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A randomized, double-blind, placebo-controlled study on the improvement of sleep quality with Earthing mat

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ABSTRACT

Earthing is a therapeutic technique that involves "grounding" activities. The body reconnects electrically to the Earth. Sleep is very important for physical, mental, and emotional well-being. Sleep and stress are known to be interrelated, but limited research has been conducted to investigate the interaction between them over a long period of time. Existing studies presented sleep quality predictions by focusing on single qualitative aspects of sleep, such as sleep efficiency. This study was evaluated in a pilot study conducted to test the hypothesis that grounding the human body to earth during sleep will result in quantifiable changes and sleep quality. Sixty eligible participants were assigned to the control or experimental group by computer randomization. Instructions were provided to take a test mat, a grounding mat (Experimental group), or a non-grounding mat (Control group) for 6 h/day for 31 days. We used the Pittsburgh sleep quality index (PSQI), Epworth sleep scale (ESS), brief interact psychosocial instrument (BEPSI), and insomnia severity index (ISI) and actigraph for total sleep time to evaluate sleep quality and stress response, respectively, on days 0 (pre-test), 31 (post-test) and 38 (follow-up test). PSQI, IS, ESS, and BEPSI scores were significantly improved in the Experimental group ($P < 0.05$; pre-test vs. post-test). Also, total sleep time in the Experimental group was significantly increased compared to the Control group ($P < 0.05$). In the follow-up study (on day 38), the Experimental group showed a significant improvement in ISI scores compared to the Control group ($P < 0.05$). Taken together, our findings showed that earthing mats reduced stress, insomnia severity, and daytime sleepiness compared to before use. These results contribute to the beneficial effect of earthing mat on increasing sleep quality.

1. Introduction

Sleep is very important for the health of not only the entire human body but also each organ and system. A good night's sleep improves brain function, mood, and health. Despite the important role that sleep plays in maintaining and promoting physical and mental health, many people do not get enough sleep or suffer from sleep disorders [1]. In modern life, sleep deprivation is caused by occupation, social demands, psychological problems, physical disabilities, sleep disorders, etc. Short sleep duration or poor sleep quality affects not only physical health but also mental health [2]. Sleep disorders include sleep apnea, circadian rhythm disorders, insomnia, and sleep disorders caused by lifestyle habits, environmental factors, and other diseases can cause serious morbidity [3,4]. There are many medications to treat sleep disorders, but they do not apply to all patients. Therefore, researchers studied various methods to improve sleep quality, but few good methods other than drug treatment can be found.

Earthing includes basic activities such as walking barefoot outdoors and/or barefoot indoors, working, sleeping [5]. The Earthing hypothesis is that the Earth's subtle negative electric surface charge is equal to the Earth's electric potential [5,6]. The Earth's negative surface charge consists of a virtually infinite reservoir of free electrons that is constantly

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replenished by the Earth's atmospheric electrical circuit [7,8]. A recent pilot study found that facial blood flow was improved, and autonomic regulation of peripheral circulation was enhanced within one hour [9]. Our previous study reported that grounding mats reduced stress-related responses through modulation of corticotrophinergic system [10]. Another study proved that the findings, grounding the human body to the earth during sleep reduces nightly cortisol levels and resynchronizes cortisol secretion to better match the natural 24-h circadian rhythms. In particular, the effects were most pronounced in females. Furthermore, subjective reports have shown that grounding the human body during sleep improves sleep and reduces pain and stress [11]. Also, another pilot project reported that one hour of earthing statistically significantly improved pleasant and positive moods. Although earthing has many positive effects, there are no studies on the benefits of grounding in the sleep quality. The present study was conducted to evaluate the effect of an earthing mat on improving sleep quality in healthy participants and to elucidate the mechanisms underlying this effect in humans.

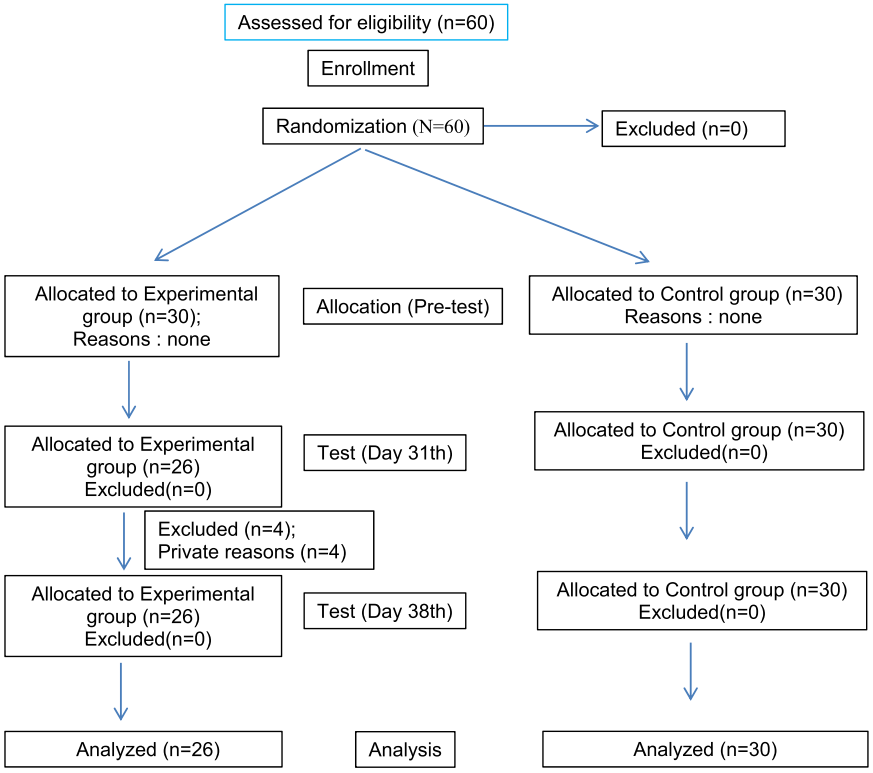
2. Materials and methods

2.1. Participants

All participants provided signed informed consent prior to the experiment. Participants' responses were treated confidentially and anonymously. Sixty participants participated in the study. Three participants were not included in the analysis due to either not completing the experiment or failure to follow instructions. The final group included in the analysis consisted of 56 participants (control group (n = 26) and experimental group (n = 30)) (Table 1A–B). This study was approved from the institutional review board of Kyung Hee University (KHSIRB-22–546). Candidates were asked to complete the Pittsburgh Sleep Quality Index (PSQI) during their first visit while waiting. Index score of $\geq$ 5 is considered to be within normal range.

Table 1
A) Study Flow Chart, B) Experimental procedure.

A) Study Flow Chart



B) Experimental procedure

Step	Screening	Treatment		
No. of visit	1	2	3	4
Time	Baseline (Day 0)	(Day 14th)	(Day 31th)	(Day 38th)
Written consent	O			
Preliminary test	O			
History taking (disease, drug)	O			
Pittsburgh Sleep Quality Index (PSQI)	O			
Inclusion/exclusion criteria	O			
Randomization	O			
Epworth Sleepness Scale (ESS)	O		O	O
Brief Interact Psychosocial Instrument (BEPSI)	O		O	O
Insomnia Severity Index (ISI)	O		O	O
Actigraph	O		O	O
Compliance check	O	O	O	O
Adverse reaction check	O	O	O	O

2.2. Study design

2.2.1. Randomization and blinding

Participants were randomly assigned a subject number. Numbered packets were arranged to counterbalance the order of Earthing mats and non-earthing mats assigned to participants. However, participants and researchers did not know which tablet an individual would receive (double-blind design). Earthing mats and non-earthing mats are packaged similarly. Coding files were kept confidential until the end of the study. Testing was completed before the first session (baseline) and participants were provided with a 3-week mat. Participants were contacted by phone approximately 2–4 weeks after the trial period to encourage compliance. A second testing session was conducted approximately four weeks later, at which time participants were instructed not to use the mat.

2.2.2. Earthing mat and non-earthing mat

The earthing mat was provided by the World Home Dr. Company (Anyang City, Kyunggido, Republic of Korea). The earthing mat system consists of cotton sheet, and electric emission plate is connected to a ground port of an electrical outlet [10]. The grounding port helps reconnect the conductive participants' bodies to the Earth's natural and subtle surface electric charge. Instructions were given to take the trial mat over 6 h/ day, earthing mat (Experimental group) or non-earthing mat (Control group) (Table 2).

2.2.3. Efficacy measurements

All assessments were performed by an experienced Korean medicine doctor and clinical research coordinators. The therapeutic responses were measured by using the scales as follows.

2.2.3.1. The Insomnia Severity Index (ISI). The Insomnia Severity Index (ISI) is a 7-item questionnaire measuring the severity of insomnia symptoms over a 2-week period, with each item scored on a 5-point scale (response range 0–4). The ISI is scored on a continuous scale with higher scores indicating more severe insomnia symptoms. Validated cutoff scores for insomnia detection vary from 8 to 14, with an abnormal insomnia cutoff severity cutoff score of 8 or higher as used previously [12].

2.2.3.2. The Pittsburgh Sleep Quality Index (PSQI). The Pittsburgh Sleep Quality Index (PSQI) was developed by Daniel J. Buysse and collaborators to measure quality of sleep quality and help distinguish between people who experience sleep deprivation and those who sleep well. The scale consists of two parts: 19 self-rate questions, and 5 questions rated by the bed partner. The scale may be given by a clinician or research assistant. Most items consist of multiple choices questions and are short and easy to understand and answer. PSQI questions are rated from 0 = no difficulty to 3 = severe difficulty, producing scores that correspond to areas of the scale. Scores range from 0 to 21, and the authors suggest that a score of 5 or higher be considered a significant sleep disorder [13].

2.2.3.3. Epworth Sleepiness Scale (ESS). Participants' subjective sleepiness was measured with the Epworth Sleepness Scale (ESS). The ESS is a method of eight items, each scored on a scale of severity from 0 to 3, giving each subject a total score between 0 and 24 to differentiate individuals in their level of daytime sleepiness. An ESS score > 10 may reflect sleepiness and consultation with a sleep medicine specialist to diagnose and treat possible causes of drowsiness [14].

2.2.3.4. Brief Interact Psychosocial Instrument (BEPSI). Participants' stress levels were measured by the Brief Interact Psychosocial Instrument (BEPSI) Korean version [15]. This scale measures the participant's level of stress with five questions on a 5-point Likert scale [16].

2.2.3.5. Amount of sleep. Physical activity, sedentary behavior, and sleep were measured using an ActiGraph wGT3X BT® (ActiGraph, Pensacola, FL). Participants were asked to wear the ActiGraph wGT3X BT® continuously for 24 h, taking it off only during water-related activities (e.g., showering). The ActiGraph wGT3X BT® was placed on the right side, at lumbar level, midmaxillary line, and iliac crest. Data was downloaded from the accelerometer in epochs of 60 s using Actillife 6.13.4® software (Pensacola, FL, USA). This study utilized sleep time and wake time data expressed in minutes [17].

2.3. Statistical analysis

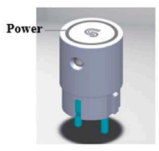
All data analyzed intention to treat analysis (ITT) and last observation carried forward (LOCF). Demographics data were compared between the two groups using an independent *t*-test or paired sample *t*-test. The statistical package for Prism (GraphPad software 8.0, La Jolla, CA, USA) was used for the statistical analyses.

3. Results

3.1. Demographic and baseline demographic characteristics

Three participants were not included in the analysis due to either not completing the experiment or failure to follow instructions. The final group included in the analysis consisted of 56 participants (control group (n = 26) and experimental group (n = 30)). As shown in Table 3, the control and experimental group were not significantly different in terms of gender and age distribution.

Table 2
Differences in composition between grounded mats and non-grounded mats.

	earthing mat	non-earthing mat
G-plug	Green light	Red light
		

It is equipped with a varistor, a component to prevent external noise voltage, and basically has a discharge resistor to prevent electric shock. The LED lights up (pulse voltage state) through an internal bridge diode inside the product. In this case, it must be grounded for normal operation. When there is no grounding, the LIGHT SENSOR detects this and turns on the RED LED. When AC220V is connected to the product, the voltage is lowered to about AC22V through the condenser and surge protection resistor. When DC 5 V is output, voltage is applied to various touch ICs and logic ICs. There is no MICOM.

Table 3
Baseline demographic.

	Control group (n = 30)	Experimental group (n = 28)
Gender		
Male	12	14
Female	18	14
Age (years)	33.7 ± 3.4	45.5 ± 4.0
Medical history (Memory dysfunction)	none	none

3.2. Questionnaire analysis

3.2.1. Insomnia Severity Index (ISI)

The mean and standard deviation values of the ISI before earthing were 7.6 ± 0.7 and 12 ± 1.2 in the control group and experimental group, respectively, with statistically significant difference ($P < 0.001$). After earthing for 30 days, the score of ISI in the control group was 5.83 ± 0.6, and that in the experimental group was 6.9 ± 1.1, without statistically significant difference ($P = 0.275$). However, as shown in Fig. 1 (A), the ISI-K evaluation index, there was a significant difference between the two groups on day 38 ($P < 0.05$ $t = 2.6$). After not using the mat for 7 days, the ISI-K index results showed a slight increase in the experimental group ($P < 0.05$, t=2.6).

3.2.2. The Pittsburgh Sleep Quality Index (PSQI)

The mean and standard deviation values of the PSQI before earthing were 8.3 ± 0.6 and 9.4 ± 0.7 in the control group and experimental group, respectively, without statistically significant difference ($P = 0.226$). After earthing for 30 days, the score of PSQI in the control group was 5.7 ± 0.5, and that in the experimental group was 6.3 ± 0.8, without statistically significant difference ($P = 0.562$). However, as shown in Fig. 1 (B), the PSQI score was no significant difference in the comparison between the two groups. However, after not using the mat for 7 days and visiting on day 38, the PSQI index results tended to slightly increase in the experimental group.

3.2.3. Epworth Sleepness Scale (ESS)

The mean and standard deviation values of the ESS before earthing were 9.1 ± 0.7 and 8.7 ± 0.8 in the control group and experimental group, respectively, without statistically significant difference ($P = 0.690$). After earthing for 30 days, the score of ESS in the control group was 6.8 ± 0.6, and that in the experimental group was 6.8 ± 0.6, without statistically significant difference ($P = 0.962$). However, after not using the mat for 7 days, the ESS index results did not change in these two groups (Fig. 1(C)).

3.2.4. Brief Interact Psychosocial Instrument (BEPSI)

The mean and standard deviation values of the BEPSI before earthing were 1.6 ± 0.1 and 2.0 ± 0.2 in the control group and experimental group, respectively, without statistically significant difference ($P < 0.05$). After earthing for 30 days, the score of BEPSI in the control group was 1.4 ± 0.1, and that in the experimental group was 1.5 ± 0.1, without statistically significant difference ($P = 0.756$). However, after not using the mat for 7 days, the BEPSI index results tended to slightly increase in the experimental group (Fig. 1(D)).

3.2.5. Amount of sleep

As shown in Fig. 2, the actigraph evaluation index, there was a significant difference between the two groups on day 31 (Day 38: $P < 0.01$, $t = 3.5$). However, after using the earthing mat for 30 days, sleep time significantly increased in the experimental group compared to the control group ($P < 0.01$).

4. Discussion

The main finding of the present study demonstrated that earthing

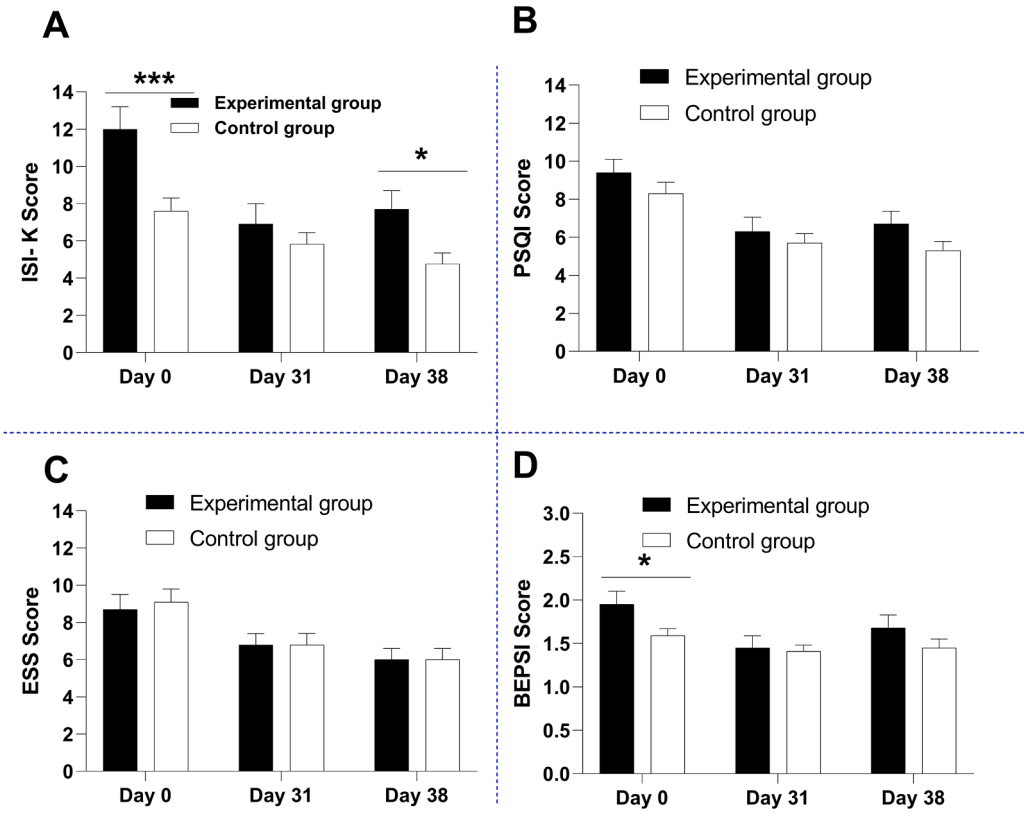


Fig. 1. Analysis of questionnaire data. (A) ISI-K, (B) PSQI, (C) ESS score and (D) BEPSI score. Data are presented as standard errors of mean. * Significant difference between the Experimental group and Control group.

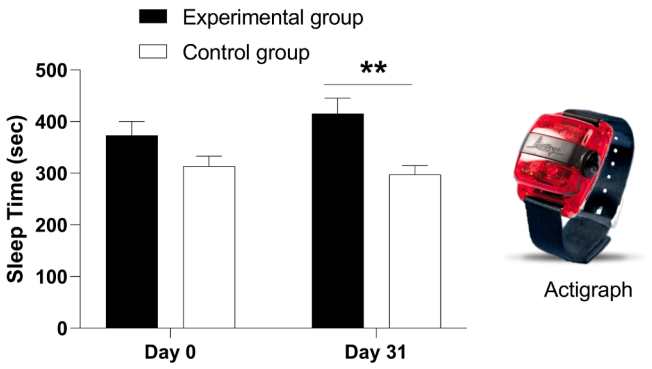


Fig. 2. Changes in the total sleep time over time. * Significant difference between the Experimental group and Control group. Data are presented as standard errors of mean.

mats reduced stress, insomnia severity, and daytime sleepiness compared to before use. However, earthing had no positive effect on *Epworth Sleepiness Scale* in the present study.

Sleep disorder is a very prevalent condition and has a significant burden in terms of dysfunction, healthcare costs, and an increased risk of depression [18]. Despite its high prevalence and significant morbidity, insomnia often remains unrecognized and untreated, in part due to multiple barriers to assessment [19]. Assessment of insomnia should be multidimensional and ideally include a clinical assessment, supplemented by daily sleep diaries and self-report questionnaires. Some of the most widely used tools for this purpose include, for example, the Insomnia Severity Index (ISI) [20–22], the Pittsburgh Sleep Quality Index (PSQI) [23–25], Epworth Sleepness Scale (ESS) [26,27], and the Brief Interact Psychosocial Instrument (BEPSI) [28]. Present results showed that earthing mats reduced stress response, insomnia severity, and daytime sleepiness compared to before use. Total ISI scores were positively correlated with subjective sleep estimates and PSQI total scores, indicating good convergence validity. Also, PSQI, ISI, ESS, and BEPSI scores were significantly improved in the Experimental group (pre-test vs. post-test). Also, after using the earthing mat for 30 days, total sleep time tended to slightly increase in the experimental group, but there was no change in the control group. These findings are consistent with several studies that show a strong association between insomnia and psychological symptoms and fatigue. These results contribute to the beneficial effect of increasing sleep quality.

Grounding, also called earth, is a technique used by some people to connect their physical bodies to the electrical energy of the earth [8,29,30]. Planet Earth has a negative charge. Some scientists have theorized that free electrons are transferred to the human body during grounding [9,10,31,32]. Earth exploration research provides insight into the stability of internal bioelectrical functions and the clinical potential of barefoot contact with the Earth barefoot or simulated indoors via a simple conductive system [33]. The goal of grounding is to restore the electrical connection with the Earth. Especially for people with chronic health disorders, the equipment is easy to use and often yields quick results. There are two basic methods of earthing: 1) indoors with an inexpensive earthing system (conductive mats while sitting or sleeping, and 2) free by spending time outdoors barefoot, in its most natural form, and in contact with natural conductive surfaces such as dirt, stones, and sand [5,33]. Sleep quality was markedly improved in the experimental group in our study. Earthing mat therapy improved PSQI, ISI, ESS, and BEPSI scores, total sleep time, and sleep efficiency by regulating the stress response.

The greatest strength of this study is that it is the first study to investigate the effect of ground on sleep quality in normal people. Although the benefits of ground have been found, there are some limitations to this study.

5. Conclusion

Taken together, earthing is beneficial for improving reduced stress, insomnia severity, and daytime sleepiness. These results contribute to increasing sleep time and provide preliminary evidence for the beneficial effect of increasing sleep quality via reducing stress response. Further research is needed to explore the effects of grounding over a longer period, and larger sample sizes of participants are needed.

6. Limitations

In this study, 1) the period of use of the mat was short, and 2) the number of samples was small, so trends could be confirmed through four types of questionnaires and total sleep time analysis. It is expected that meaningful results will be obtained if the research is conducted by changing the conditions in the future.

Ethical statement

Ethical approval was obtained from the institutional review board of Kyung Hee University (KHSIRB-22-546).

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CRediT authorship contribution statement

Lee Gyeong Ran: Data curation. **Park Hyun Jung:** Conceptualization. **Kim Jiyoun:** Conceptualization. **Kim Yongsuk:** Conceptualization. **Kim So Hee:** Data curation. **Sohn Mira:** Data curation. **Rhie Sung Ja:** Data curation. **Shim Insop:** Conceptualization. **Kim Kyu-Ri:** Data curation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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