whether taking a city trip can also affect NK activity, we performed another experiment. Eleven healthy male subjects, aged 35–56 years, went on a 3-day/2-night trip to Nagoya City in mid-May 2006 (Li et al., 2008a). The city trip did not increase NK activity, numbers of NK cells, or the expression of the abovementioned anticancer proteins in lymphocyte, indicating that increased NK activity during the forest trip was not due to the trip itself but due to the forest environment (Li et al., 2008a). The important finding is that visiting a forest, rather than a city, increases NK activity and the intracellular levels of perforin, GRN, and GrA/B.

4.1.2.2 How long does the increased NK activity last after a forest park visiting?

Another question remain to be resolved: how long does the increased NK activity last after a forest bathing trip? An investigation was conducted to determine the duration of NK activity after a forest visit (Li et al., 2008a). Twelve healthy male subjects aged 35–56 years participated in a 3-day/2-night trip to forest areas at Agematsu Town, Nagano Prefecture, in northwest Japan in early September 2006 (Li et al., 2008a). NK activity significantly increased in these subjects during the forest visit. NK activity, the numbers of NK cells, and the percentages of GRN-, perforin-, and GrA/B-expressing cells in PBL, which confirmed the previous findings (Li et al., 2007a). The increased NK activity, number of NK cells, and percentages of GRN-, perforin-, and GrA/B-expressing cells lasted more than 7 days and even for 30 days in the cases of NK activity, the number of NK cells, and GRN- and GrB-expressing cells. These findings indicate that a forest bathing trip increased NK activity, the number of NK cells, and the levels of intracellular perforin, GRN, and GrA/B, and that these effects lasted for at least 7 days after the trip (Li et al., 2008a).

4.1.2.3 Effect of forest environments on NK activity in female subjects

Although it has been demonstrated that forest bathing trips enhance human NK activity in male subjects, it still remained to be resolved whether or not forest bathing trips also increase NK activity in female subjects. Since it has been reported that menstruation significantly affects NK activity (Souza et al., 2001),the influence of menstruation on NK activity was controlled during our experiments in female subjects.

In this part of the study (Li et al., 2008b), 13 healthy nurses aged 25–43 years with 4–18 years professional careers participated in a 3-day/2-night trip to forest areas around Shinano Town, Nagano Prefecture, in early September 2007. The trip significantly increased NK activity and the positive rates of NK, perforin-, GRN-, and GrA/B-expressing cells. The increased NK activity and the positive rates of NK, perforin, GRN, and GrA/B-expressing cells lasted for more than 7 days after the trip (Li et al., 2008b), similar to the findings in male subjects (Li et al., 2008a). These findings indicate that a forest bathing trip also increased NK activity, the number of NK cells, and the levels of intracellular anti-cancer proteins in female subjects, and that this effect lasted for at least 7 days after the trip.

4.1.2.4 A day trip to a forest park also increased human NK activity

Although longer trips to forest areas significantly increased NK activity, it was unclear whether a shorter trip to a suburban forest park would also have a similar effect. Our investigation found that a day trip to a forested park also increased NK activity and expression of anticancer proteins in male subjects (Li et al., 2010). In this study, 12 healthy male subjects aged 35–53 years participated in a day trip to a forested park in the suburbs of Tokyo. NK activity and numbers of NK cells, perforin, GRN, and GrA/B-expressing lymphocytes significantly increased, while concentrations of cortisol in blood and adrenaline in urine significantly decreased. The increased NK activity lasted for 7 days after the trip. 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.

4.1.2.5 Mechanism of increase in NK activity

The question arises as to why does NK activity increase and what factors in the forest environment activate NK cells. We speculate that aromatic volatile substances (phytoncides) derived from trees such as α-pinene and limonene play an important role. We detected several phytoncides such as isoprene, α-pinene, β-pinene, and d-limonene in the forest areas during various trips (Li et al., 2007a, 2008a, 2008b, 2010).

To investigate the effect of phytoncides on NK function, human NK cells were incubated in the presence of phytoncides extracted from trees in the areas visited. NK activity and intracellular levels of perforin, GrA, and GRN were then measured. Phytoncides significantly increased NK activity and intracellular levels of perforin, GrA, and GRN in vitro (Li et al., 2006). Moreover, we found that in vivo exposure to phytoncides from *Chamaecyparis obtusa* stem oil for 3 nights significantly increased NK activity and the percentages of NK cells, perforin, GRN, and GrA/B-expressing cells (Li et al., 2009). These findings suggest that phytoncides contribute to the enhanced NK activity during the forest visits (Li et al., 2006, 2009).

We also found that forest visits significantly decreased the concentrations of adrenaline and noradrenaline in urine (Li et al., 2008a, 2008b, 2010, 2011), which also contribute to increase in NK activity.

Finally, we found that Japanese people living in areas with lower forest coverage had significantly higher standardized mortality ratios for cancers compared with people living in areas with higher forest coverage, suggesting that forest environments may partially contribute to decreased mortality ratios for some cancers (Li et al., 2008c).

Taken together, these findings indicate that forest visits increase NK activity, which was mediated by increases in the number of NK cells and the levels of intracellular anti-cancer proteins. Phytoncides released from trees as well as decreased production of stress hormones may also partially contribute to this increased NK activity (Li, 2010a; Li & Kawada, 2011). Because NK cells can kill tumor cells by releasing anti-cancer proteins such as perforin, GRN, and GrA/B (Okada et al., 2003; Li et al., 2004, 2005b) and forest visits increase NK activity and intracellular levels of anticancer proteins, we can conclude that forest visits may have a preventive effect on cancer cell generation and development.

4.2 Indoor experiments

To clarify the relaxation effects of nature therapy, studies must be conducted both in the field and indoors for comparison purposes. A field study is very valuable in revealing the effects of nature therapy, but reproducibility cannot be assured because of the ever-changing conditions in a field environment. On the other hand, reproducibility can be achieved in indoor studies, where different stimuli can be used and the relaxation effects induced by each stimulus can be examined. Another advantage of indoor studies is that more detailed measurements can be taken, allowing us to focus on the physiological mechanisms leading to a relaxed state (Sakuragawa et al., 2005, 2008; Tsunetsugu & Miyazaki, 2005; Tsunetsugu et al., 2002, 2005, 2007a, 2010).

4.2.1 Olfactory stimulation study

4.2.1.1 Phytoncides

The term “phytoncide” is derived from “phyto,” meaning plant, and “cide,” meaning killing. This term was first used by B. P. Tokin in the Soviet Union around 1930. Later, in 1942, Tokin wrote an article in a booklet published by the National Medical Publishing House in Moscow. In 1946, the term appeared in the first issue of the *Journal of Clinical and Experimental Medicine* (*Igaku No Ayumi*) published in Japan. As stated in these articles, Tokin originally considered that phytoncides were volatile ingredients of plant oils. However, in his later publication, “A Mysterious Phytoncide in Plants” issued in 1980, he defined phytoncides as the “substances produced by all kinds of plants, which may or may not be volatile and which have an influence on other organisms.” The major substances produced by forests and lumber, such as α-pinene and limonene, are good examples of phytoncides. The strong smell of onion or garlic can stimulate our lacrimal (tear) glands when cooking because these smells also contain phytoncides.

4.2.1.2 Relaxation effects of phytoncides

When the air in a forest is analyzed, more than 100 different types of phytoncides can be detected. In many cases, α-pinene and limonene are the major components. To clarify the physiological effects of relaxation uniquely induced by phytoncides, we conducted an inhalation study using α-pinene and limonene in an indoor artificial climate room. Test subjects were exposed to a low concentration of each substance, and blood pressure readings were taken once per second for a period of 90 s. Statistically significant reductions in systolic blood pressure were noted after inhalation of α-pinene and limonene, respectively.

We also conducted an inhalation study using fragrances produced by the wood chips of *sugi* (*Cryptomeria japonica*) and *hiba* or *asunaro* (*Thujopsis dolabrata*). We found that systolic blood pressure decreased significantly after inhalation of these fragrances. Brain activity was also significantly subdued. Subjective assessments using a questionnaire indicated that the subjects were in a state of natural comfort. We can therefore interpret these data as indicating that inhalation of the fragrances of wood chips of *sugi* and *hiba* has a relaxing effect on humans. Interestingly, even in those volunteers who found the fragrances of *sugi* and *hiba* unpleasant, systolic blood pressure did not increase and no stressful conditions were observed.

As mentioned previously, human biological functions are naturally synchronized with the rhythms of the environment. This explains why even when our subjects disliked the fragrance of *sugi*, they still did not experience stress because of the inherent natural adaptation of the human biological system. The same phenomena have been observed in our studies involving tactile and visual stimulation.

4.2.2 Visual stimulation study

Using the indoor artificial climate room, we have measured the physiological responses of volunteers looking at all kinds of views as they walked in the forest or took part in forest therapy. We found that changes elicited by nature-derived visual stimulation were very similar among all subjects, as reflected by subdued activity in the cerebral prefrontal cortex and the autonomic nervous system and reduced blood pressure. Even in cases of single sensory stimulation, the human body demonstrated the ability to find its natural state: a relaxed condition. The only exception to this was when the subjects were viewing *sakura* (Japanese cherry trees). When the volunteers saw cherry trees in full bloom, elevated activity of the cerebral prefrontal cortex and increased heart rate were observed, implying body excitement. We regard this as a case where the fascinating natural beauty of *sakura* could actually change the physiological state of the subjects of our study.

4.2.3 Auditory stimulation study

Auditory stimulation in forests can be a factor in physiological relaxation. Therefore, activity in the prefrontal area of the brain and HRV during auditory stimulation were investigated. Subjects were asked to listen to various sounds from the forest, ranging from the noise of a stream to the singing of nightingales and other birds with their eyes closed. As with the visual stimulation study, we observed subdued activity in the prefrontal cortex and the sympathetic nervous system, indicators of the physiological effects of exposure to these sounds. However, subjects who imagined being in the forest during the experiment showed more signs of relaxation, while those who did not have much interest in the sound or who associated the sound of the forest stream with the flushing sound of a toilet exhibited no objective relaxation effects. Thus, the same sound may be interpreted in different ways by different people, and its effects may therefore differ.

5. Individual differences in health benefits

5.1 Individual differences in human responses

People respond differently even to the same stimuli. There is always considerable variation in the response magnitude between individuals and in the direction of the response. In a previous experiment, the authors found that changes in hemoglobin concentrations in the prefrontal area during exposure to the taste and odor of a piece of chocolate varied from person to person (Fig. 11). In some participants, hemoglobin concentrations increased, which implies increased activity in the prefrontal cortex, while in other participants, it decreased, which reflects decrease in brain activity.

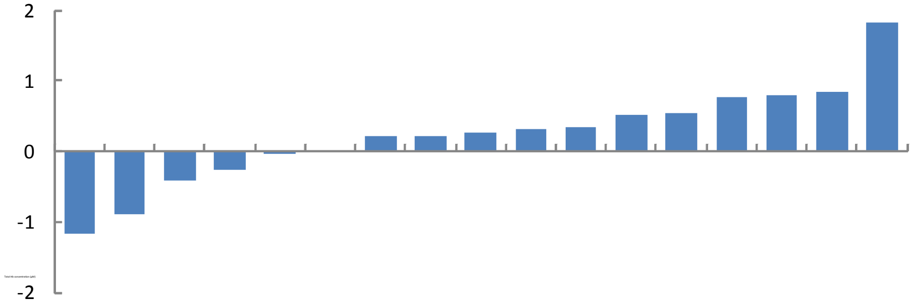


Fig. 11. Changes in total hemoglobin concentration in the left prefrontal rea in 17 young male subjects

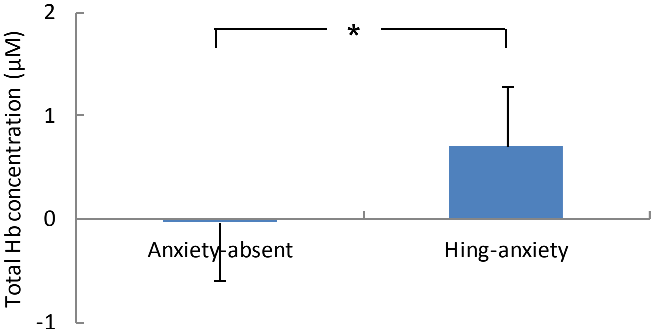
Why do we respond differently? What causes this variation? In an attempt toanswer these questions, Korte et al. (2005) revealed that two types of stress-coping personalities are widely observed in the animal kingdom: aggressive (proactive Hawks) and relatively cooperative (passive Doves). They have different physiological characteristics and show different reactions to changes in their environments. Both types exist in equilibrium within a population and have different strategies to cope with stress, which are effective under different environmental conditions.

Thus, we investigated individual personality as one of the possible factors affecting physiological response (Tsunetsugu et al., 2003). To analyze the previously mentioned hemoglobin data, we examined anxiety to determine if being easily anxious was associated with variations in brain activity. First, we determined each participant's personality type according to their scores on personality tests and divided them into two groups: high anxiety or no anxiety. We then divided the participants into two other groups according to hemoglobin changes, namely the increased and decreased groups, and investigated how many participants of each personality type fell into the two groups. The results were somewhat different than we expected. Significant biases were observed between the increased and decreased groups in terms of the number of high-anxiety people (Table 1). A significant difference was also observed when groups of different anxiety levels were compared in terms of average values of change in hemoglobin concentration (Fig. 12). The high-anxiety group showed a large increase in brain activity during stimulation, while the anxiety-absent group showed only a slight change. These results suggest that individual personality traits could influence physiological responses.

Individual differences in physiological responses have been not scientifically investigated in our study on nature therapy mainly because of problems of accuracy or relevance of the measurement. People nevertheless show large variations and it is naturally necessary to consider this when treating with nature therapy.

	High-anxiety	Anxiety-absent	Total
Decreased group	0	5	5
Increased group	6	6	12
Total	6	11	17

Table 1. Number of participants in each category and cerebral activity in response to olfactory and gustatory stimuli



N = 11 (anxiety-absent), N = 6 (high-anxiety); Mean ± SD; * $p < 0.05$; p-value by unpaired t-test.

Fig. 12. Changes in total hemoglobin concentration in the left prefrontal area of two different personality groups.

Recent improvements in technology related to physiological measurements have enabled data to be obtained from more participants with relative ease. Consequently, discussion on how to approach individual variations scientifically will be ongoing in the near future. In the following section, some examples of analysis focusing on individual personality and the initial values of physiological parameters will be presented.

5.2 Personality and physiological responses

As mentioned previously, certain personality traits may explain individual variations in cerebral activity during olfactory and gustatory stimulation. Here we discuss whether personality traits can also explain individual variations in physiological responses to natural environments.

	Morning	Walking (N = 43)			Viewing (N = 115–116)		
	(N = 117)	Before	After	Change	Before	After	Change
Type A	0.238**	0.282^{+}	0.372*	0.323*	0.260**	0.276**	0.043
Anxiety	0.125	0.158	0.255^{+}	0.288^{+}	0.156^{+}	0.204*	0.115

**p < 0.05, *p < 0.01. "Change" values were calculated by subtracting the "Before" value from the "After" value.

Table 2. Correlation coefficients between personality scores and systolic blood pressure

Experiments were performed in 10 forests in Japan from May to July in 2005, 2006, and 2007. Subjects were 120 male students (12 male students at each experimental site) aged 21.9 ± 1.6 years. Scores for type A behavior pattern and trait anxiety for each subject were calculated according to KG's Daily Life Questionnaire and the Japanese version of the State-Trait Anxiety Inventory (STAI). Systolic blood pressure was measured five times: in the morning before breakfast at the place of accommodation, before and after the subjects walked a predetermined course in the forest for 14 ± 2 min, and before and after they sat still on a chair viewing the scenery in the forest for 14 ± 2 min. Correlation coefficients were calculated between scores of the personality questionnaires and blood pressure (Table 2).

There was a significant positive correlation between type A scores and systolic blood pressure measured in the morning before breakfast, after walking, before watching, and after watching. A significant positive correlation was also observed between type A scores and changes in systolic blood pressure due to walking, which indicated that systolic blood pressure increased in type A subjects while it decreased in type B subjects (Fig. 13). Trait anxiety and systolic blood pressure showed a weak positive correlation after walking and before watching and a significant positive correlation after watching.

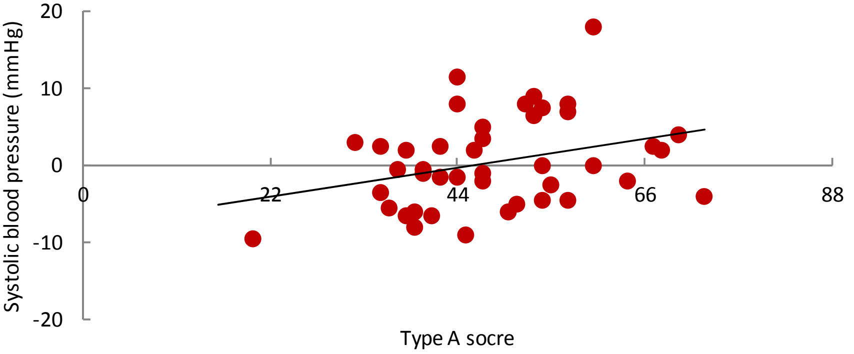


Fig. 13. Relationship between type A scores and changes in systolic blood pressure after walking approximately 14 min in a forest environment (N = 43).

In another study, we focused on salivary alpha-amylase (sAA), a relatively new index of sympathetic nervous activity. Type A behavior patterns and trait anxiety were investigated to determine their effect on sAA levels. sAA of 82 male participants (aged 22.2 ± 1.6 years) was measured four times during their time in a forest environment as well as in the morning and evening. Comparing the mean values of the type A and B groups, we found that the morning sAA levels were significantly lower in the type A group than in the type B group (Fig. 14), whereas morning salivary cortisol levels did not differ between the two groups. The difference in sAA levels between the two groups was maintained for the entire day(Fig. 14).

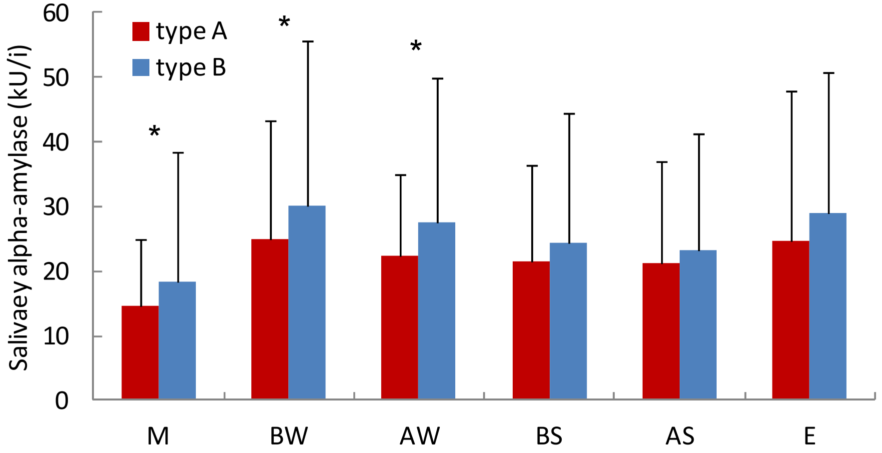


Fig. 14. Time-course changes in salivary alpha-amylase activity in type A and type B groups (mean ± SD, N = 52 (type A), N = 30 (type B). *$p < 0.05$ (unpaired t-test)).

These results demonstrated that personality traits such as a type A behavior pattern or trait anxiety could be among the factors causing individual variations in the baseline values (values in the morning or before walking and before viewing) of certain physiological parameters and could thus affect changes in physiological responses to forest therapy.

5.3 Baseline values and physiological responses to forest therapy

The law of initial value originally propounded by Wilder (1957) states that the intensity and direction of a body function depend largely on the initial level of that function. Wilder demonstrated that blood pressure or pulse rate responses were higher when the initial values were lower. He also pointed out that most investigators failed to consider the initial values. Does the law of initial value hold true in the case of rather new physiological indicators such as salivary biomarkers?

Stress levels may be assessed by determining the amounts of immune substances secreted in response to stressors. Immunoglobulin A (IgA), an antibody found in blood and other body fluids, is often considered an index of immune system activity. IgA concentration is known to decrease under severe chronic stress (Martin & Dobbin, 1988), whereas it has been reported to increase in response to acute stress (Yamada et al., 1995). Interestingly, however, it has also been demonstrated that IgA levels in those engaged in stressful jobs are significantly higher than in those not engaged in comparable activity (Henningsen et al., 1992). In our field studies, the results for IgA concentration were inconsistent. One of the reasons for this ambiguity could be the large individual differences in baseline values of salivary IgA.

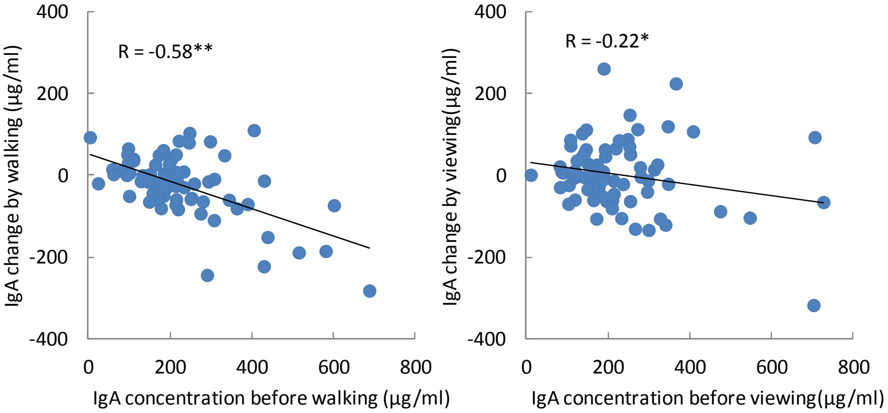


Fig. 15. Relationship between the initial values of salivary IgA concentration and relative changes when walking or viewing in forest environments (N = 75, **$p < 0.01$, *$p < 0.05$).

We investigated salivary IgA concentration in 84 male subjects (22.2 ± 1.6 years old) taken when they walked along a predetermined course for 10–15 min and also when they were seated watching the landscape for 10–15 min in a forest environment. Saliva was sampled four times, i.e., before and after the walk and before and after the landscape viewing. Correlation analysis was performed between the initial values (before walking/viewing) and the changes (after walking/viewing minus before walking/viewing).

A significant negative correlation between the initial value and the degree of change when walking and watching was found (Fig. 15). These results support Wilder's law of initial value and suggest that it is necessary to take the initial value into account in order to understand salivary biomarker data.

6. Current initiatives on nature and human health

The relationship between human health and well-being and forest ecosystems has in recent years received increasing attention not only within multidisciplinary research but also in international and national discussions and policy processes. One global initiative is the International Union of Forest Research Organizations (IUFRO) special project (task force) on Forests and Human Health (IUFRO, 2011). The particular aim of this task force is to specifically address the relationship between forests and human health on a global scale. Its purpose is to support the cross-sectoral dialogue between the different players in this field, especially forestry and health professionals.

The IUFRO Task Force is coordinated by the Finnish Forest Research Institute. It has two priorities: maximizing health benefits of forests and managing health risks connected with forests. The activities of the Health Task Force include organizing conferences and round-table discussions, producing a state-of-the-art report, releasing newsletters and other publications, delivering information, and improving networking through web portals. The task force also aims to facilitate new international research projects and to promote the health benefits of forests. It has conducted several international symposiums and events since 2007.

Another global effort is the Cooperation on Health and Biodiversity (COHAB) initiative, which responds to gaps in awareness and policies linking biodiversity with human health and well-being (COHAB, 2011). This initiative aims to establish a framework to support existing activities on international development, biodiversity conservation, and population health and to support the United Nation's Millennium Development Goals.

Another recent European example of a joint research effort is the scientific and technical network of Forests, Trees, and Human Health and Well-Being (COST action E39) funded by the European Commission. This network summarized current knowledge about the contribution of natural places to the health and well-being of people in Europe and identified future research needs (Nilsson et al., 2010).

Practical organizations such as the International Union for Conservation of Nature (IUCN) have also launched global initiatives to raise awareness of the value of nature areas to human health. IUCN has established the Healthy Parks Healthy People (HPHP) Task Force, which is coordinated by Parks Victoria in Australia. This action follows on from the highly successful first International Healthy Parks Healthy People Congress held in Melbourne in April 2010. The HPHP Task Force aims to provide guidance to IUCN, national policymakers, and practitioners with regard to the relationships between human health, community well-being, economic prosperity (for example, nature-based tourism), ecosystem services, and protected areas. It also seeks to establish alliances with government and nongovernment sectors to progress research and development of the links between parks, society, and economies and to demonstrate the health benefits of nature (Healthy Parks, 2011). The link between health benefits and nature conservation areas such as national parks has recently been actively incorporated into policy documents and management goals of protected areas in Australia, Canada, and Finland, for example.

It seems evident that forest-based health-related products and services have considerable future potential. There is also an increasing understanding that wider application of forest therapy and provision of easily accessible nature-based health services could significantly reduce public health care budgets. However, putting research into practice calls for stronger cooperation between different sectors, especially between forest, health, and environmental professionals (Karjalainen et al., 2010).

A stronger dialogue between researchers in different disciplines will improve theoretical frameworks and methodology. Moreover, a firmer evidence base is needed on the physiological and psychological health benefits of forest therapy. For example, the influence of the quality of forest environments on the therapeutic and restorative benefits of forests is unknown. Cultural, individual, and social differences in experiencing the health benefits of green environments are also not fully understood (Nilsson et al., 2010). In forest-based therapy, a more solid scientific basis for practical applications is also required. Future research might investigate the long-term health benefits of exposure to nearby nature in residential or working environments. These and other questions are currently addressed in recently launched studies such as "Stress reducing effects of urban green areas"' funded by the Academy of Finland and Japan Society for the Promotion of Science (2011–2012).

Although there are promising examples of implementing research results in practice, major implementation of these results is still lacking. An important issue is how to assess the value of the benefits resulting from nature care and other "green-health" approaches. This requires the development of valuation systems to quantify the costs and benefits of interventions (Willis & Crabtree, 2010). At present, public funds are still the main source of direct and indirect payments for health care services. Without an overview of the economic dimensions of these nature-based health-promoting activities, it will be difficult to effectively promote them in a policy setting.

Today, lifestyle-related health problems are of concern in all developed countries. Health problems increasingly relate to modern lifestyles, which are more sedentary and stressful, and mainly oriented indoors. Forests in urban and rural areas have great potential for promoting healthier lifestyles and improved mental health in urbanized societies. However, public authorities do not yet widely promote the use of forests and nature for improved health. Natural areas are still not considered a necessity, particularly in urban areas where the competition for land is intense and land values are high. Compact city policies have led to even greater pressure on urban green areas (Tyrväinen et al., 2005). The health benefits of nature could be better incorporated into urban and land-use planning or in discussions about the need for urban densification. Therefore, the public health benefits of forests must be better understood and more effectively communicated.

7. Conclusion

In this chapter, we introduced nature therapy from the perspective of preventive medicine, illustrating the relationship between nature and human beings, describing the concepts of comfort and health, providing concrete methodology for investigating the effects of nature therapy, and outlining the results of our scientific investigations of the effects of forest therapy on physiological relaxation and immune function. In addition, we also addressed the issues of individual differences in responses to the therapeutic effects of nature. However, despite our efforts, more scientific evidence is required to verify the effects of nature therapy on humans. In future, data from a range of subjects, including young children and middle-aged and elderly people, will facilitate study of the preventive medical effects of nature.

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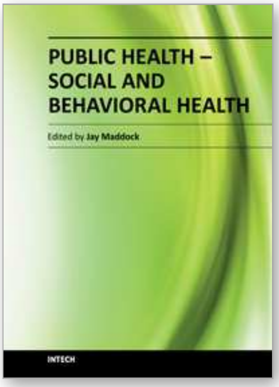

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Human behavior accounts for the majority of morbidity and premature mortality throughout the world. This book explores several areas of human behavior including physical activity, nutrition and food, addictive substances, gun violence, sexual transmitted diseases and more. Several cutting edge methods are also examined including empowering nurses, community based participatory research and nature therapy. Less well known public health topics including human trafficking, tuberculosis control in prisons and public health issues in the deaf community are also covered. The authors come from around the world to describe issues that are both of local and worldwide importance to protect and preserve the health of populations. This book demonstrates the scope and some of the solutions to addressing today's most pressing public health issues.

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