

Smart Rubber Active Mattress “*Taiatsu Bunsan*”

Tomonori HAYAKAWA*, Akitsugu MISAKI, Shin-ichiro TAKASUGI, and Masutaka FURUE

Sumitomo Riko Company Limited has developed the smart rubber (SR) active mattress “*Taiatsu Bunsan*” for preventing bedsores. Consisting of stretchable SR sensors and double-decked air cells, this mattress automatically disperses the weight of bed-ridden patients to prevent ulcers. We are aiming to provide this product to clinics in order to improve the quality of life (QOL) of the patients and support their independence. This product will also lessen burden on caregivers by reducing the frequency of postural changes. We believe the *Taiatsu Bunsan* helps both patients and caregivers.

Keywords: mattress, bed sore, sensor, air cell

1. Introduction

With a declining birth rate and an increasing aging population, the issue of elderly care has been widely taken up. We have been tackling the problem of bedsores occurring in bedridden patients. Bedsores are a symptom of skin tissue necrosis caused by a blood-flow blockage due to a compression and/or a shear force applied continuously to a body for a certain period of time. Currently, in order to prevent bedsores, a caregiver changes a patient's body posture regularly (e.g., every two hours), thereby preventing continuous compression on the same part of the skin for a long time. This is a caring or nursing operation called “body position exchange.” However, it is actually difficult to perform this properly and frequently due to labor shortages and aging caretakers.

Aiming to reduce the burden of caring and nursing, we have developed the “*Taiatsu Bunsan*,” a smart rubber (SR) active mattress that has a body pressure sensing function. With this function, the surface of the mattress is automatically deformed depending on the patient's body shape and posture change to keep the body pressure equally distributed.

2. Outline of the System

The *Taiatsu Bunsan* has an SR sensor sheet and 6×18 pieces of tiltable double-decked air cells. The SR sensor sheet is arranged directly under the surface sheet on which a patient lies down in order to detect high-pressure portions. Under the SR sensor sheet, the air cells are arranged in a 6×18 matrix form. Based on body pressure information obtained by the SR sensor, each of the air cells is deformed to fit the body shape and posture of the patient, thereby eliminating high-pressure portions and achieving body pressure dispersion.⁽¹⁾

2-1 SR sensor

The SR sensor is a flexible capacitance-type pressure detection sensor composed mainly of a flexible substrate and electrodes. In this mattress, the SR sensor covers the entire mattress surface to constantly monitor identified high-pressure portions of a body as shown in Fig. 1 and change the body pressure distribution as the patient moves.

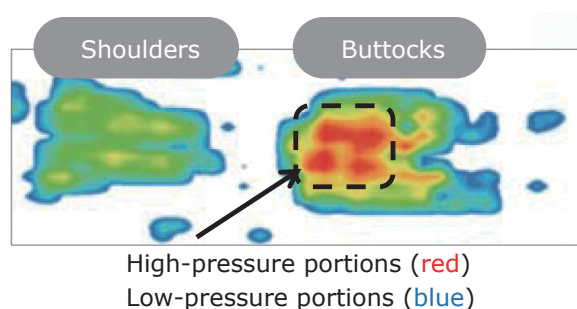


Fig. 1. Body pressure distribution measured by SR sensor

2-2 Tiltable double-decked air cells

The surface of the mattress is provided with a structural design that prevents a shearing force from being applied to a body. Each air cell, which measures 90×90 mm, has a stroke of about 100 mm in the vertical direction (Fig. 2) and a constricted portion formed in the middle in its height direction. This allows individual air cells to move laterally and vertically, thereby reducing the force in the shear direction. Owing to this structure, each air cell is deformed or tilted around the constriction, toward a maximum load center as shown in Fig. 3, ensuring the body sinks gently into the mattress.

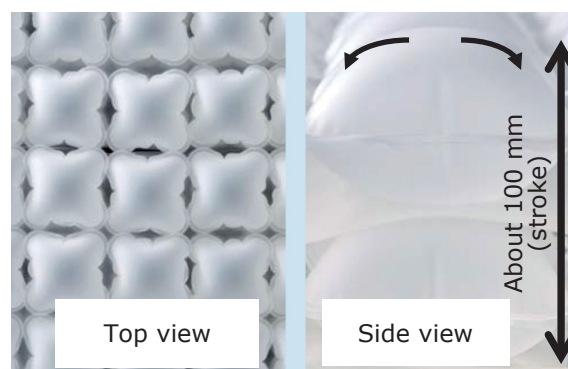


Fig. 2. Tiltable double-decked air cell

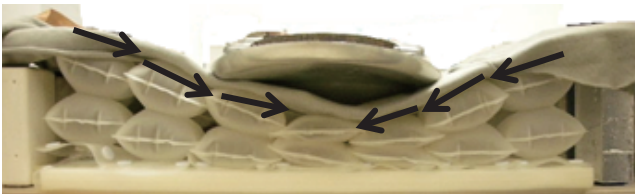


Fig. 3. Deformation behavior of tiltable double-decked air cell

2-3 Motion algorithm

This section outlines the motion of this mattress. The SR sensor constantly measures the body pressure distribution. When patient movement is detected, the surface of the mattress starts operation automatically. More specifically, first, in order to properly recognize the patient's body shape and posture, the entire mattress is flattened (Fig. 4 ①). After the flattening is completed, at least one high-pressure portion is determined based on the body pressure distribution information obtained by the SR sensor. Then, target values are set for controlling an air pressure in each of the air cells located at a position corresponding to the detected high-pressure portion, and the internal air pressure of each air cell is adjusted. As a result, the shape of the mattress is adjusted to conform to the body shape of the patient, thereby dispersing the body pressure (Fig. 4 ②). After that, the patient's movement is constantly monitored by the SR sensor. When there is a certain change in body pressure due to the patient's turning over in the night, etc., the body movement detecting function is actuated and repeats the successive operations starting from recovering the flattened state.

As is mentioned above, this mattress has the functions of automatically detecting high-pressure portions and changing the form to disperse the body pressure. Changes in the posture are also detected automatically and then the

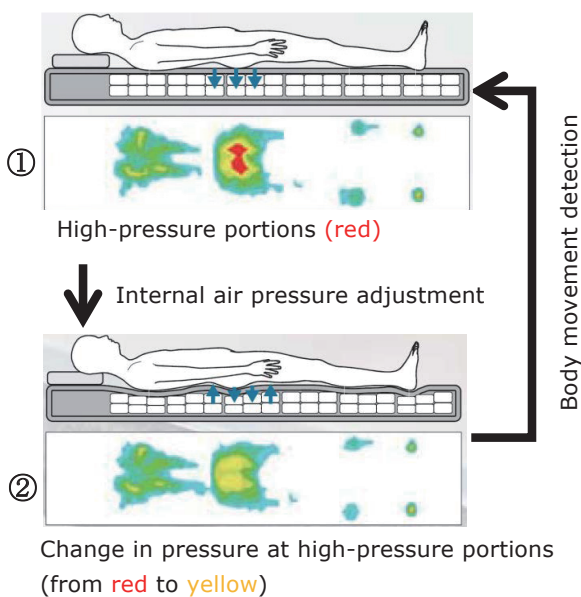


Fig. 4. Automatic body pressure dispersion operation

dispersion of the body pressure is performed automatically as appropriate. When the patient's movement is not detected, the adjusted shape of the mattress is maintained for a certain time so as not to prevent sound sleep.

3. Evaluation of Body Pressure Dispersion Function

Through the actual use of the mattress in the clinical field, we evaluated its effectiveness by examining its operational status and the skin conditions of patients.⁽²⁾ We also carried out the usability evaluation of the mattress by analyzing the reaction of patients, convenience for caregivers, and feedback from caretakers.

Firstly, body pressure distribution data were obtained from one long-term bedridden patient who is at a high risk of bedsores, by using the urethane mattress originally used and the Taiatsu Bunsan. By continuously using the Taiatsu Bunsan, the patient's skin condition (i.e., the presence of bedsores), the operational status, and usability of the mattress were examined. The research was performed from February 24, to March 9, 2016. In order to perform the research, our activity was explained to a proxy on behalf of the patient and approved by the Ethics Committee.

Case: A 59-year-old female, height 141 cm, weight 49 kg, Down syndrome, mental retardation, hospital stay duration of 4 years, and no generation of bedsores (Design-R:0)

The evaluation results of the body pressure dispersion function are shown in Fig. 5. For comparison, the data in the case of lying on the conventional urethane mattress were obtained. The results confirmed that the maximum body pressure was smaller and the contact area was larger when lying on the Taiatsu Bunsan than on the urethane

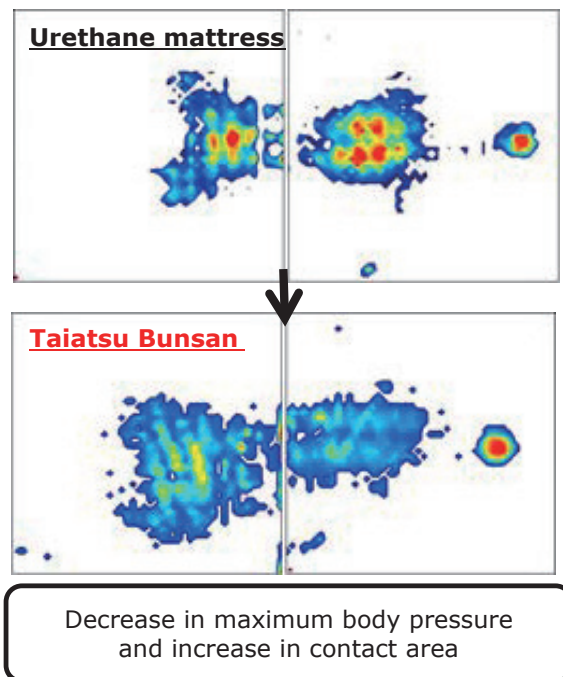


Fig. 5. Comparison of body pressure dispersion between different mattresses

mattress. Furthermore, the generation of new bedsores was not observed during the clinical test.

4. Approach to Improve Usability

The usability evaluation was carried out together with the clinical evaluation. We collected feedback from nurses who used the product through a questionnaire. As a result, the following good points and a point to be improved were made clear.

[Good points]

- The hardness and stability of the end parts of the mattress are appropriate.
- The mattress can be used easily without complicated button operations.
- The mattress can be folded to be carried easily (Fig. 6).
- The operational noise of the mattress does not cause a problem.

[Point to be improved]

- The pump unit is large.



Fig. 6. Foldable structure for portability

5. Conclusion

In response to requests from the medical and caring fields for eliminating bedsores, we have developed the SR active mattress “Taiatsu Bunsan.” Through the interviews with medical personnel at the early stage of the development, we were able to meet their demands in the design of the mattress. At present, some improvements, such as downsizing of the pump unit, are still necessary. We will continue the improvement of the mattress for enhanced usability.

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• “Smart Rubber,” “SR Active Mattress” and “Taiatsu Bunsan” are trademarks of Sumitomo Riko Company Limited.

Technical Term

- *1 WOC nurse: Nurse certified in wound, ostomy and continence care.

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