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Cardboard Bed Without Mattress Is Ineffective in Improving the body Contact Pressure-a Preliminary Study Using a Dummy Model

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Abstract

Objective: This study aimed to describe and evaluate the dispersion of body-mattress contact pressure on a cardboard bed and investigate whether the cardboard bed has a positive effect on evacuees' musculoskeletal burden.

Materials and Methods: A high-performance nursing simulator was used to measure the contact pressure and the body surface contour area of the bed, and these values were collected with the patient in the supine position using the Body Pressure Measurement System. Data of each test were acquired 10 times and were compared among 4 conditions (plastic sheet, cardboard bed, cardboard bed with a blanket, and cardboard bed with a mattress-topper). The data analysis for body-mattress contacts pressure and the surface contour area of the whole body, head, chest, and buttocks were conducted by one-way repeated analysis of variance and Bonferroni post-hoc test.

Results: The average body-contact pressure on the cardboard bed did not decrease compared with that on the floor with plastic sheets. In contrast, the body surface contour area was significantly different among any other conditions, but the gap was only approximately 16%. However, the body-contact pressure and the body surface contour area were improved when a mattress-topper was added on the cardboard bed. When a blanket was laid on the cardboard bed, the contact area was increased.

Conclusion: Our results indicate that the pressure dispersion ability of the cardboard bed was not sufficient; however, adding the mattress-topper or the blanket could contribute to an improvement in the evacuees' musculoskeletal burden. Many evacuees lay a mattress topper or futon on a cardboard bed after installing cardboard beds. Our findings may also support the scientific validity of the evacuees' actual sleeping style in Japan. This preliminary study provides the basis for future research on exploring an appropriate sleeping bed condition in evacuee shelters.

Keywords

evacuation shelter, evacuee, cardboard bed, musculoskeletal burden, body pressure distribution, body contact pressure, Emergency shelter

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Highlights

What do we already know about this topic?
After the Great East Japan Earthquake, cardboard beds have been installed in the evacuation shelters in Japan to prevent evacuees' clinical symptoms including cough, insomnia, lower back pain, and deep vein thrombosis.

How does your research contribute to the field?
This result can contribute to future consideration on stockpiling the bed in evacuation shelters.

What are your research's implications towards theory, practice, or policy?
This study could provide basic evidence for reviewing Japan's disaster management plan, where large-scale disasters occur regularly.

Introduction

Following a large-scale disaster, school buildings and gymnasiums have been taken advantage of as evacuation shelters where many evacuees are forced to live for extended periods of time in a crowded condition in Japan. Japanese evacuees are prone to back pain or sleep disorders because they sit on the floor without chairs and lie on the floor at night.[1,2] In addition, it has been suggested that evacuees' poor sleep, mental stress, or fatigue caused by the inferior living environment of evacuation shelters may lead to disaster-related diseases.[3,4] The incidence and mortality of disaster-related diseases increased in the months after the Great East Japan Earthquake in 2011.[5] However, a survey conducted in the Ishinomaki area, which was the area with most damage after the Great East Japan Earthquake, reported that evacuees' clinical symptoms including cough, insomnia, and lower back pain improved after installing cardboard beds.[6] This study has also mentioned that cardboard beds may help prevent deep vein thrombosis. Other study has been suggested that a cardboard sheet and a cardboard bed with a height of 35 cm helps in reducing the cold temperature transmitted from the floor.[7,8]

Body-mattress contact pressure is known to play an important role in sleep quality.[9,10] A previous study suggested that medium-firm mattresses improved musculoskeletal pain and modified sleep latency.[9,11,12] At Japanese evacuation shelters, evacuees are forced to lie directly on the floor immediately after the disaster. Even after the installation of cardboard beds at the evacuation shelters in the following weeks, several evacuees preferred laying a mattress or futon which is a popular mattress for sleeping on the floor in Japan on a cardboard bed to sleep. However, there is no direct evidence of the pressure-dispersing effect of the cardboard bed.

Therefore, the study to evaluate whether cardboard beds have a positive effect on evacuees' musculoskeletal burden was planned. However, it was difficult for subjects to participate in our study, because of the global expansion of COVID-19 pandemic. Therefore, I conducted the simulation with a dummy model in order to investigate the measurement conditions of future studies for the contact pressure of humans. This simulation is a preliminary study to assess the pressure dispersing ability of a cardboard bed. To investigate the interface pressure dispersion of the cardboard bed, the mattress-body contact pressure and the body surface contour area were compared with those for a plastic sheet, a cardboard bed with a blanket, and a cardboard bed with a mattress topper.

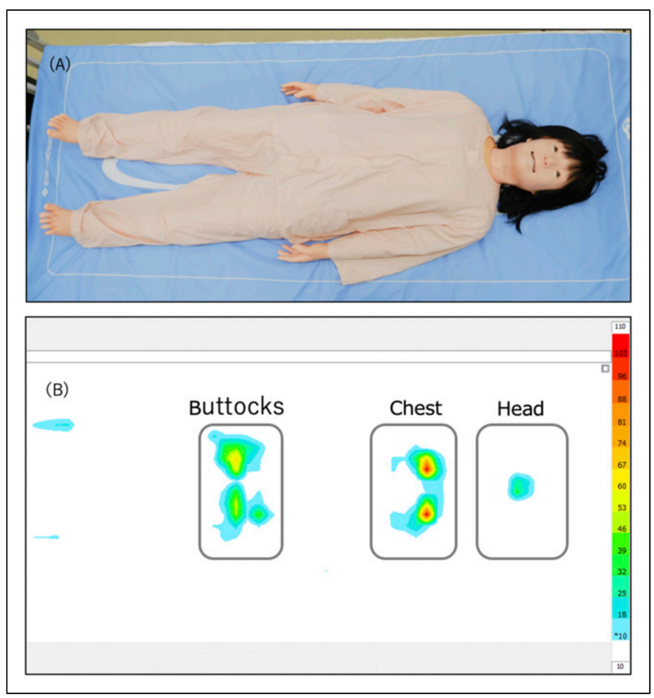

Figure 1. (A) A high-performance nursing simulator (SCENARIO), (B) Measurement area for contact pressure of dummy model.

Materials and Methods

Dummy model

A high-performance nursing simulator, SCENARIO (KYOTO KAGAKU), with a height of 152 cm and weight of 20 kg, was used to measure the pressure in different parts of the body in the supine position. When BMI was calculated by considering the dummy model as a person, dummy's BMI was 8.66. The weight of this dummy model is very light (BMI = 8.66), and this weight distribution differ from the humans because of the internal machinery. However, 3 contour areas equivalent to the head, chest, and buttocks of the model showed high contact pressure like a human body. Therefore, these 3 regions that are stably sensed when the dummy model is laid down were defined as Head, Chest, and Buttocks, and the body-mattress contact pressure and the contour area of body contour of these regions and the whole body were measured (Figure 1).

Measurements

SR Soft Vision (Fukoku Co., Ltd., Tokyo) was the body pressure measurement system (BPMS), and the device was arranged with a total of 1600 (64×25) pressure sensors. To assume the ability for interface pressure dispersion, body-mattress contact pressure and the body contour area of the dummy model were measured using BPMS. The dummy model wore the same clothes to minimize the effect of clothes. Further, the detection range of contact pressure was set to 10–110 mmHg so as not to detect the pressure of the clothes (Figure 1).

Intervention

The experimental conditions in this study were set as a plastic sheet on a floor (A), a cardboard bed (B), a cardboard bed with a blanket (C), and a cardboard bed with a mattress-topper (D). The mattress-topper was made of urethane foam and had a 150 N elastic force (Figure 2).

Procedure

The body-mattress contact pressure distribution of the dummy model was measured under 4 conditions (A-D) 10 times each (Figure 3). In order to stabilize the measured values, the contact pressure distribution of the model was measured approximately 30 seconds after the model was laid down. The data analysis for body-mattress contacts pressure and the body surface contour area were conducted with division into the head, chest, and buttocks. All experiments in the present study were conducted in December 2020 and September 2021.

Statistical Analysis

All data were analyzed using repeated-measures one-way analysis of variance (ANOVA) and Bonferroni post-hoc comparison with correction for multiple comparisons. The analyses were conducted using SPSS Statistics 26 software (IBM, CA, United States). The criterion for significance was set at α = .05.

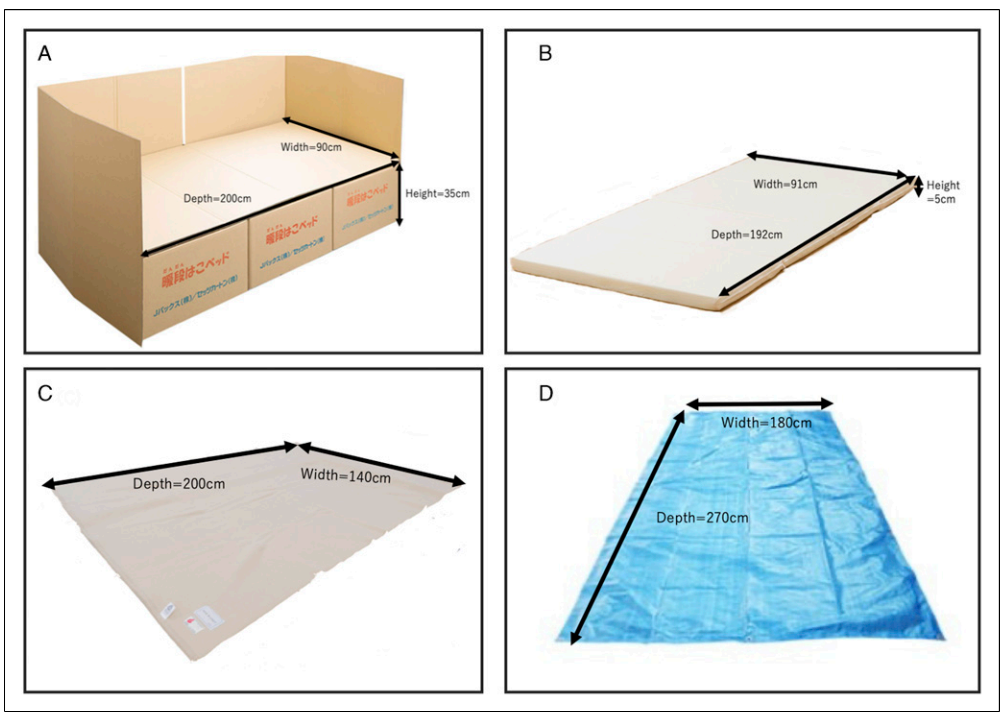

Figure 2. (A) Cardboard bed, (B) Mattress topper, (C) Blanket, (D) Plastic sheet.

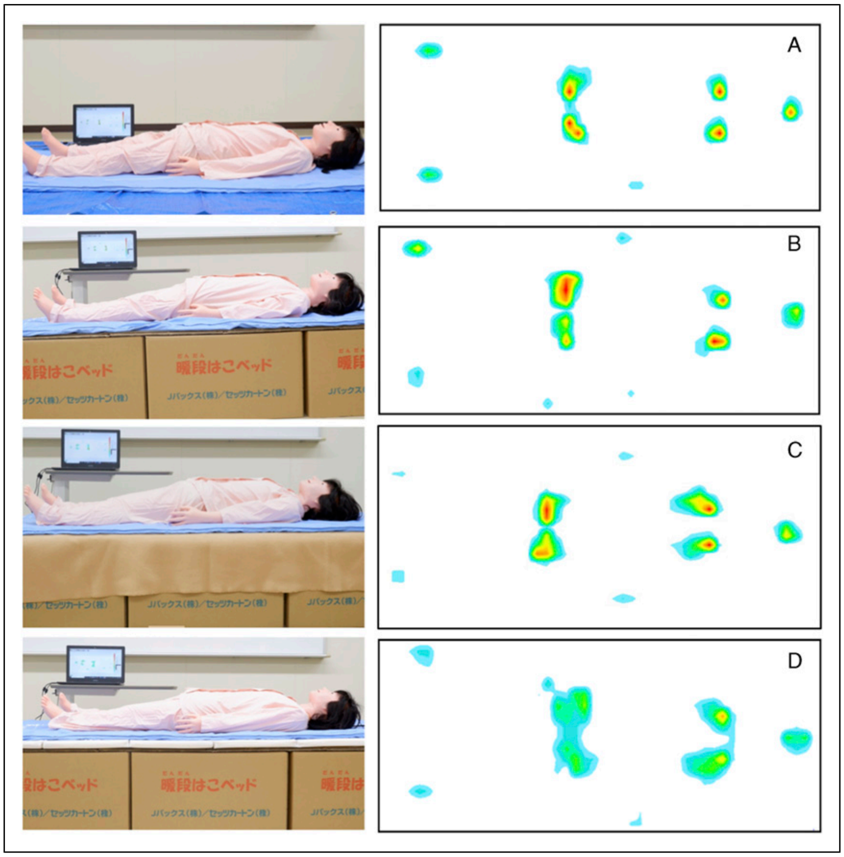

Figure 3. Representation of the distribution area of the contact pressure in lying on a plastic sheet (A), cardboard bed (B), blanket on cardboard bed (C), and mattress topper on cardboard bed (D).

Table 1: One-way repeated measures ANOVA results for body contact pressure and the surface contour area

	Plastic sheet	Cardboard bed	Cardboard bed + blanket	Cardboard bed + topper	F	P-value
Contact pressure (mmHg)						
Whole body	30.40 ± 1.90	30.70 ± 1.57	30.70 ± 1.64	21.50 ± 0.97	129.89	< 0.001
Head	31.80 ± 8.83	35.80 ± 6.88	30.00 ± 3.83	21.20 ± 2.82	13.05	< 0.001
Chest	35.70 ± 5.87	37.10 ± 5.97	32.70 ± 2.06	24.40 ± 1.43	21.34	< 0.001
Buttocks	36.30 ± 4.24	35.40 ± 4.97	36.20 ± 2.53	22.60 ± 1.51	35.10	< 0.001
Surface contour area (mm^2)						
Whole body	3120.32 ± 315.34	3716 ± 212.95	5284.16 ± 251.21	6193.60 ± 464.56	224.50	< 0.001
Head	305.76 ± 57.85	337.12 ± 52.92	486.08 ± 49.58	486.08 ± 61.84	30.85	< 0.001
Chest	666.40 ± 66.63	917.28 ± 143.38	1975.68 ± 89.01	2116.80 ± 152.38	407.00	< 0.001
Buttocks	1332.80 ± 202.43	1387.68 ± 98.13	1889.44 ± 100.88	2563.68 ± 224.96	137.91	< 0.001

Results

To compare the contact pressure distribution of the cardboard bed, the average contact pressure and the contour area in all parts (the whole body, head, chest, and buttocks) were shown when the simulator was laid on a plastic sheet on a floor (A), a cardboard bed (B), a cardboard bed with a blanket (C), and a cardboard bed with a mattress-topper (D). Table 1 shows the results of the one-way ANOVA. The values are presented as the mean and standard deviation of the contact pressure and the body contour area. All results relative to the contact pressure and the contour area of one-way repeated-measures ANOVA showed significant differences among the 4 conditions (Table 1). The Bonferroni post-hoc test related to the whole body showed that the contact pressure was significantly lower when using the cardboard bed with mattress topper than when using beds in the other conditions. However, there were no significant differences among another 3 conditions (Figure 4). The post-hoc test in the contour area of the whole body also indicated significantly differences among each condition. The

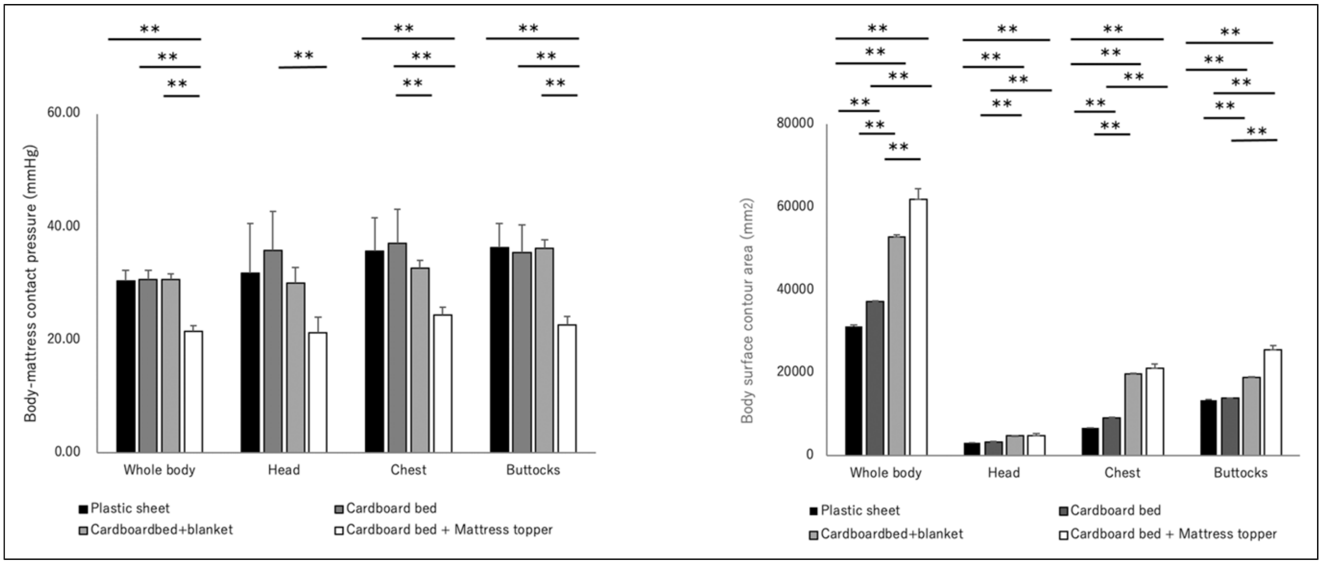

Figure 4. Comparison of body-mattress contact pressure (A) and the body surface contour area (B) among four different conditions using one-way repeated measures ANOVA and Bonferroni post-hoc test. Data are represented as mean values ± SD (** $p<0.01$).

body contour area when using a cardboard bed was 19% wider than that of a plastic sheet. Furthermore, the ratio of a cardboard bed with a blanket and the mattress topper to a plastic sheet were 169% and 198%, respectively.

Discussion

In this study, there were no significant differences in the mean contact pressure among the 3 groups except for the cardboard bed with a mattress topper. It was possible that there were no differences in the average contact pressure among any other beddings, because the dummy model was very light (BMI = 8.5). In contrast, the contour area of dummy model on a plastic sheet was significantly smaller than that on any other beddings.

In the present study, when the cardboard bed with the mattress topper was used, the contour area was increased by 98% compared to the plastic sheet, while when the cardboard was used independently, that was increased by only 19%. It was also shown that when the cardboard bed with a blanket was used, the perceptual area of contact pressure was increased by 69%. Previous study reported that the shelter life in the Great East Japan Earthquake exacerbated the evacuee's musculoskeletal pain.[13] The other study reported that lumbago and insomnia of evacuees were relieved after the installation of a cardboard bed in their research on the Great East Japan Earthquake, which occurred in 2011.[9] Many evacuees would lay a mattress topper or futon on the cardboard bed after the cardboard bed was installed into the shelters. According to Okamoto-Mizuno et al, when the blanket was laid on the cardboard bed, the number of people who felt subjective stiffness and pain in the waist was less than that when the blanket was laid on the floor. In contrast, their stiffness and pain in the back were not improved. However, their results were based on a two-hour nap in the gymnasium (15°C), so an overnight sleep could have showed different results regarding the statement of their back pain and stiffness. In our trial, the contour area of dummy was increased by using a blanket on the cardboard bed, but the pressure dispersion of cardboard bed may be insufficient to prevent back pain. However, our results were also suggested that a cardboard bed by adding appropriate topper may contribute to improve evacuee's body pressure distribution. Considering appropriate bedding in shelters may contribute to reduce the evacuees suffering from their musculoskeletal stiffness and pain. Previous studies have reported that medium-firm mattresses improved musculoskeletal pain compared to high-firm mattresses.[9,11,12] However, the elastic force of the mattress topper which was used in this simulation was 150 N, which was much higher than that of the medium-firm mattress (28–55 N) in their previous studies.[9] Therefore, even the mattress topper used in this study may be too firm to prevent back pain. A mattress with lower elasticity may be needed to reduce the musculoskeletal burden. However, since Japanese municipalities have not stockpile them, it is too difficult to provide them for quite a lot of evacuees when the large-scale disaster as Nankai trough earthquake. Sleep quality is also influenced by the contact pressure distribution.[14,15] It has been known that a mattress with insufficient force dispersion could not improve poor sleep quality.[16] Previous study indicated that the cardboard bed with a blanket could not improve sleep EEG indexes in two-hour nap compared to the blanket on the floor.[8] However, their trial was conducted in February, and the room temperature was maintained 15° C. Therefore, it is possible that their poor sleep quality was affected by low temperature of the room than their body pressure concentration.

In the present study, when the cardboard bed with the mattress topper was used, the contour area was increased by 98% compared to the plastic sheet, while when the cardboard was used independently, that was increased by only 19%. It was also shown that when the cardboard bed with a blanket was used, the perceptual area of contact pressure was increased by 69%. However, the average value of body-mattress contact pressure when a blanket was used on a cardboard bed was not different from that when a plastic sheet was on a floor or single use of a cardboard bed. Previous study reported that the shelter life in the Great East Japan Earthquake exacerbated the evacuee's musculoskeletal pain.[13] The other study reported that lumbago and insomnia of evacuees were relieved after the installation of a cardboard bed in their research on the Great East Japan Earthquake, which occurred in 2011.[9] Many evacuees would lay a mattress topper or futon on the cardboard bed after the cardboard bed was installed into the shelters. According to Okamoto-Mizuno et al, when the blanket was laid on the cardboard bed, the number of people who felt subjective stiffness and pain in the waist was less than that when the blanket was laid on the floor. In contrast, their stiffness and pain in the back were not improved. However, their results were based on a two-hour nap in the gymnasium (15°C), so an overnight sleep could have showed different results regarding the statement of their back pain and stiffness. In our trial, the contour area of dummy was increased by using a blanket on the cardboard bed, but the pressure dispersion of cardboard bed may be insufficient to prevent back pain. However, our results were also suggested that a cardboard bed by adding appropriate topper may contribute to improve evacuee's body pressure distribution. Considering appropriate bedding in shelters may contribute to reduce the evacuees suffering from their musculoskeletal stiffness and pain. Previous studies have reported that medium-firm mattresses improved musculoskeletal pain compared to high-firm mattresses.[9,11,12] However, the elastic force of the mattress topper which was used in this simulation was 150 N, which was much higher than that of the medium-firm mattress (28–55 N) in their previous studies.[9] Therefore, even the mattress topper used in this study may be too firm to prevent back pain. However, since Japanese municipalities have not stockpile them, it is too difficult to provide them for quite a lot of evacuees when the large-scale disaster as Nankai trough earthquake. Sleep quality is also influenced by the contact pressure distribution.[14,15] It has been known that a mattress with insufficient force dispersion could not improve poor sleep quality.[16] Previous study indicated that the cardboard bed with a blanket could not improve sleep EEG indexes in two-hour nap compared to the blanket on the floor.[8] However, their trial was conducted in February, and the room temperature was maintained 15° C. Therefore, it is possible that their poor sleep quality was affected by low temperature of the room than their body pressure concentration. Further, since the present trial was using dummy model, it was not possible to examine what a bed condition was effective in preventing back pain. A mattress with lower elasticity may be needed to reduce the musculoskeletal burden. Therefore, the research on humans will be necessary to examine how much can the difference of bed conditions decrease evacuee's subjective back stiffness and pain in the future. According to Japanese guideline for evacuation shelter management, municipalities must consider if evacuees' beds and mattress including futon should be installed from 3 days after following a disaster occurrence.[17] Most Japanese municipalities have agreements with the Japan Corrugated Case Association (JCCA) to supply cardboard beds; hence, in the event of a disaster, cardboard beds can be produced in large quantities in factories near the disaster area in a short time.[18] For that reason, the municipality does not have many stockpiles of cardboard beds for evacuees.[19] Regarding evacuees' mattresses, the network for supplying them promptly following a large-scale disaster is unorganized, as with the lack of stockpiled them in each municipality. Thus, swift provision of cardboard beds and mattresses in the event of a large-scale disaster such as the Nankai Trough earthquake, which is estimated to generate approximately 20 times as many evacuees as those in the Great East Japan Earthquake, might prove challenging. To the best of our knowledge, this is the first report to indicate insufficient pressure dispersion of a cardboard bed.

There are some limitations of the present simulations. First, our results indicate that the use of cardboard beds only may not be useful to prevent musculoskeletal pain and stiffness. However, the dummy model used in this study was very light, and this weight distribution was different from the humans due to the internal mechanism. Therefore, the data obtained in this study may not be directly applicable to humans. Since the present study with dummy model is not ideal, I am planning to carry out the research on human based on the current simulation. Second, futons have been often laid on cardboard beds in the evacuation shelters. However, since the contents of the futon are diverse and this distribution is not uniform, the mattress topper with uniform elastic force was used in this study. Therefore, the results in this study might not match the data using futon. However, I believe that the findings of this study could be available to determine the future study conditions on the body pressure dispersion of beddings for evacuees.

Conclusion

In conclusion, the present simulation suggested that cardboard beds without a mattress topper could not improve the contact pressure of dummy model compared with lying on the floor with a plastic sheet.

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Declaration of conflicting interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Ethical approval

Our preliminary study was carried out using a dummy model and did not use any research materials that required the approval of the Ethics Commission.

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