Boost your immune system with ‘forest bathing’

What is forest bathing?

The term emerged in Japan in the 1980s as a physiological and psychological exercise called *shinrin-yoku* (“forest bathing” or “taking in the forest atmosphere”). The purpose was twofold: to offer an eco-antidote to tech-boom burnout and to inspire residents to reconnect with and protect the country’s forests.

The Japanese quickly embraced this form of ecotherapy. In the 1990s, researchers began studying the physiological benefits of forest bathing, providing the science to support what we innately know: time spent immersed in nature is good for us. While Japan is credited with the term *shinrin-yoku*, the concept at the heart of the practice is not new. Many cultures have long recognized the importance of the natural world to human health.

Native evergreens are both aromatic and release a high concentration of **phytoncides**—airborne essential oils that provide a natural immunity boost. The health benefits of this phytoncide “shower” can last for weeks. Evergreen needles are rich in antioxidants and vitamin C and some—such as spruce, eastern hemlock, balsam, and pine.

Exposure to forests and trees:

- boosts the immune system
- lowers blood pressure
- reduces stress
- improves mood
- increases ability to focus, even in children with ADHD
- accelerates recovery from surgery or illness
- increases energy level
- improves sleep

Forest bathing and NK cells

While we breathe in the fresh air, we breathe in phytoncides, airborne chemicals that plants give off to protect themselves from insects. Phytoncides have antibacterial and antifungal qualities which help plants fight disease. When people breathe in these chemicals, our bodies respond by increasing the number and activity of a type of white blood cell called natural killer cells or NK. These cells kill tumor- and virus-infected cells in our bodies.

Some of the well-known phytoncides are: alpha-pinene, beta-pinene, camphene, camphor, terpinenes, limonene, cymene, myrcene

Natural killer cells (or NK cells) are a type of lymphocyte critical to the innate immune system. NK cells provide a rapid response to cells infected by viruses, or to bacterial cells. The response happens about 3 days after infection. NK cells also respond to tumour formation.

NK cells are unique: they have the ability to recognise stressed cells in the absence of antibodies and major histocompatibility complex (MHC). This allows for a much faster immune reaction.

To control their cytotoxic activity, NK cells have two types of surface receptors: activating receptors and inhibitory receptors. When the NK cell is activated, it destroys the cells which have switched it on.

Small granules in their cytoplasm contain proteins and enzymes called **granzymes**. They are released close to a cell which has triggered their action. A protein **perforin** forms pores in the cell membrane of the target cell, creating a channel through which enzymes and other molecules can enter. This kills the target cell. The details vary according to whether the target is a virus, a bacterium or a tumour cell.

Granulysin is released by cytotoxic T cells and NK cells when they are attached to infected body cells. It creates holes in the target cell membrane and destroy it. Granulysin is able to induce apoptosis in target cells and also has antimicrobial action. Granulysin is broadly antimicrobial, killing microbes that cause, for example, tuberculosis and malaria, and can destroy some tumors.

Three studies that proves the link between NK cells boosting and "forest bathing"

First study

A first report published in 2007 demonstrated that a forest bathing trip can enhance the immune response as measured by human NK activity, and the percentage and absolute numbers of NK cells.

Method:

Twelve healthy male subjects, aged 37-55 were selected from three large companies in Tokyo. The subjects experienced a three-day/ two-night trip at three different forest fields in early September, 2005. On the first day, subjects walked for 2 hours in the afternoon in a forest field, and then stayed at a nearby hotel within the forest. On the second day, subjects walked for 2 hours in the morning and afternoon, respectively, in two different forest fields. Each course was 2.5 km, closely resembling normal physical activity for the subjects on normal working days

Blood was sampled on the second and third days and three days prior to the trip as a control. Since it has been reported that human NK cell activity shows circadian rhythms, all samples

were obtained at 8:00 am. NK activity; proportions of NK, granulysin, perforin, and granzymes were measured.

Results:

- Forest bathing also significantly increased NK cells in all subjects, with significant differences before and after the trip and between days I and 2 in both the percentage
- Eleven of twelve subjects displayed increased NK activity during and after the trip as compared to three days before. Significant differences were observed both before and after the trip and between days I and 2 in NK activity (Fig. IA).
- The forest bathing trip also significantly increased the percentages and total number of granulysin, perforin, and granzymes.

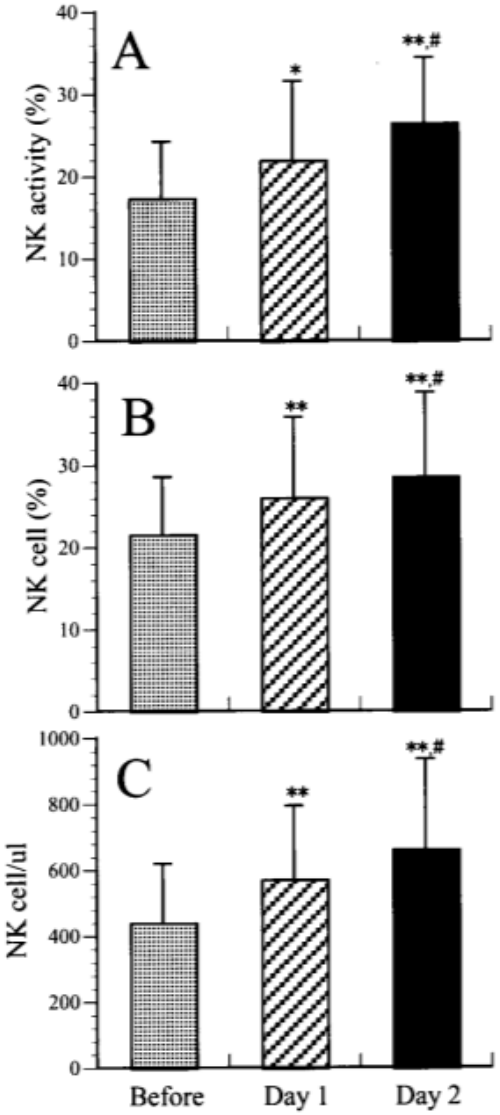

Fig. 1. *Effect of the forest bathing trip on NK activity (A), the percentages (B) and total number (C) of NK cells. Data are presented as the mean+SD (n=12). ANOVA indicated that the forest bathing trip significantly affected the NK activity, the percentages and total number of NK cells (all $p<0.01$). *: $p<0.05$, **: $p<0.01$, significantly different from before the trip, #: $p<0.05$ significantly different from Day 1 by the paired t-test. The activity values for an E/T ratio of 20/1 are shown, and the similar results were also obtained with E/T ratios of 40/1 and 10/1.*

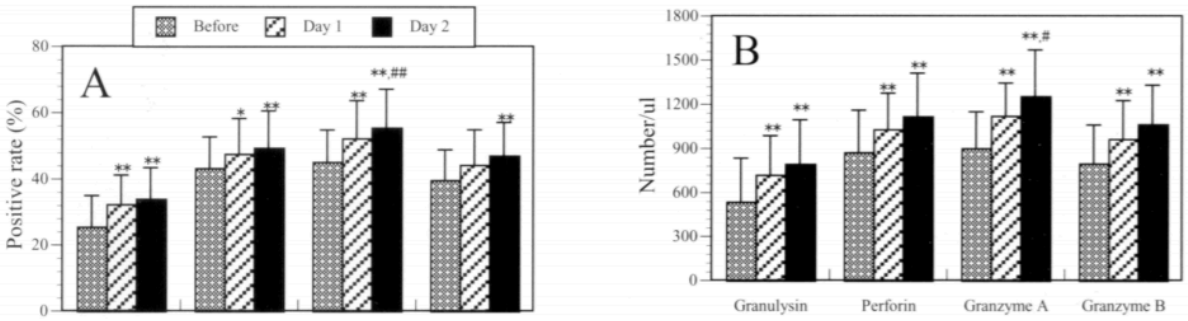

Fig. 2. *Effect of the forest bathing trip on the proportion (A) and number (B) of GRN, perforin, GrA/B-expressing cells in PBL. Data are presented as the mean +SD (n=12). ANOVA indicated that the forest bathing trip significantly affected the proportion and number of GRN, perforin, GrA/B-expressing cells in PBL (all p<0.01). *: p<0.05, **: p<0.01, significantly different from before the trip, #: p<0.05, ##: p<0.01 significantly different from Day 1 by the paired t-test.*

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Second study

Method

In 2008, once again, in the forest bathing trip, the subjects experienced a three-day/two-night trip to three different forest fields at Agematsu town in Nagano prefecture located in northwest Japan in early September, 2006. On the first day, the subjects walked for two hours in the afternoon in a forest field, and then stayed at a nearby hotel within the forest. On the second day, the subjects walked for 2 hours in the morning and afternoon, respectively, in two different forest fields. On day 3, the subjects finished the trip and returned to Tokyo after drawing blood and completing the questionnaire.

In contrast, on the city tourist visit, eleven subjects experienced a three-day/two-night trip to Nagoya city in mid-May, 2006. Nagoya is located in Aichi prefecture roughly in the center of Japan with a population of 2 million and is an important crossroads for transportation in Japan. On the first day, the subjects walked for two hours in the afternoon along a tourist route, which is through an old style district in Nagoya, and then stayed at a hotel in Nagoya. On the second day, the subjects walked for 2 hours around Nagoya baseball . Dome in the morning and 2 hours around/in Nagoya airport nearby Nagoya city in the afternoon. On day 3, the subjects finished the trip and returned to Tokyo after drawing blood and completing the questionnaire. There are some areas of trees in Nagoya city, but there are almost no trees in the areas visited. Each course in both trips was 2.5 km, closely resembling normal physical activity for the subjects on an average of normal working days.

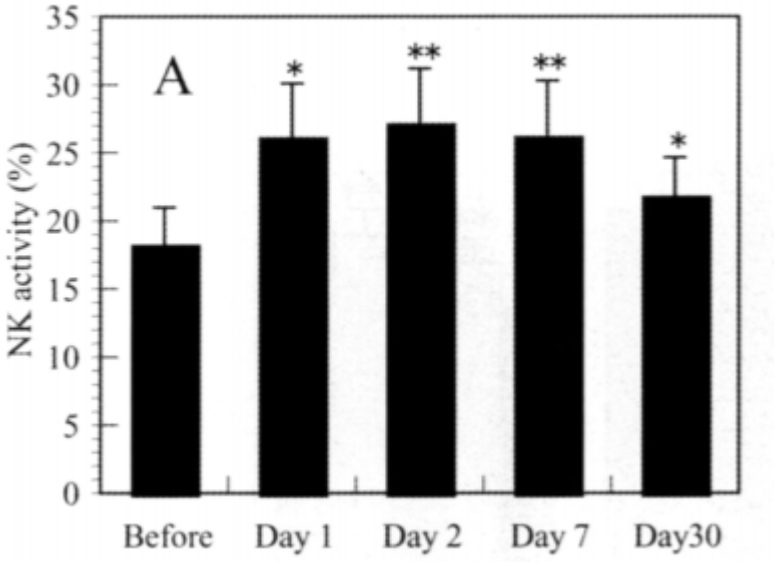
Results

This study confirmed that a forest bathing trip enhances the immune response as measured by human NK activity and the numbers ofNK cells, as reported previously. In contrast, a trip to

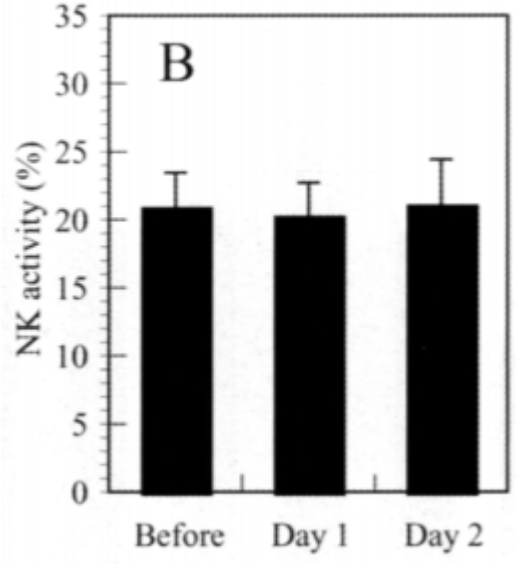
places without forests (city tourist visit) has no effect on NK activity or the numbers of NK cells, indicating that forest bathing does indeed enhance human NK activity.

Moreover, researchers also found that the increased NK activity and numbers of NK cells induced by a forest bathing trip last more than 7 days, even 30 days, after the trip. This suggests that if people visit a forest once a month, they may be able to maintain increased NK activity.

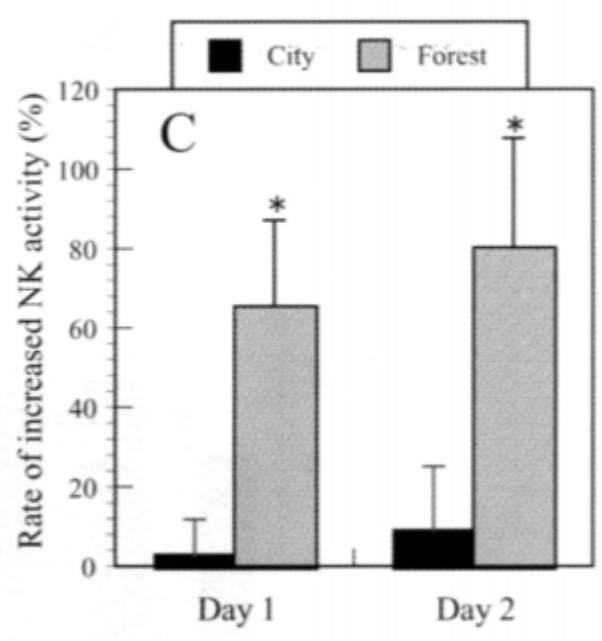
NK activity in the forest:



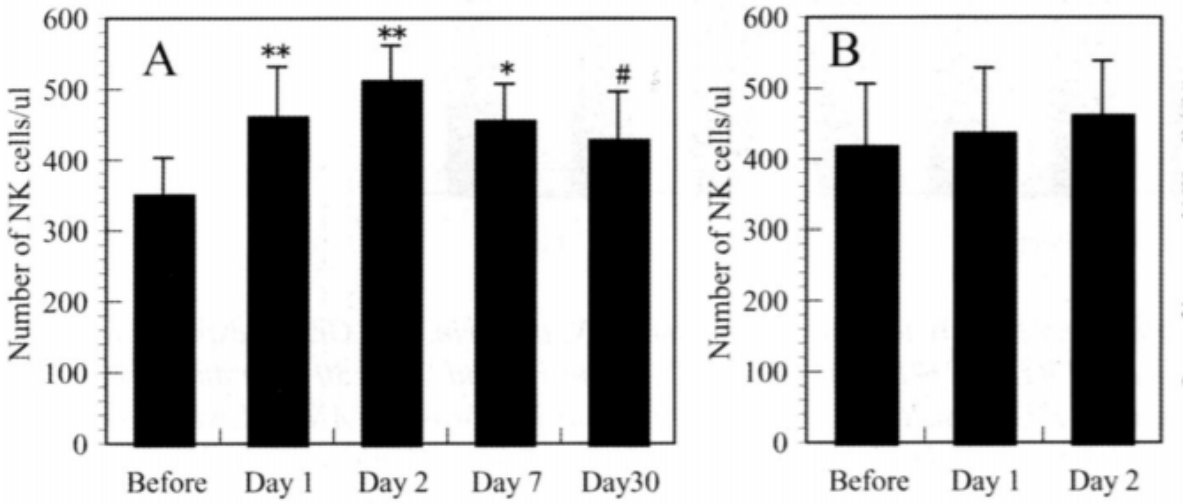
NK activity in the city:



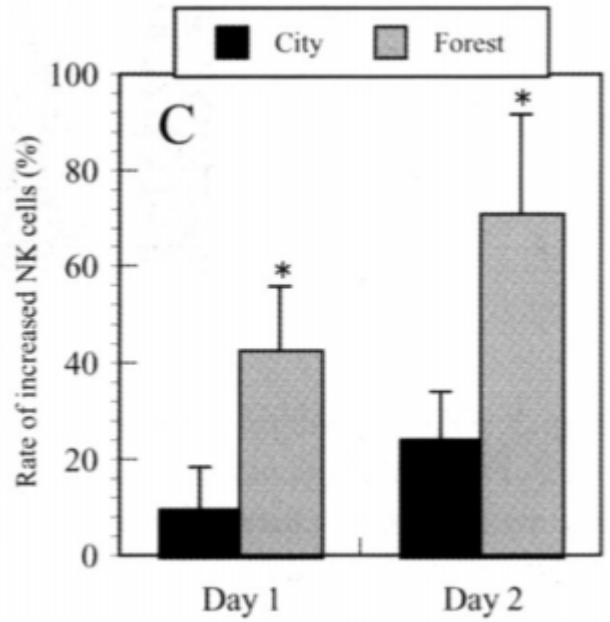
Comparison ofthe rate ofincrease in NK activity between the forest bathing trip and the city tourist visit:



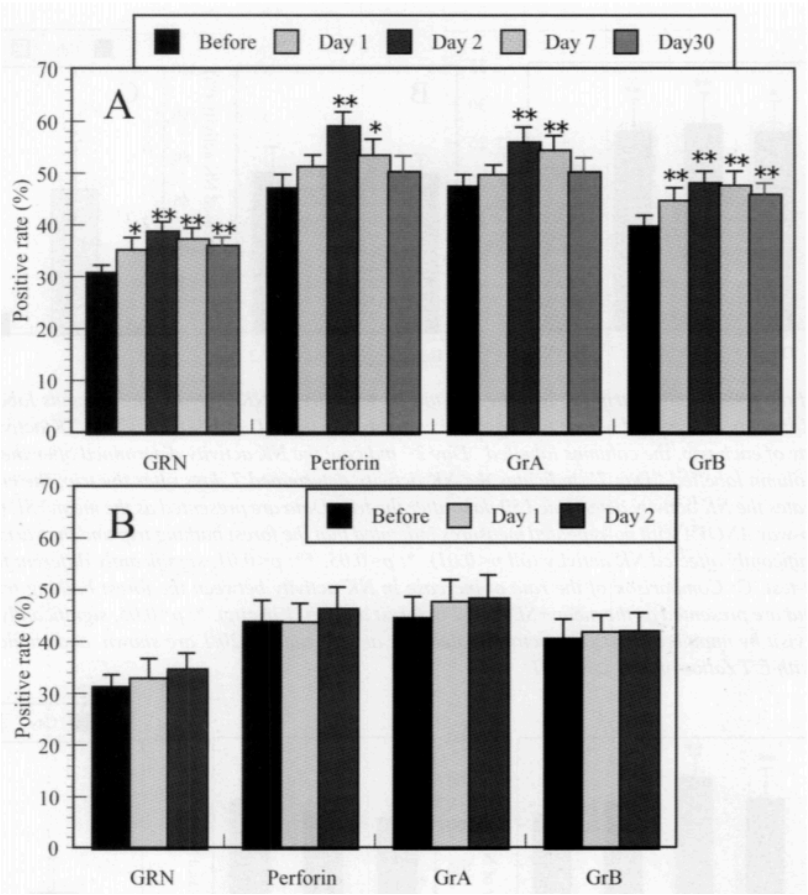
Effect of th eforest bathing trip (A) and the city tourist visit (B) on the number of NK cells



(C) Comparison of the rate of increase in NK number between the forest bathing trip and the city tourist visit



Effect ofthe forest bathing trip (A) and the city tourist visit (B) on GRN (granulosyn), perforin, and granzyme A/B



Lastly, phytoncides, such as alpha-pinene, betapinene, tricyc1ene, camphene, and limonene, were detected in higher concentrations in the forest fields during the investigation, but were not detected in the urban area of Tokyo, or in the city tourist visit on day 2 although only very low concentrations of alpha-pinene and limonene were detected on day 1.

Table II. *Concentration of volatile substances (phytoncide) in the air of forest fields and in the air of city calculated as alpha-pinene (ng/m³).*

	Forest bathing trip		City tourist visit	
Measuring points	Field 1 Day 1 pm	Field 2 Day 2	Old style district in Nagoya Day 1 pm	Nagoya baseball Dome Day 2
Kind of Trees	*Chamaecyparis obtusa*	*Chamaecyparis obtuse, Thuja occidentalis*		
Tricyclene	299.7	805.5	n.d	n.d
α-Pinene	2,886.7	1,281.7	6	n.d
Camphene	375.6	486.8	n.d	n.d
β-Pinene	137.5	66.9	n.d	n.d
Myrcene	109.4	71.8	n.d	n.d
δ-3-Carene	66.6	25.3	n.d	n.d
α-Terpinene	43.8	26.9	n.d	n.d
p-Cymene	109.4	67.3	n.d	n.d
Limonene	111.1	48.4	17	n.d
γ-Terpinene	n.d	33.2	n.d	n.d
Terpinolene	87.5	13.4	n.d	n.d
Camphor	32.8	14.8	n.d	n.d
Bornyl acetate	54.7	43.4	n.d	n.d

n.d: not detected

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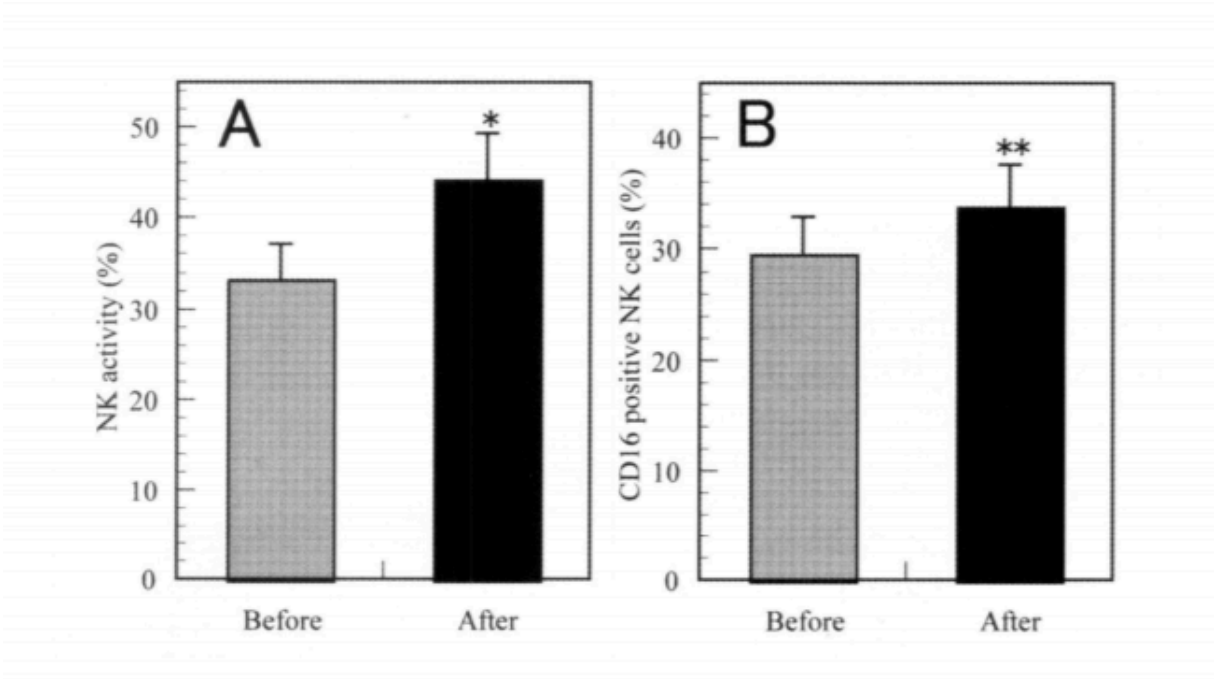
Third study

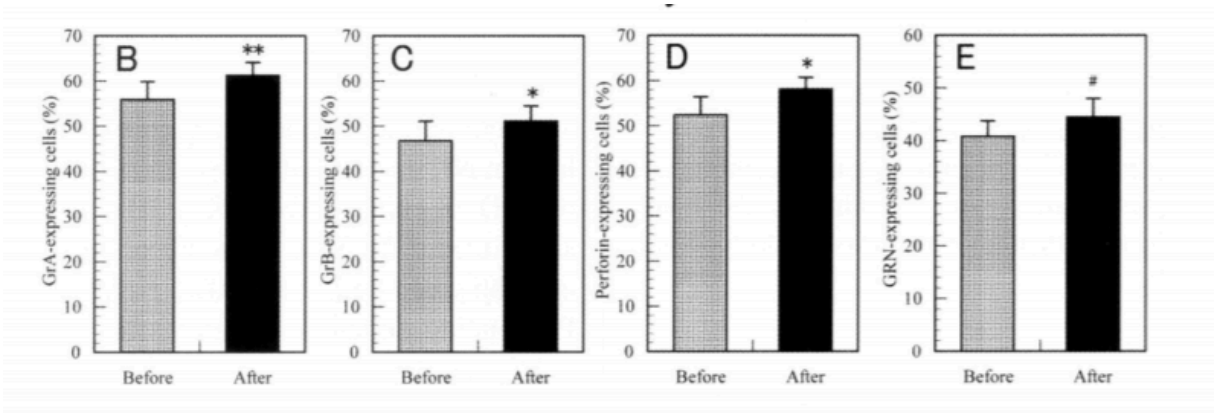
In 2009, the same researchers investigated in 12 male subjects whether phytoncide exposure in vivo affects human immune function. They released phytoncides in the hotel room air and found that phytoncide exposure significantly enhances human NK cell activity, the number of NK cells and amount of its products granulosyn, perforin and granzymes A and B. These findings suggest that phytoncides contributed to the enhanced NK activity during the stay at the hotel.

In addition, researchers also found that phytoncide exposure significantly decreased the concentrations of adrenaline and noradrenaline in urine, suggesting that the subjects were under conditions of lower stress during the hotel stay.

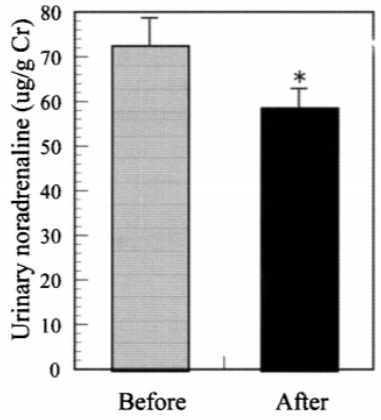
Effect of phytoncide exposure on human NK cell activity (A) and the percentage of CD16+ NK cells:



Effect of phytoncide exposure on granzyme A and B (B-C), perforin (D)-, and granulosyn (E)



Effect of phytoncide exposure on urinary noradrenaline:



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