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Psychological and Physiological Effects of Sleeping Bag-shaped Aluminum Sheets on Night-time Sleep in Winter: A Disaster Medicine Study

Original Research

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Abstract

Objective: This study investigated the psychological and physiological effects of using sleeping bag-shaped aluminum sheets during night-time sleep in winter to reduce cold stimulation and improve the sleeping environment in disaster evacuation shelters.

Methods: Sixteen healthy male participants in Hiroshima City underwent 2 experimental conditions in January and December 2023: night-time sleep in winter with and without a sleeping bag-shaped aluminum sheets. Sleep–wake rhythm during night-time sleep (discriminant analysis method), subjective sleep soundness, mood state profile, heart rate, blood pressure, and cardiac autonomic nervous system modulation were measured. Wilcoxon's signed-rank sum test, Friedman's test, and paired *t*-test were performed.

Results: Thermal sensation of warmth and subjective sleep soundness were significantly greater with than without the aluminum sheets. Total sleep time and sleep efficiency were also significantly greater, whereas the frequency and duration of wakefulness after sleep onset were significantly less. Total mood disturbance, fatigue-inertia, and vivid-activity were significantly different between the control, aluminum sheets, and home conditions. Physiological parameters did not differ significantly.

Conclusions: These data suggest that using sleeping bag-shaped aluminum sheets in disaster evacuation shelters in winter could be effective in improving sleep–wake rhythms and subjective sleep soundness, although negative emotions were not improved.

Japan has been frequently affected by various natural disasters due to its geographical characteristics.[1] Climate change has caused an increase in typhoons, heavy rain, floods, and landslides in recent years.[2] After a serious disaster, many people must live in public evacuation shelters such as school gymnasiums and community centers. The living environments in disaster evacuation shelters are extremely harsh.

Many evacuation drills are conducted aiming at primary evacuation (actions to protect lives in the event of a disaster); for example, training for evacuation behavior in the event of an earthquake occurring during a regular class or movement to a disaster evacuation center when there is flooding. Evacuation drills aimed at secondary evacuation (living in a disaster evacuation center) focus on cooking and eating emergency food, creating and using portable toilets, and securing light in events where lifelines, such as electricity and water supply, are cut off. People are often unable to return to their homes due to house collapse and must live in evacuation shelters for long periods of time.[3] For example, evacuation shelters were opened for 9 months following the Great Hanshin-Awaji Earthquake in 1995.[3]

Poor living environments in disaster evacuation shelters in Japan continue with each serious disaster.[4] The poor environments cause health problems such as insomnia, cardiovascular diseases, and disaster-related deaths.[4] Poor mental health is a major issue. For example, in the aftermath of the 2011 Great East Japan earthquake and tsunami, 13.6% of people without pre-disaster depressive symptoms developed depressive symptoms 2.5 years later.[5] Local governments across Japan have identify the following urgent issues for improving these environments: ensuring privacy (54%), improving sleeping environments (43%), improving toilet facilities (40%), and providing equipment for heating and cooling (32%).[4] Although local governments recognize that improvements in these environments are urgent, little progress, if any, has been made.

Health maintenance after a disaster is an important issue. Deteriorating health status is associated with factors such as reduced access to health care, decreased physical activity, altered diets, and difficulty in sleeping in evacuation shelters.[6,7] Many people in evacuation shelters have reported insomnia symptoms, including difficulty in initiating and maintaining sleep. Sleep plays an important role in mental health, daytime function, and quality of life.[8] Furthermore, difficulty in sleeping causes health problems such as decreased daytime physical activity, lifestyle-related diseases, and mental illnesses such as depression.[9,10] The Evacuation Center Management Guidelines recommend strategies including simple bedding, alleviating cold and heat by providing blankets and ensuring ventilation, and preventing health damage caused by inhaling dust to improve the sleeping environment and prevent venous thromboembolism at disaster evacuation shelters.[11] Although these measures are assumed to have a positive effect on the mental health of evacuees, few studies have examined this relationship in detail. Kamada et al. reported that the introduction of cardboard beds within 7 days and the installation of flush toilets at disaster evacuation shelters are factors that reduce the incidence of deep vein thrombosis.[12] However, few local governments in Japan stockpile cardboard beds,[13] and it is assumed that in many cases in the early stages of evacuation, people will use the items they already have as simple bedding or use portable items as simple bedding. A previous study reported that exercise mats, which are regularly provided in gymnasiums and community centers, are effective as simple bedding when establishing disaster evacuation shelters.[14] However, the study did not evaluate mood scales in disaster evacuation shelters. Furthermore, compared to sleeping at home, the degree of deep sleep, as evaluated using the Visual Analog Scale (VAS), was significantly lower.[14] Moreover, reducing cold stimulation was an issue in winter.[13] Measures have been taken to reduce a cold stimulus, such as using heating, wearing warm clothing, and using aluminum sheets during disaster management.

Aluminum sheets can reduce cold stimulation using the reflection of infrared rays emitted by humans and absorbing radiant heat.[15] Onodera et al. reported that the use of disaster prevention aluminum sheets is effective in preventing hypothermia during winter mountain activities. Their effects include suppressing a decrease in rectal temperature, suppressing the increase in subjective sensation of cold, and reducing physical stress parameters.[16] Because disaster prevention aluminum sheets are commercially available, they may be used in disaster evacuation shelters. This study hypothesized that reducing the cold stimulus using aluminum sheets in disaster evacuation shelters would help to improve the sleep environment. However, knowledge regarding the effects of using aluminum sheets during night-time sleep in winter on physiological and psychological responses is lacking. Therefore, the purpose of the present study was to obtain basic information regarding the use of sleeping bag-shaped aluminum sheets (SB-SAS) in disaster evacuation shelters during winter.

This study focused on an SB-SAS that can be easily transported by evacuees. Specifically, the psychological and physiological effects of using an SB-SAS during night-time sleep were investigated by assessing the sleep–wake rhythm, subjective sleep parameters, emotional profile test (Profile of Mood States, second edition [POMS2]), blood pressure (BP), heart rate (HR), and cardiac autonomic nervous system (ANS) modulation.

Methods

Participants

Sixteen healthy Japanese men (mean age, 21.3 ± 1.2 years; height, 170.3 ± 4.8 cm; body weight, 64.7 ± 6.3 kg; body mass index, 21.3 ± 1.2 kg/m^2; Pittsburgh Sleep Quality Index score, 5.5 ± 2.7; and Morningness–Eveningness Questionnaire score, 56 ± 7) volunteered to participate in the present study. All participants were normotensive, non-obese, non-smokers, non-food allergic, and non-shift workers, with no evidence of cardiovascular disease based on medical history, resting electrocardiogram, self-reported sleep problems, or regular use of medications.

Procedures

The experiments were conducted in January and December 2023. An acclimatization night was set, and the participants rested for 1 night in the same measurement environment as used in this experiment. The participants stayed in this environment from 6:30 pm-7:30 am the next day, in a measurement room resembling the sleep environment of the evacuation shelters: length 8000 × width 6000 × height 2600 mm. The participants were provided with an exercise mat (length 1800 × width 900 × thickness 2 mm) and an emergency blanket (polyester and rayon; length 1800 × width 860 mm), which was spread out on the floor of the measurement room.

This study established 2 experimental conditions: night-time sleep with an SB-SAS (Ishizaki Shizai LTD., Kashihawa, Japan; polyethylene terephthalate and polyethylene; length 1800 × width 860 × thickness 0.045 mm; weight, 145 g) (aluminum-sheets condition) and without the aluminum sheets (control condition). Measurements were conducted with people in pairs in random order, 1 week apart. The lights-out time was from 11 pm to 7 am the next day. The participants ate a specially prepared dinner (899 kcal, 23.0 g protein, 27.7 g fat, 144.0 g carbohydrates, 2.8 g sodium, 425 mg potassium, 267 mg phosphorus, and 10.6 g dietary fiber) at 7:00 pm. They drank the specified commercially available mineral barley tea (650 mL; 0 kcal, 0 g protein, 0 g fat, 0 g carbohydrates, 0.2 g sodium, 3 mg magnesium, 0–0.07 mg zinc, 78 mg potassium, 8 mg phosphorus, 0–0.07 mg manganese, and caffeine-free) to ensure that the conditions were not otherwise biased. The participants were given 10 min to eat their meals and were only allowed to consume the provided food and drinks. On the day of measurements, the participants were not allowed to nap; however, they were instructed to restrict their physical activity to a minimum and spend their time quietly, such as reading a book or attending a lecture while seated. The participants wore long-sleeved shirts and long pants and performed every trial wearing the same clothes. On the day of the experiment, the participants were restricted from ingesting caffeinated drinks and alcohol, and television use was restricted from dinner to the end of lights-out time. The participants were not allowed to use smartphones or talk during the lights-out time. To eliminate the effects of blue light from smartphones, participants were asked to try to sleep even if they were unable to sleep while the lights were off.

The room temperature and relative humidity at the lights-out time were 16.0 ± 1.7°C and 39.8 ± 10.2%, respectively, and those at the lighting time were 12.3 ± 2.2°C and 41.3 ± 7.0%, respectively.

Measurements

The sleep–wake rhythm, subjective soundness of sleep, thermal sensation, comfort sensation, POMS2, HR, cardiac ANS modulation, and BP were measured for each experimental condition. The sleep–wake rhythm was evaluated using a sleep analysis program (Sleep Sign Act ver.2.0 [SSA] software; Kissei Comtec Co., Ltd., Matsumoto, Japan) based on records of physical activity using a small activity meter (FS-770; Acos., LTD., Iida, Japan). The FS-770 was worn on the waist. This device (external dimensions: width 73.8 × heigh 32.8 × depth 10.8 mm; weight, 25 g, including the battery) records the amount of activity using an internal 3-axis accelerometer. The posture can also be determined in 6 directions. Every 0.125 s, the number of times the acceleration exceeded a reference value was summed, and the value was recorded as the amount of activity and posture change over 2-min time-bins. Data were analyzed using the SSA software. To detect the sleeping and awake durations from the FS-770 data, the in-bed and out-of-bed times were manually determined with reference to the subjective napping time reported by the participants. The default settings of SSA were used, with the parameters detected following a previously reported algorithm.[17]

$$z = 0.24669x_{-2} + 0.2562x_{-1} + 0.408771x + 0.155046x_{+1} + 0.136728x_{+2}$$

$z \geq 1$ denotes wake and $z < 1$ denotes sleep. x−2, x−1, x, x+1, and x+2 indicate the activity intensity at 4 min before the evaluation epoch, at 2 min before, at the evaluation epoch, at 2 min after the evaluation epoch, and at 4 min after, respectively.

The evaluation parameters were set as total sleep time (TST), sleep latency (SL), frequency and time of wakefulness after sleep onset (WASO), sleep efficiency (SE), and number of posture changes. The time in bed (TIB) was defined as the recording period, starting at 11:00 pm when the lights were turned off and ending at 7:00 am when the lights were turned on the next morning. TST was defined as the time between the start and end of TIB. This study calculated the sum of the periods in which participants were judged to have fallen asleep. SL was defined as the interval between changing posture from standing to lying down and the start of the sleep episode. SE was defined as the percentage of TST for TIB. The time or frequency of WASO was defined as the amount of time or frequency of being awake during the interval between sleep onset and offset.

The subjective soundness of sleep, thermal sensation, and comfort sensation were examined using VAS. The subjective soundness of sleep was evaluated using a recording sheet with a 100-mm-long numbered line, with “0: very bad sleep” written on the far left end, “50: normal” in the center, and “100: very good sleep” on the far right end. The thermal sensation was evaluated using a recording sheet with “0: very cold” on the left end, “50: normal” in the center, and “100: very warm” on the right end. The comfort sensation was evaluated using a recording sheet with the far left end marked as “0: very uncomfortable,” the center as “50: normal,” and the right side as “100: very comfortable.” The participants answered questions about these subjective parameters immediately after awakening.

Mood state was examined using POMS2.[18,19] Although POMS2 is a descriptive questionnaire that conventionally determines the mood state for approximately the previous week, in the present study, the participants were asked to assess their mood state after waking. POMS2 comprises 35 questions, with answers that range in 5 stages from “not at all” to “extremely.”[20] The “feeling condition” was measured according to the following 6 scales: A-H was defined as anger–hostility, with higher scores indicating increased anger. C-B was defined as confusion–bewilderment, with higher scores indicating increased confusion and less thought. D-D was defined as depression–dejection, with higher scores indicating an increased loss of confidence. F-I was defined as fatigue–inertia, with higher score indicating an increased feeling of tiredness. T-A was defined as tension–anxiety, with a higher score indicating that the participant felt more nervous. V-A was defined as vivid activity. As this item was positive, unlike the other 5 scales, a lower score indicated a loss of activity. F was defined as friendly. Total Mood Disturbance (TMD) was also calculated. This is a comprehensive expression of negative mood states, calculated using the following formula: TMD = A-H + C-B + D-D + F-I + T-A – V-A. The higher the main score, the more negative the mood. The participants completed POMS2 at 7:15 am (15 min after waking up). The participants were also asked to complete POMS2 15 min after waking up at home on days other than the measurement day for psychological evaluation after sleeping at home (home condition).

HR was defined as the number of R waves in 1 min on electrocardiogram waveforms, which were obtained using bipolar chest leads (LRR-033 memory HR monitor; Arm Electronics, Tokyo, Japan), and was recorded over the sleep time (8 h), with the mean value recorded for analysis.

Cardiac ANS modulation was measured by the maximum entropy calculation method (MemCalc) using the MemCalc/Tarawa software system for real-time analysis of HR fluctuations (GMS, Tokyo, Japan). The electrocardiogram data obtained and amplified from the bipolar chest leads were digitized using a 12-bit analog-to-digital converter (AD12-8 [PM]; Contec, Qinhuangdao, China) and loaded onto a personal computer (IBM, Armonk, NY, USA) running Microsoft Windows. Through this system, the frequency analysis of R-R interval variability over the last 30 s was performed with MemCalc, wherein the power of the low frequency (LF; 0.04–0.15 Hz) and high frequency (HF; 0.15–0.40 Hz) bands of the HR variability spectrum was calculated, based on a previous study.[21]

In addition, the HF component, which was converted to a natural logarithm (ln HF) to ensure a normal distribution, was used to indicate the level of cardiovascular parasympathetic nervous system activity.[22,23] Total power was defined as the sum of the LF and HF bands. The LH/HF ratio was defined as the ratio obtained by dividing the HF band by the LF band. The LF/HF ratio was used to indicate the level of cardiovascular parasympathetic nervous system activity. These parameters were recorded over the sleep time (8 h), and the mean value was recorded for analysis.

BP was measured using a portable automatic sphygmomanometer (TM-2433; A&D Co. Ltd. Tokyo, Japan) at the upper arm. Measurements were taken every 30 min from 11 pm to 7 am, and an analysis terminal for sphygmomanometers (TM-2485; A&D Co., Ltd. Tokyo, Japan) was used for analysis. Systolic BP, diastolic BP, and pulse pressure were evaluated, and the mean values were recorded for analysis.

Statistical Analysis

The subjective soundness of sleep and thermal and comfort sensation were ordinal variables expressed as the median (interquartile range). Wilcoxon’s signed-rank sum test was performed to compare the control and aluminum-sheets conditions. Additionally, the effect size and power analysis were calculated. Friedman’s test was performed to compare the POMS scores under the control, aluminum-sheets, and home conditions. For evaluation parameters for which significant differences were observed, the Wilcoxon signed-rank sum test was performed for multiple comparisons using Ryan’s method. Because the other parameters were continuous variables, Kolmogorov–Smirnov normality tests were performed. The data for SL, total power, and LF/HF ratio were not confirmed to have a normal distribution. Therefore, data are expressed as median (interquartile range) and were compared between groups using Wilcoxon's signed-rank sum test. The parameters with a normal distribution are expressed as mean ± standard deviation. A paired *t*-test was performed to compare the mean values of the control and aluminum-sheets conditions. Effect sizes and 95% confidence intervals were calculated. Statistical significance was set at a 2-sided *P* value of <0.05. All calculations were performed using Statistical Package for the Social Sciences for Windows version 25 (IBM, Armonk, NY, USA).

Ethics Approval

All participants were informed of the benefits and risks of the study. Participants were assured that their data would be treated confidentially and stored securely, and that anonymity would be maintained. They were informed that their participation was voluntary and that they could withdraw from the study at any time, without penalty or fear of retribution. All participants provided written informed consent before being enrolled.

All procedures were reviewed and approved (approval number;19-001) by the Ethics Committee of the Hiroshima Institute of Technology, and the study protocol conformed to the principles of the Declaration of Helsinki.

Results

Table 1 shows the sleep–wake rhythm parameters during night-time sleep under the 2 conditions. The TST in the aluminum-sheets condition was significantly higher than that in the control condition. However, no significant differences in SL or the number of postural changes were found between the 2 conditions. The time and frequency of WASO in the aluminum-sheets condition were significantly lower than those in the control condition. Furthermore, the SE in the aluminum-sheets condition was significantly higher than that in the control condition.

Table 2 shows the subjective parameters under the 2 conditions. The subjective soundness of sleep in the aluminum-sheets condition was significantly higher than that in the control condition. Furthermore, thermal sensation in the aluminum-sheets condition was significantly higher than that in the control condition. However, no significant differences in the comfort sensation were found between the 2 conditions.

Table 3 shows the mood states and TMD for the 3 conditions (aluminum-sheets, control, and home conditions) based on POMS2. TMD differed significantly among the 3 conditions. TMD in the aluminum-sheets and control conditions was significantly higher than that in the home condition. Furthermore, F-I and V-A differed significantly among the 3 conditions. The F-I in the aluminum-sheets and control conditions was significantly higher than that in the home condition. Moreover, the V-A in the aluminum-sheets and control conditions was significantly lower than that in the home condition. However, no significant differences in A-H, C-B, D-D, T-A, or F were found among the 3 conditions.

Table 4 shows the HR, cardiac ANS modulation, and BP values during night-time sleep under the control and aluminum-sheets conditions. There were no significant differences in HR, ln HF, total power, LF/HF, systolic and diastolic BP, or pulse pressure between the control and aluminum-sheets conditions.

Discussion

This study examined the effects of sleeping under an SB-SAS during winter on sleep–wake rhythms and on the subjective and physiological parameters in an experimentally recreated evacuation shelter sleep environment. The use of an SB-SAS resulted in significantly higher levels of warm thermal sensation during sleep and led to a decrease in the time and frequency of WASO. These responses are believed to be responsible for an increase in subjective sleep soundness, prolonged sleep time, and improvements in SE. However, compared to daily sleep at home, TMD was significantly lower. Furthermore, the F-I component of POMS2 showed significantly higher values, whereas the V-A component showed significantly lower values for the control and aluminum-sheets conditions. The results indicated that the use of SB-SAS at disaster evacuation shelters during winter could be effective in improving sleep–wake rhythms and subjective sleep soundness but would not improve negative emotions.

The use of an SB-SAS resulted in a significantly higher warm thermal sensation, which indicates that the sheets led to reduction of cold stimulation during sleep in winter. This reduction in cold stimulation suppresses WASO, prolongs sleep duration, and improves SE. In addition, subjective sleep soundness was rated high. Thus, preparing SB-SAS at disaster evacuation shelters for use in winter is expected to improve the sleeping environment. A previous study reported that WASO, as measured by actigraphy, increased under conditions recreating the sleep environment of an evacuation shelter in winter.[24] It is assumed that the SB-SAS

Table 1. The sleep–wake rhythm parameters during night-time sleep are under the control and aluminum-sheets conditions

	Control condition	Aluminum-sheets condition	*P* value	Effect size	95% confidence interval	power analysis
Total sleep time (min)	327.9 ± 64.2	386.3 ± 56.5	0.002	0.68	−92.76 – −24.17	0.907
Sleep latency(min)	33 (20.0–54.0)	26 (10.5–35.7)	0.139	0.37	–	0.261
Time of wake after sleep onset (min)	92.9 ± 43.2	52.8 ± 42.9	0.019	0.56	7.71 – 72.56	0.890
Frequency of wake after sleep onset (times)	6.8 ± 2.6	3.9 ± 2.9	0.009	0.61	0.83 –5.03	0.937
Sleep efficiency (%)	68.3 ± 13.4	81.0 ± 11.2	0.002	0.69	−20.03 – −5.33	0.930
Number of postural changes (times)	15.7 ± 5.2	13.6 ± 8.0	0.263	0.29	−1.72 – 5.86	0.216

Data were expressed as the mean ± standard deviation.
Data of sleep latency was expressed as the median (interquartile range).

Table 2. The subjective parameters are under the 2 conditions

	Control condition	Aluminum-sheets condition	*P* value	Effect size	Power analysis
Subjective soundness of sleep (mm)	38.00(26.75–45.75)	44.50(42.00–47.75)	0.009	0.65	0.892
Subjective thermal sensation (mm)	33.50(21.25–44.25)	48.00(40.00–57.75)	0.002	0.77	0.964
Subjective conform sensation (mm)	37.00(17.25–45.00)	38.50(29.75–45.00)	0.679	0.10	0.124

Data were expressed as the median (interquartile range).

Table 3a. The mood states and Total Mood Disturbance for the 3 conditions (aluminum-sheets, control, and home conditions), based on POMS2

	Control condition	Aluminum-sheets condition	Home condition	*P* value
Anger-hostility	0 (0–2.75)	0 (0–1.75)	0 (0–0.75)	0.054
Confusion-bewilderment	1.5 (0–3.75)	2.0 (0.25–4.75)	0 (0–3.75)	0.240
Depression-dejection	0 (0–2.00)	0.5 (0–1.75)	0.5 (0–2.50)	0.976
Fatigue-inertia	3.0 (2.25–5.75)	2.5 (0–7.00)	0 (0–3.50)	0.001
Tension-anxiety	1.0 (0–3.00)	2.5 (0–6.00)	1 (0–6.75)	0.559
Vivid-activity	8.5 (5.25–11.00)	9.0 (6.00–12.00)	11.0 (10.00–15.25)	0.001
Friendly	10.5 (9.00–12.75)	10.5 (9.25–12.75)	13.0 (9.75–15.75)	0.069
Total Mood Disturbance	–1.0 (–6.00–8.50)	0 (–6.00–11.00)	–6.0 (–15.25–8.25)	0.004

Data were expressed as the median (interquartile range).

Table 3b. The results of post-hoc test

	Control condition vs aluminum-sheets condition		Control condition vs home condition		Aluminum sheet condition vs home condition	
	P value	Effect size	*P* value	Effect size	*P* value	Effect size
Anger-hostility	0.396	0.21	0.024	0.570	0.461	0.180
Confusion-bewilderment	0.837	0.05	0.28	0.270	0.187	0.330
Depression-dejection	0.904	0.03	0.751	0.080	0.903	0.030
Fatigue-inertia	0.342	0.24	0.002	0.770	0.007	0.670
Tension-anxiety	0.303	0.26	0.782	0.070	0.404	0.210
Vivid-activity	0.721	0.09	0.005	0.700	0.006	0.690
Friendly	0.924	0.02	0.114	0.400	0.078	0.440
Total Mood Disturbance	0.706	0.10	0.017	0.600	0.002	0.760

Table 4. The physiological parameters during night-time sleep under the 2 conditions

	Control condition	Aluminum-sheets condition	*P* value	Effect size	95% Confidence interval	Power analysis
Heart rate (bpm)	57.1±5.4	57.5±6.1	0.506	0.17	–1.68 – 0.87	0.045
ln HF	6.725±0.691	6.653±0.706	0.294	0.27	–0.07 – 2.15	0.059
Total power (msec^2)	7983 (6556–10094)	7286 (5557–8768)	0.272	0.28	–	0.070
LF/HF	2.028 (1.423–3.180)	1.801 (1.400–2.938)	0.754	0.08	–	0.029
Systolic blood pressure (mmHg)	116.8±10.1	120.4±11.2	0.234	0.30	–9.97 – 2.64	0.246
Diastolic blood pressure (mmHg)	67.6±6.2	66.7±6.1	0.548	0.16	–2.20 – 3.99	0.081
Pulse pressure (mmHg)	49.0±7.2	52.5±7.5	0.112	0.40	–7.96 – 0.92	0.425

Data were expressed as the mean ± standard deviation.
Data of total power and LF/HF were expressed as the median (interquartile range).
ln HF, natural logarithm high-frequency; LH/HF, dividing the high-frequency band from the low-frequency band.

reduces the cold stimulus because the aluminum sheets reflect the infrared rays emitted by human bodies[15] and absorbs radiant heat. Thus, this study observed a reduction in the time and frequency of WASO as a specific effect of using an SB-SAS. A lower frequency and shorter duration of WASO are responsible for the higher level of sound sleep, prolonged sleep time, and increased SE. A study with multiple participants reported that wearing aluminum sheets while staying in a snow cave, simulating a winter mountain accident, contributed to the prevention of hypothermia by suppressing the decline in rectal temperature and reducing subjective cold thermal sensation.[16] Aluminum sheets and cold-weather clothing are commercially available to reduce cold stimulation. The results of the present study suggest that preparing SB-SAS as personal equipment for use during disaster evacuation may improve the sleeping environment in the early stages of disaster evacuation and is therefore strongly recommended. However, the use of an SB-SAS had little effect on subjective comfort and mood state parameters, as evaluated using the POMS2. After the measurements, participants were verbally asked about their impressions of their sleep. The participants made comments such as “Using the sleeping bag-type aluminum sheets made it difficult to turn over,” and “The sleeping bag-type aluminum sheets I used this time could not be closed, so I felt cold air.” These experiences may explain why no significant differences were observed in the subjective comfort or POMS2 parameters between the control and aluminum-sheets conditions. In addition, TMD was significantly lower in both conditions than that in the home condition. These data indicated that sleeping in disaster shelters increases negative emotions and that the use of an SB-SAS did not improve negative emotions. Future studies should implement measures to ensure that subjective sleep parameters and POM2’s assessment of negative emotions are at the same level as those based on sleep at home. Mental health problems during disasters are a major issue. One of the factors possibly contributing to this issue is the deterioration of living conditions in disaster evacuation shelters. Improving the living environment at disaster evacuation centers might improve mental health; however, in-depth studies are needed in the future.

The living environments in Japan’s disaster evacuation shelters are reported as poor.[4] Although each local government recognizes that improvements are an urgent issue, no improvements have been made due to various problems such as stockpiling and distribution of evacuation supplies, budgets, and know-how.[4] Because disaster evacuation is a state of emergency, poor environments tend to be accepted, and it is assumed that evacuees and others are unlikely to request improvements. As a countermeasure to these problems, this study proposes holding trial sessions using SB-SAS during evacuation drills, disaster prevention education for local governments, and school education. In such conditions, unlike during disaster evacuation, constructive opinions will be proposed for the improvement of disaster evacuation shelters, and this study suggests that the opinions of older individuals, women, children, and others should be used to contribute to improving the environment of disaster evacuation shelters. We further propose that a mood scale should be introduced as an evaluation index. It is presumed that the problem of the open SB-SAS mentioned above can be solved by closing the opening, similar to commercially available sleeping bags. In addition, evacuees can contribute to taking necessary measures on their own through their experience. In addition to evacuation drills that have focused on primary evacuation during disaster evacuation to date, secondary evacuation drills, which simulate life in a disaster evacuation center (emergency food, emergency toilets, sleeping on simple bedding, etc.), should be emphasized.

Limitations

The present study has some limitations. First, it did not simulate the anxiety related to disasters or living together with others in an actual evacuation shelter. Second, the participants were young men with a high level of sleep maintenance,[25] which may have buffered differences in sleep–awake rhythm and subjective parameters between the 2 conditions, although a significant difference was observed. Finally, the conditions were set based on the presence or absence of an SB-SAS. Although no significant difference in POMS2 was observed between the 2 conditions, a significant difference was observed between these conditions and sleeping at home. In the future, it will be necessary to compare SE, midway awakening, and subjective parameters during sleep at home. The present study serves as a reference work. In the future, it will be necessary to provide scientific evidence that contributes to environmental improvement in disaster evacuation shelters by targeting actual disaster evacuation shelters, children, women, and older individuals.

Conclusions

This study investigated the psychological and physiological effects of sleeping in sleeping bag-shaped aluminum sheets during winter. The results showed that using aluminum sheets reduced cold stimulation, improved sleep quality, and may have reduced disaster-related deaths but did not improve negative emotions. These findings should be confirmed in further studies in future.

Data availability statement. Data supporting the findings of this study are available from the corresponding author upon request. The data are not publicly available due to privacy and ethical restrictions.

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