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Research Article

Effect of Forest-Based Health and Wellness on Sleep Quality of Middle-Aged People

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To explore the effect of forest-based health and wellness experiences on sleep quality for middle-aged people, we observed 12 healthy volunteers, aged 35–39 years, for three days and two nights during "forest bathing." Huawei honor-4 bracelets were used to continuously monitor their exercise and sleep patterns. After the forest-based health and wellness experience, the average sleep score of the volunteers increased by 6 points, and the length of night sleep increased by 1.6 hours. The proportion of deep sleep increased by 3%, the proportion of rapid eye movement increased by 1%, and the proportion of shallow sleep decreased by 4%. Overall, sleep quality was improved; however, this was not sustained. The effects of forest-based health and wellness experience on the sleep indicators showed both individual and gender differences; sleep quality generally improved better for females than males.

1. Introduction

The term "forest-based health and wellness" was first coined in China but has not yet been universally adopted or defined. Similar concepts are found in the United States (with the same term), "forest medical treatment" in Germany, and "forest bathing" in Japan. What they have in common is to harness natural resources and environment of the forest to promote the maintenance of physical and mental well-being. In China, it is believed that forest-based health and wellness primarily nourish the body, mind, temperament, wisdom, and morality [1]. With the rapid economic and societal development and the continuous changes in human civilization, the benefit of forest resources and environment on the human health has attracted increasing attention.

The National Bureau of Statistics of China has determined that the standard age range for middle-aged people is 35–60 years. As the dominant workforce age, the quality of sleep of the middle-aged has been shown to be lower than that of other age groups due to social and familial responsibilities [2]. One-third of a person's life is spent sleeping; therefore, quality of sleep can have a direct impact on human health. Good sleep can regulate physiological functions and maintain nervous system balance [3]. Studies have shown that forest-based health and wellness are effective as human health care and adequate sleep is an important factor in maintaining immune function [4].

Forest experiences can affect sleep. Compared with the pre-trip period, sleeping time during the forest bathing trip has been shown to increase significantly [4]. The effect of forest bathing on improving sleep quality in military pilots was significant and superior to conventional convalescence [5]. After adding forest bathing measures to the traditional recuperation program, the sleep quality index and the satisfaction rate of nursing caregivers were significantly improved [6].

The diet and accommodation for this study were arranged in Yueman forest-based health and wellness base in Wencheng County, which is a demonstration base in Wenzhou City. Through continuous monitoring of exercise, heart rate, and sleep data of the volunteers, the effect of forest-based health and wellness experience activities on sleep changes among middle-aged volunteers was measured. The purpose of this

Table 1: Basic statistics of the volunteers.

Sex	Number	Age (year)		Height (cm)		Weight (kg)		BMI index	
		Range	Average	Range	Average	Range	Average	Range	Average
Male	5	37–39	38	169.5–184.5	178.5	61.6–87.0	74.8	19.1–25.6	23.5
Female	7	35–39	37	151.0–172.5	161.4	45.3–72.9	58.0	19.4–24.5	22.3
Average	12	35–39	37	151.0–184.5	168.5	45.3–87.0	65.0	19.1–25.6	22.8

study was to provide a scientific basis for the enhancing the development and rational utilization of forest-based health and wellness resources in Wencheng County and promoting the development of this wellness industry.

2. Research Methods

2.1. Introduction of Volunteers. Five healthy middle-aged men and seven women were selected as volunteers, aged between 35 and 39 years (average 37 years), height range: 151.0–184.5 cm (average 168.5 cm), weight range 45.3–87.0 kg (average 65.0 kg), and BMI range 19.1–25.6 (average 22.8) (Table 1).

2.2. Experimental Design. In Wencheng County, Wenzhou, Zhejiang Province, a 3-day/2-night forest-based health and wellness experience study was conducted. Wencheng County is located in the mountainous area of southern Zhejiang Province of China. Its geographic coordinates are 119°46′–120°15′E, 27°34′–57°59′N. Wencheng County boundary has subtropical marine monsoon climate, forest coverage rate is 71.5%, annual average temperature is 14–18.5°C, and perennial frost-free period is 285 days.

The volunteers used Huawei Glory-4 bracelets to monitor their sleep patterns and daily exercise. A forest walk was arranged on the afternoon of the first day; a forest walk, a lotus watch, a visit to Liu Bowen's hometown, and a forest hot spring bath were arranged on the second day; a forest walk was arranged on the morning of the third day. Commitment and informed consent of family members were obtained from all volunteers. During the experiment period, the volunteers were confirmed healthy without any discomfort and did not take any drugs. To set up the controls and study, the sustainability of forest-based health and wellness experience, all measurements were made one week prior to (30 June–5 July 2019) and after (9–15 July 2019) the experience. The first day of the experiment (6 July 2019) serves as the buffer adaptation stage, and the data were collected from the second day (7 July 2019). This study was approved by the ethics committee of Dian Diagnostic.

2.3. Statistical Analysis. WPS Office 2022 was used for data calculation and mapping. Differences in sleep score, sleep continuity, and sleep ratio at different stages were tested by paired t-test with SPSS Statistics version 17.

3. Results

3.1. Sports Situation

3.1.1. The Influence on the Number of Exercise Steps. During the forest-based health and wellness experience, the number of exercise steps of 12 volunteers increased. There was an average increase of 5444 steps compared with the previous week—a significant difference between before and after the experience ($P < 0.01$). In the week after the experience, the number of exercise steps of the volunteers decreased by an average of 6944, as compared with that of the healthy experiencing activities.

3.1.2. Influence on the Distance. During the forest-based health and wellness experience period, the distance walked by 12 experimenters increased by 4.23 km on average compared with the previous week. The distance walked during forest-based health and wellness experience was significantly different from before to after the experience ($P < 0.01$). One week after the experience, the distance covered by the volunteer decreased by an average of 5.31 km compared with the period of forest-based health and wellness experience.

3.1.3. The Influence of Exercise Calories. During the forest-based health and wellness experience period, the exercise calories of the volunteers increased, and the average exercise calories of volunteers increased by 220 kilocalories compared with the week before recuperation. The exercise calories during forest-based health and wellness experience were significantly different from before to after the experience ($P < 0.01$). One week after the experience, the volunteer's exercise calories were recorded as 264 kilocalories less than that during the recreational experience (Table 2).

3.2. The Effect on the Heart Rate of the Volunteers

3.2.1. The Effect on the Minimum Heart Rate. During the forest-based health and wellness experience period, the minimum heart rate of the volunteers increased by an average of 6.5 beats per minute, compared with the previous week, and 83.33% of their volunteers' minimum heart rate was increased. In the week after the experience, the minimum heart rate of the volunteers' decreased by an average of 6.7 beats per minute. The minimum heart rate during the experience period was significantly different from that before ($P < 0.05$) to after ($P < 0.01$).

3.2.2. The Effect on the Maximum Heart Rate. During the experience period, the maximum heart rate of the volunteers decreased by an average of 8.6 beats per minute compared with the previous week, and 66.67% of the volunteers had a decrease in their maximum heart rate. The maximum heart rate of the volunteers increased by average 6.8 beats per minute in the week after the experience, compared with the period during the experience. There was no significant

Table 2: Survey of volunteers' sports.

Sex	Stage	Steps	Distance (km)	Heat (kcal)
Total	Before	9017.5 ± 2520.2	6.6 ± 2.0	281.8 ± 134.3
	During	14462.0 ± 4759.7	10.9 ± 4.2	502.2 ± 342.3
	After	7518.4 ± 2411.7	5.5 ± 1.9	238.4 ± 151.1
Male	Before	11084.8 ± 918.0	8.4 ± 1.3	410.0 ± 81.5
	During	18773.8 ± 5102.4	14.6 ± 5.1	815.5 ± 359.7
	After	9500.6 ± 1650.5	7.2 ± 1.5	367.4 ± 149.4
Female	Before	7540.9 ± 2231.0	5.3 ± 1.3	190.1 ± 71.7
	During	12220.7 ± 2553.8	9.0 ± 1.8	354.9 ± 201.5
	After	6102.6 ± 1798.5	4.3 ± 1.2	146.3 ± 56.4

Table 3: Heart rate profile of volunteers.

Sex	Stage	Minimum heart rate	Maximum heart rate	Resting heart rate
Total	Before	45.0 ± 7.7	145.1 ± 21.3	66.0 ± 4.5
	During	51.5 ± 6.1	136.5 ± 14.4	65.7 ± 5.3
	After	44.8 ± 4.7	143.3 ± 16.8	65.8 ± 4.6
Male	Before	45.0 ± 3.4	137.8 ± 20.1	66.3 ± 4.0
	During	47.2 ± 6.9	142.6 ± 19.5	62.6 ± 4.3
	After	43.4 ± 5.9	154.4 ± 20.8	65.4 ± 4.8
Female	Before	45.0 ± 9.6	149.3 ± 22.3	65.9 ± 5.0
	During	54.6 ± 3.3	132.1 ± 8.5	67.9 ± 5.2
	After	45.9 ± 3.8	135.4 ± 7.5	66.0 ± 4.7

difference in the maximum heart rate between stages ($P > 0.05$).

3.2.3. The Effect on Resting Heart Rate. Compared with the previous week, the resting heart rate during forest-based health and wellness experience period increased by 50% and decreased by 50%. There were differences in the effects of forest-based health and wellness on the resting heart rate between different volunteers; however, there was no significant difference in resting heart rate among the three stages ($P > 0.05$) (Table 3).

3.3. Effect on Sleep Patterns of the Volunteers

3.3.1. The Effect on Sleep Score. During the forest-based health and wellness experience period, 83.33% of the volunteers had higher sleep scores than the previous week, while two had lower sleep scores. According to the survey (Figure 1), two volunteers had difficulties during the recreational experience activities, and the decreased mood may have affected their sleep quality of that night. The average sleep score of the volunteers was increased by 6 points, 3 points in males, and 7 points in females. One week after the experience, the sleep score of male and female volunteers was 5 points lower than that during the experience, and 83.33% of the volunteers had lower sleep scores. The sleep scores of the volunteers during the experience were very significantly different from those before and after the experience ($P < 0.01$). There was no significant difference in the sleep scores of the volunteers before and after the experience ($P > 0.05$). The high sleep quality during the experience did not last after the experience, and the improvement of sleep quality was not sustainable.

3.3.2. The Effect on Night Sleep Length. During the forest-based health and wellness experience period, the night sleep length of males increased by 1.4 hours and that of female by 1.8 hours, with an a (Figure 2); the night sleep length increased rate was higher in females than that in males. One week after the experience, the length of sleep at night of all the volunteers was lower than that of the experience period, with a decrease of 1.5 hours in males and 0.9 hours in females. Overall, an average decrease of 1.1 hours was noted for all the volunteers, and the decrease rate of females

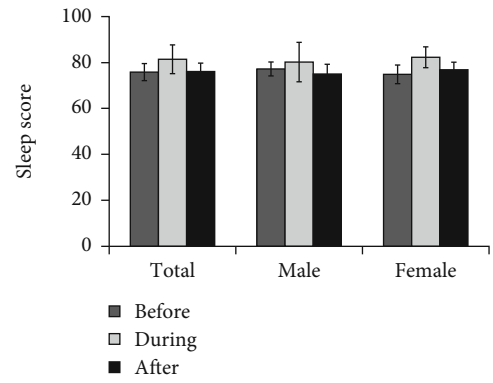

Figure 1: Comparison of sleep scores among experimental stages by gender.

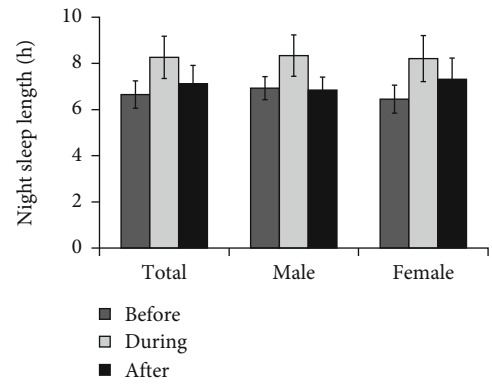

Figure 2: Comparison of night sleep length among experimental stages by gender.

was less than that of the males. The night sleep length of the volunteers in the forest-based health and wellness experience was significantly different from those before and after the experience ($P < 0.01$), but there was no significant difference in the length of night sleep among volunteers before and after the experience ($P > 0.05$). The effect of forest-based health and wellness experience on night sleep length did not persist, and it decreased to the same level as before the experience. However, the effect of forest-based health and

wellness experience on night sleep length of female was better than that of males.

3.3.3. The Effect on Sleep Continuity. During the forest recreation experience period, the sleep continuity average score in males was 2 points lower than that of the previous week, while that in females was 5 points higher. Among them, 50% of the volunteers' sleep continuity scores increased, while that of other 50% decreased, showing significant differences between the individuals. One week after the experience, the sleep continuity score of males increased by average of 2 points, while that of females decreased by 6 points on average. Among them, 66.67% of the volunteers had lower sleep continuity scores while 33.33% of the volunteers had higher sleep continuity scores (Figure 3); forest-based health and wellness experiences have opposite effects on sleep continuity on male and female volunteers. The improvement effect of female sleep continuity was better than among males. Although the scores of sleep continuity in forest-based health and wellness experience were different from those before and after the experience, this difference was not statistically significant ($P > 0.05$).

3.3.4. The Effect on Sleep Ratio. The deep sleep stage is that of fully resting and has a powerful effect to eliminate fatigue (Table 4). Generally speaking, the higher the proportion of deep sleep, the better the quality of sleep. Shallow sleep is also a normal physiological need, but if the proportion of shallow sleep is too high, sleep quality deteriorates. Maintaining normal rapid eye movement (REM) is especially important for mental health, which helps to increase creativity and relieve stress.

In the forest-based health and wellness experience, the proportion of deep sleep of the experiencer increased by an average of 3% in two male and four female volunteers. The proportion of volunteers' REM increased by an average of 1% in four males and five females. The proportion of shallow sleep in the volunteers decreased by an average of 4% in three males and four females.

After the experience, the proportion of deep sleep of the volunteers decreased by an average of 4% in two males and four females. The proportion of volunteers' REM decreased by an average of 2% in three males decreased by two with unchanged patterns, and five females decreased by one with unchanged patterns. The proportion of shallow sleep in the volunteers increased by an average of 6% in three males and six females (Figure 4).

The proportion of deep sleep and REM of the volunteers in the forest-based health and wellness experience showed no significant difference from before to after the experience ($P > 0.05$). During the experience, the proportion of shallow sleep was significantly different from those before and after the experience ($P < 0.05$). However, there was no significant difference in the proportion of shallow sleep before and after experiencing forest bathing ($P > 0.05$). Compared with pre-experience and postexperience, the proportion of deep sleep and REM in forest-based health and wellness experience increased, while the proportion of shallow sleep decreased. Of the three phases (before, during, and after the experience), sleep proportion was best during the experience and played a positive role in improving overall sleep quality. The proportion of shallow sleep in the experience did not last after the experience, and the effect of reducing the proportion of shallow sleep was not sustained.

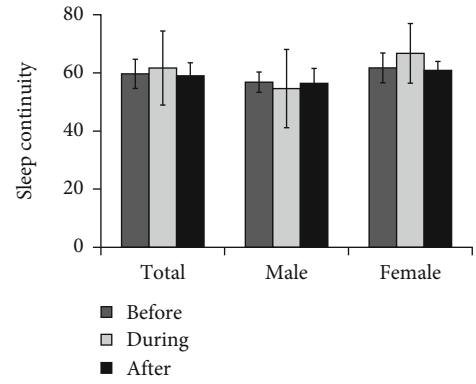

Figure 3: Comparison of sleep continuity at different experimental stages by gender.

Table 4: Normal reference value of the sleep ratio.

Category	Ratio (%)
Deep sleep	20–60
Shallow sleep	<55
REM	10–30

4. Discussion

Sleep disturbance is a quite common within the general population, particularly as society modernizes. It is important to improve sleep quality among those who complain of sleep difficulties. Concrete and practical methods to improve sleep that are applicable in daily life are increasingly necessary. Forest walking and experiences are thought to contribute to improving sleep quality among such people. Exercise and emotional improvement initiated by walking in forested areas may bring both increased sleeping hours and improved sleep quality [7].

During this forest-based health and wellness experience, the number of exercise steps and energy expenditure increased, which appeared to help improve sleep time. In our study, the length of night sleep time increased by 1.6 hours, which is longer than an earlier study showing an increase by 30 min after forest experience [8]. Sleep time has a weak relationship with exercise [4]. An earlier study showed that a decrease in arm immobilization slows wave activity in subsequent sleep; slow wave activity is thought to reflect sleep needs [9]. Exercise may elevate core body temperature. A steep decline of core body temperature before nocturnal sleep has been reported to induce sleep [10].

A green environment has been reported to have beneficial effects on human health. Forest walking and presence in a natural environment may improve sleep quality because

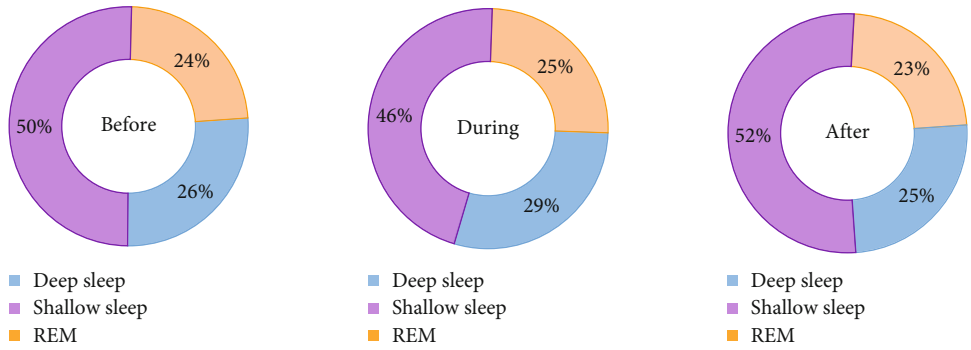

Figure 4: Comparison of sleep ratios at different stages of forest experience.

of its benefits on stress reduction and involvement of the physical exercise [7]. Healthy stimulation of the five senses in the forest, forest oils such as phytoncide, circadian-rhythm recovery through a regular sleep–wake cycle, timed exercise, and healthy diet and meals provided during forest therapy could be considered as relevant contributing factors [8]. The negative oxygen ion in air has a regulating effect on autonomic nervous system and high-level central nervous system, thus effectively improving the function of cerebral cortex, eliminating fatigue, and improving the work efficiency. It has a further, positive effect on improving sleep and neurasthenia [11]. There are variable conclusions on the effects of natural killer cells on sleep time [12–16].

During the forest-based health and wellness experience, a hot spring bath can eliminate fatigue and play a role in improving the sleep quality. Two volunteers who had a quarrel had lower sleep quality scores, so sleep improvement may depend on not only exercise but also on psychological factors.

Our study designed in this preliminary investigation had some limitations that could be overcome in future studies. These include a small number of participants, the absence of a control group, and its short duration (three days and two nights). The improvement of sleep quality was the result of multiple, combined factors, and our design prevented us from distinguishing them.

5. Conclusion

By means of the experience, the positive effects of forest-based health and wellness on sleep quality of middle-aged people were further confirmed. The outcomes could be summarized as increasing the length of night sleep, increasing the proportion of deep sleep and REM, improving the sleep score and quality, and reducing the proportion of shallow sleep. The effect of improving the quality of sleep was greater in females than males, so forest bathing showed a beneficial effect on sleep. In order to better understand the internal mechanism, the environmental background such as ambient air quality and plant essence should be taken into account in future research.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

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