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ORIGINAL RESEARCH

Decreasing Maximum Interface Pressure in the Lateral Position by Investigating Optimal Mattress Internal Air Pressure Using an Oval Buttocks Model

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Video abstract

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Background: In clinical practice, air mattresses are frequently used for the purpose of pressure dispersion in the prevention of pressure ulcers and their treatments. However, there is unclear standard for setting the mattress internal air pressure (MIAP). Specifically, leaving the MIAP unchanged when repositioning from the supine to the lateral position may contribute to the progression of pressure ulcers.

Purpose and Methods: This study investigated optimal MIAP for decreasing maximum interface pressure in the lateral position. To achieve it, an oval metal buttocks model was used on the centre of an air mattress. The buttocks model was a 28-mm convex surface at its centre to emulate a bony protrusion. The pressure distribution at the buttocks in the lateral position was measured for 30 min at each MIAP. The degree of immersion of the buttocks was measured every minute using a laser distance meter. The changes in interface pressure and contact area of the buttocks over time were measured using a pressure-sensing mat.

Results and Discussion: MIAPs ranging from 13 to 25 mmHg resulted in immersion in the range of 11–50 mm. Increasing the MIAP decreased the maximum interface pressure by 60% in the lateral pressure redistribution, with a statistically significant difference ($P<0.01$) observed between the MIAPs of 16 mmHg and 25 mmHg. Compared with the MIAP of 16 mmHg, statistically significant differences ($P<0.01$) in the maximum interface pressure were observed at 22, 23, and 24 mmHg. Although increasing the MIAP resulted in an immersion, no envelopment occurred in the lateral pressure redistribution. Moreover, an increase in the MIAP resulted in a sixfold decrease in the rate of interface pressure change. Therefore, increasing the frequency of repositioning in the lateral position is crucial for the prevention of pressure ulcers.

Conclusion: The study result suggests that increasing the MIAPs above 22 mmHg in an active air mattress can effectively suppress the maximum interface pressure in the lateral position.

Keywords: air pressure, buttocks, pressure ulcer, posture, pelvis

Introduction

In clinical settings, the internal air pressure of air mattresses—hereafter referred to as mattress internal air pressure (MIAP)—is often set based on patient body weight and mattress firmness. One of the clinical challenges is the lack of a standardised method for determining appropriate MIAP settings. For example, the same MIAP setting is often applied in both lateral and supine positions, although the lateral position typically results in a smaller contact area and higher interface pressure. A suboptimal MIAP setting may contribute to the development or recurrence of pressure ulcers due to external forces associated with routine repositioning. Applying the MIAP setting calibrated for the supine position during lateral repositioning may result in excessive interface pressure and insufficient pressure redistribution, thereby potentially

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increasing the risk of pressure ulcer development. According to a study by Sanada et al, the maximum interface pressure was significantly higher ($P < 0.01$) in the lateral position compared with that in the supine position in healthy subjects at the same MIAP for each MIAP of 18 mmHg and 36 mmHg using a cell-type pressure-switching mattress.[1] Sasaki et al investigated the relationship between the internal air pressure and interface pressure of a prototype air mattress.[2] According to the sacral interface pressure measurement result, the authors found that the interface pressure is high when MIAP is either high or low, with the interface pressure vs MIAP plot forming a U curve.[2]

There have been several reports on the relationship between the MIAP and pressure redistribution in the supine position.[1–3] However, only a few studies have examined the relationship in the lateral position. We have previously investigated the relationship between the MIAP and pressure redistribution in the lateral position. The study results demonstrated that increasing the MIAP of an active air mattress can minimise the maximum interface pressure when changing from the supine to the lateral position in healthy participants.[4] There are the following limitations that have hindered progress in study on the lateral position: 1) the development of a lateral posture suitable for clinical applications is challenging and 2) the thicknesses of current air mattresses may be insufficient to accommodate the immersion property of mattresses in the lateral position. Consequently, few studies have focused on pressure redistribution in the lateral position, as examined in the present study. Therefore, we reviewed the literature that implemented these models. The common sites of pressure ulcers are the sacral region in the supine position and the ischial tuberosities in the seated position. Accordingly, most models have been constructed to mimic these common sites.[5–9] However, they have assumed a supine or seated position and not a lateral or cephalic fist upper position. We noted that the buttocks model proposed by Hirose[7] was a jig. The oval buttocks model[7] was adopted in this study because the pressure dispersion property in the supine and lateral positions can be compared by changing the weight of the jig. This study evaluated the effect of repositioning from the supine to the lateral position. In other words, the purpose of this study was to determine the amount of increase in the MIAP of an active air mattress that can minimise the maximum interface pressure during repositioning from the supine to lateral position using the oval buttocks model.[7]

The Tissue Viability Society proposed the concept of pressure redistribution for interface pressure dispersion in pressure ulcers in 2010.[10] This pressure redistribution has three properties: immersion, envelopment, and change in the contact area over time.[11] To identify the optimal criteria for the MIAP in the lateral position, we focused on quantifying the three properties.

We quantified immersion by referencing a previous study by Yamamoto et al,[12] who investigated the degree of immersion using a laser distance meter (Leica DISTO™ lite5; Leica Geosystems AG, Heerbrugg, Switzerland) placed 1,993 mm above the floor. Their study enabled us to evaluate the immersion of the pressure redistribution property quantitatively. Another study utilizing a different laser instrument was conducted by Ogawa et al.[13] In their study, a laser scanner was placed on the foot and head of the bed to quantify immersion when a person was lying on the bed. Several studies have also used laser instruments to measure the degree of immersion.

In a previous study, Matsuo et al[3] used a pressure mapping system (CONFORMat; NITTA Corp., Osaka, Japan) and a buttocks model to measure interface pressure and contact area, and they evaluated their relationship with the supine position and MIAP. Their results showed that at a low mattress internal pressure, the maximum interface pressure was low because the contact area was large, and vice versa. We applied the concept of "quantification of envelopment" and used a pressure mapping system (BPMS; NITTA Corp., Osaka, Japan) to "visualize envelopment" and examine the change in the contact area over time based on the change in the maximum interface pressure. To determine the amount of increase in the MIAP that minimises the maximum interface pressure in the lateral position, we used the oval buttocks model[7] and evaluated three pressure redistribution properties, namely immersion, envelopment, and change in contact area over time.

Materials and Methods

Active Air Mattress

An air mattress used in this study was the AIR MASTER TRICELL.E (CAPE CO., LTD., Yokosuka, Japan) (Figure 1), which is an independent two-layer air mattress measuring 84×192×10 cm (24 air cells in 8 cm width repeat inflation for 10 min and deflation for 5 min per cycle, with one unit for three cells). Two of the three cells always inflate and support

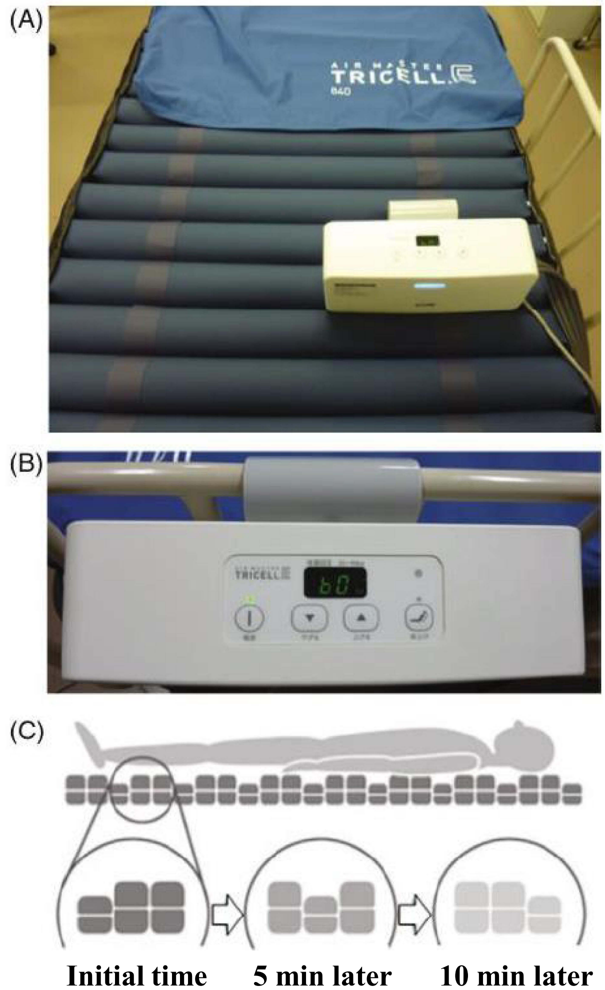

Figure 1 Image of AIR MASTER TRICELL.E (**A**) and its attached pump (**B**). AIR MASTER TRICELL.E is an air mattress used to prevent pressure ulcers. It consists of 24 completely independent two-layer air cells and an electronically controlled pump. Moreover, it is also equipped with a "back-up support function" to respond to bottoming, which occurs when raising the back. The weight setting can be adjusted from 20 to 90 kg in 5-kg increments. The citation URL in (**C**) is "https://www.cape.co.jp/products/pdt004". Reprinted from Kawabata T, Sugama J. Relationship between mattress internal air pressure and interface pressure distribution in the lateral position. *Int Wound J*. 2022;19(8):2115–2123.[4]

the body. A high internal air pressure for cell inflation was assigned as the value of the body weight from 20 kg to 90 kg in 5 kg increments. The internal air pressure was measured by connecting a pressure sensor to one of the tubes from the pressure controller. The result is presented in Table 1. Although the body weight settings ranged from 20 kg to 90 kg in 5 kg increments, the MIAP did not change linearly with the set body weight. Therefore, we designated the internal air pressure at inflation and deflation as high and low internal air pressures, respectively.

Oval Buttocks Model and Measurement Position

The oval buttocks model used in this study is shown in Figure 2. Hirose et al[7] proposed a disk-shaped sacral model made of an aluminium alloy (long diameter = 450 mm, short diameter = 250 mm, dome height = 28 mm, and mass = 4.4 kg) for the lying position (Figure 2). This buttocks model uses the sacral region as the target bone protrusion in extremely

Table 1 Mattress Internal Air Pressure (MIAP) According to Body Weight Settings

Body weight setting (kg)	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
High internal air pressure (mm Hg)	13	14	15	16	18	18	18	18	18	22	23	23	24	24	25
Low internal air pressure (mm Hg)	3	3	3	4	4	5	4	5	5	6	6	6	6	6	6

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thin people, which is common in Japan. The basic design of the jig was based on the fact that elderly people at high risk of developing a pressure ulcer had more than 40 % of their weight in the pelvis, mainly the sacrum, and that more than 85 % of pressure ulcer patients had more than mild pathological bone protrusion. In addition, the jig was designed with a weighted load to have a mass of 8 kg when the patient was in the supine position. In the lateral position, the jig was designed to be weighted so that its mass, including the jig, was 23 kg. The oval buttocks model[7] (Figure 2) was a jig designed by the National Institute of Technology and Evaluation (2–49-10 Nishihara, Shibuya-ku, Tokyo, Japan). The oval buttocks model[7] (Figure 2) was used to evaluate the pressure redistribution property using the active air mattress.

The measurement position was set to mimic the lateral position (a set weight of 23 kg) using the oval buttocks model[7] with a basic design of the pelvis of an elderly person with a pathological bony protrusion.

Design of the interface pressure and contact area measurements using a pressure-sensing mat

Changes in the contact area over time, a key aspect of pressure redistribution, were analysed using a BPMS to measure the surface pressure distribution between the active air mattress and body. A pressure-sensing mat (BIG-MAT2000 [Laminate]; NITTA Corp., Osaka, Japan) was equipped with 2112 sensors arranged in a grid of 44 rows and 48 columns. The dimensions of each sensor were 1×1 cm (Figure 3). A thin polyester (0.1mm thick) pressure-sensitive mattress was embedded in the system. When pressure was applied, the electrical resistance at the force-sensing point was converted into a digital value and transmitted to a computer. The data were displayed as a 2D or 3D pressure map using colour coding. The measurement range was 0–20 kPa, with a creep rate of 17.2%, hysteresis of 4.4%, and linearity of 5.0%. The BPMS system was calibrated following the recommendations of the manufacturer, as described in the product manual. Moreover, the system had a tracking

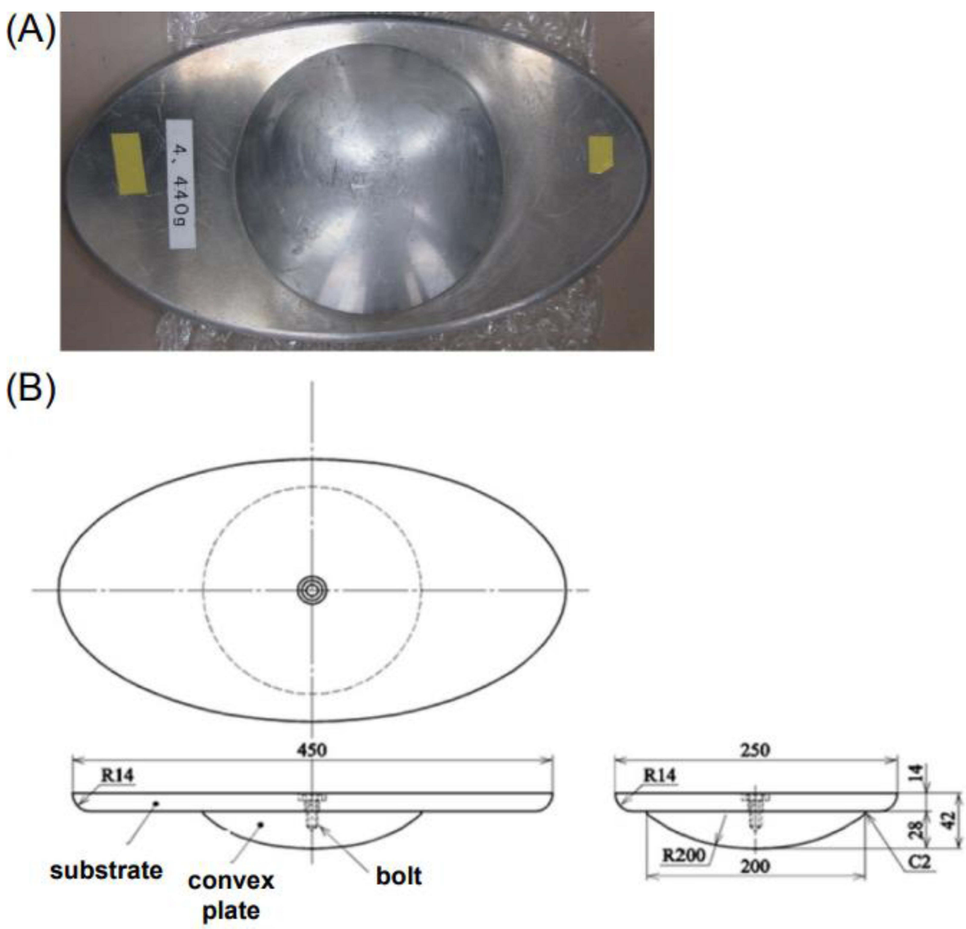
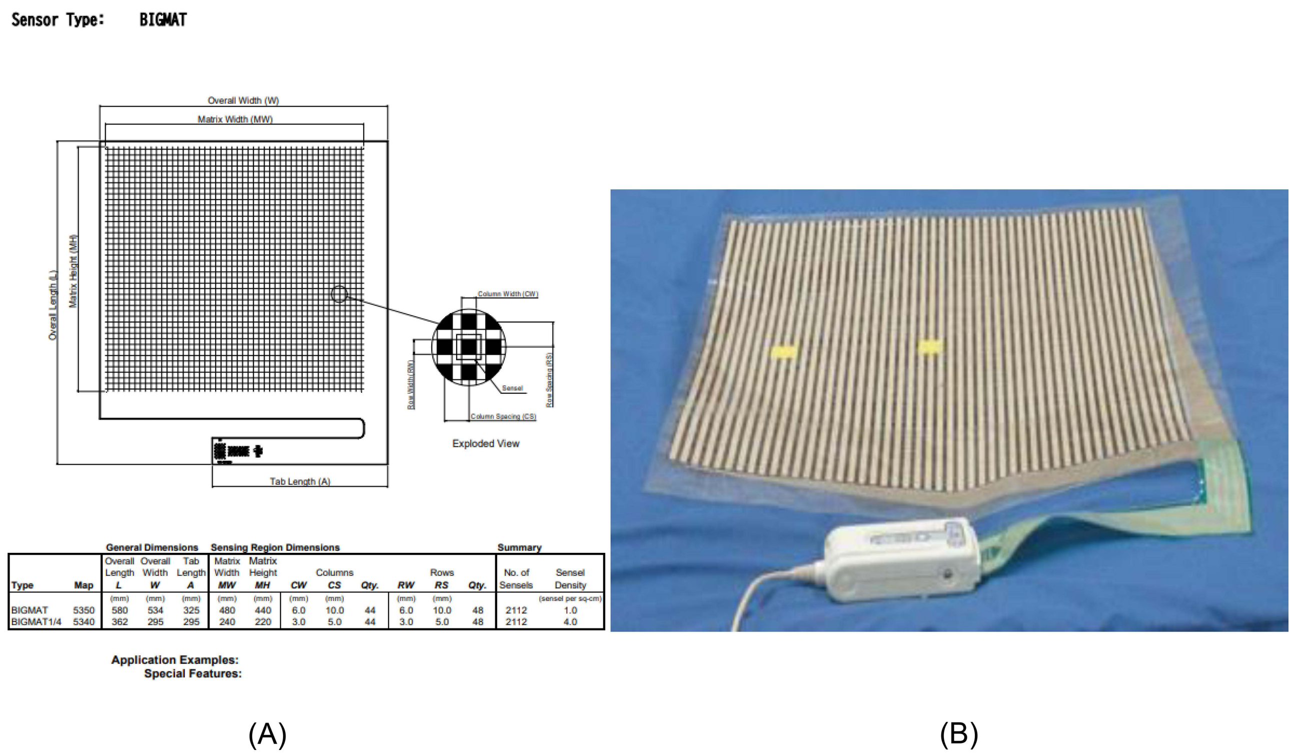


Figure 2 Oval buttocks model. (**A**) Appearance of the oval buttocks model (JIS T 9256–3). (**B**) Blueprint. The citation URL in Figure 2 (**B**) is "https://kikakurui.com/t9/T9256-3-2016-01.html".



		General Dimensions			Sensing Region Dimensions								Summary	
		Overall Length	Overall Width	Tab Length	Matrix Width	Matrix Height	Columns			Rows			No. of	Sensel
Type	Map	L	W	A	MW	MH	CW	CS	Qty.	RW	RS	Qty.	Sensels	Density
		(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)		(mm)	(mm)			(sensel per sq-cm)
BIGMAT	5350	580	534	325	480	440	6.0	10.0	44	6.0	10.0	48	2112	1.0
BIGMAT1/4	5340	362	295	295	240	220	3.0	5.0	44	3.0	5.0	48	2112	4.0

Figure 3 Pressure-sensing mat (**A**) Datasheet of BIG-MAT. The citation URL is available from: https://www.nitta.co.jp/resources/images/product/pdf/tactile_system/bigmat.pdf. (**B**) Photograph of BIG-MAT2000 (Laminate).

function such that it could be wrapped around the model, assuming no hammock-like shape, thereby minimizing the potential for measurement interference.

We used the BIG-MAT 2000 (Laminate) for 30 min to measure the interface pressure and contact area at the buttocks, with each MIAP value being used as an independent variable for measuring surface pressure distribution.

Design of the immersion distance measurement using a laser distance meter

In this study, we used a laser distance meter (Leica DISTO™ X310; Leica Geosystems AG, Heerbrugg, Switzerland) to measure the immersion of the air mattress, as shown in Figure 4. The Leica DISTO™ X310 has a broad measurement range of 0.05–80 m and is equipped with a 360° tilt sensor for slope inclination and partial height measurements. Moreover, the device has an end-piece functioning at 90°/180° and includes a room dimensioning function that enables area and volume measurements, as well as perimeter and wall area calculations (volume measurements only). The device has dimensions of 122 × 55 × 31 mm (height x depth x width), a weight of 155 g, and a measurement accuracy of ±1.0 mm. Its applications include distance, area and volume, inclination, and indirect measurements.

We used the Leica DISTO™ X310 to measure immersion distance. The laser distance meter was positioned directly above the buttocks model[7] set at a height of 1,500 mm from the floor, as shown in Figure 4, and the immersion distance was measured from the top. The laser distance meter provided an accurate measurement of the distance between the laser distance meter and model surface.

Measurements of pressure redistribution properties

The Tissue Viability Society specified the pressure redistribution index in its consensus document.[10] The main evaluation attributes of the interface pressure distribution included the maximum interface pressure, minimum interface pressure, rate of interface pressure change, pressure redistribution index, and range.[10]

The concept of pressure redistribution was proposed by the National Pressure Ulcer Advisory Panel in 2007.[11] The maximum interface pressure was defined as “the highest pressure recorded at the interface over the cycle time”.[11] In this

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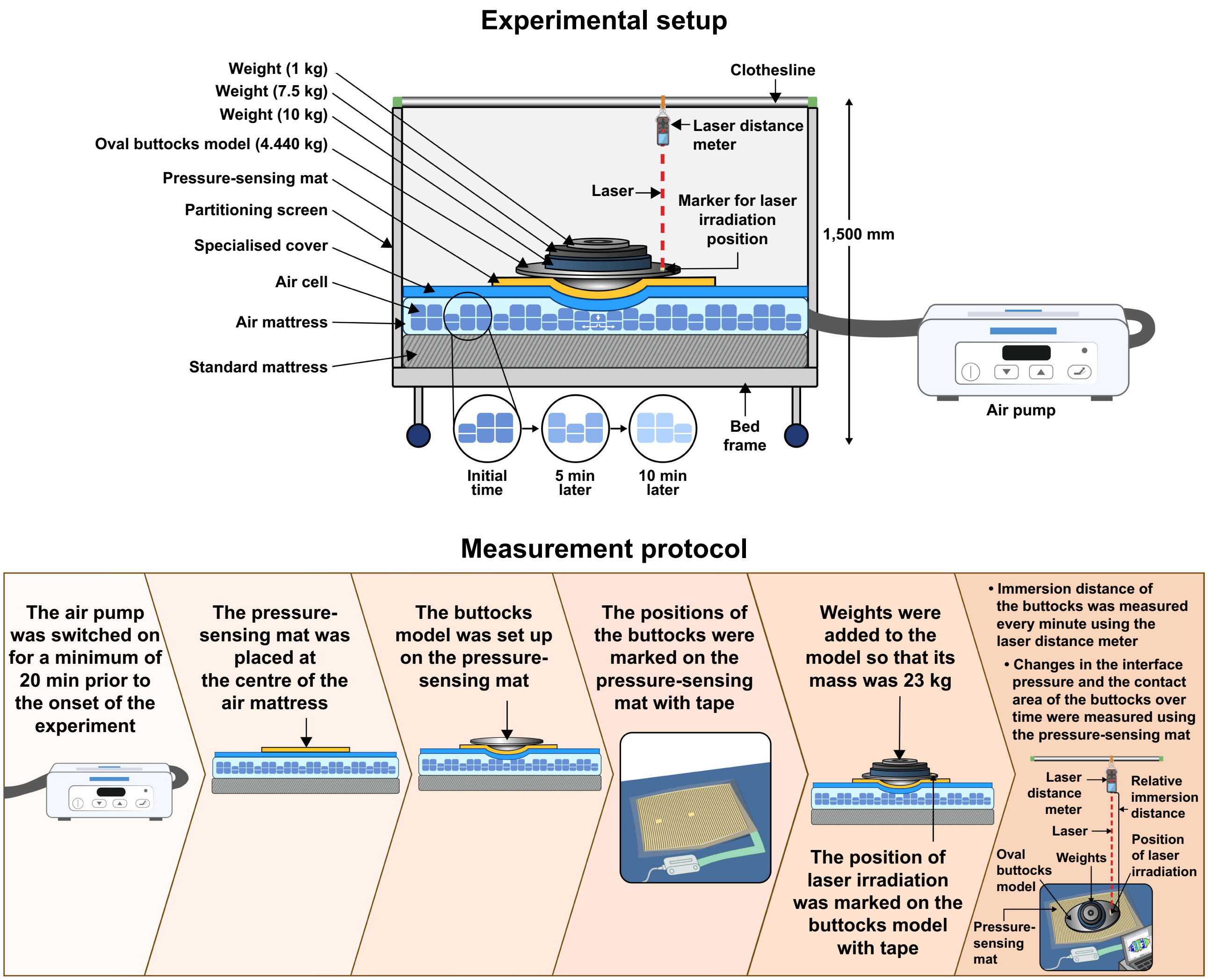

Figure 4 Schematic of the experimental setup and measurement protocol for pressure redistribution property measurements using the buttocks model.

study, the immersion distance was defined as the relative distance from the fixed position using the laser distance meter. Envelopment was considered from the amount of the contact area between the buttocks model and air mattress in this study.

Measurement protocol

The air mattress was maintained in an inflated state throughout the experiment as per the following protocol. Figure 4 shows the experimental setup and measurement protocol.

1. The attached pump was switched on for a minimum of 20 min prior to the onset of the experiment.
2. The pressure-sensing mat was placed at the centre of the air mattress.
3. The buttocks model[7] was set up on the pressure-sensing mat.
4. The positions of the buttocks were marked on the pressure-sensing mat with tape.
5. Weights were added to the model such that its mass was 23 kg. The position of laser irradiation was marked on the buttocks model using the tape.
6. The immersion distance and interface pressure, contact area for the buttocks were measured for 30 min.

Ethical considerations

The experiment did not require ethical considerations as the oval buttocks model[7] was used.

Results

Degree of Immersion

Figure 5 shows the immersion distance of the buttocks model[7] on the air mattress over 30 min measured at each MIAP (13–25 mmHg). The figure shows that the immersions were observed at all MIAPs, with the degree of immersion in the ranges of 1.8–5.0 cm at 13–16 mmHg, 1.4–3.3 cm at 18–22 mmHg, and 1.1–2.5 cm at 23–25 mmHg.

Envelopment

Figure 6 shows the distribution of the interface pressure and contact area between the buttocks model[7] and air mattress. The evaluation criteria for the interface pressure distribution shown in Figure 6 indicates that warm colours correspond to higher pressures (the red colour corresponds to the highest interface pressure) and cold ones correspond to lower pressures (the blue colours correspond to lower interface pressures, and the white colour corresponds to the lowest interface pressure). In the lateral position, no physical envelopment was identified in any of the MIAPs owing to the floating area. Table 2 presents the relationships between each MIAP and the contact area, which were measured using the BPMS system. The results in Figure 6 and Table 2 show that the MIAPs of 14 and 18 mmHg had a larger contact area and better pressure redistribution. However, envelopment was not achieved.

Change in Maximum Interface Pressure Over Time

The maximum interface pressure at different MIAPs was analysed, and the results are shown in Figure 7. The results show that in the lateral position, increasing the MIAP leads to a decrease in the maximum interface pressure. Figure 7 shows that, for MIAPs in the range of 14–18 mmHg, the maximum interface pressure was 41.0–129.8 mmHg. Meanwhile, for MIAPs in the range of 22–25 mmHg, the maximum interface pressure was 61.5–87.1 mmHg.

Discussion

This study investigated changes in the pressure redistribution properties of the buttocks model at different MIAPs in an active air mattress to determine the optimal MIAP in the lateral position. Table 1 presents the sampling intervals for the pressure measurements of the air mattress used in this study.

As shown in Figure 5, the immersion behaviour depends on the locally applied pressure as well as the surface area and weight distribution of other parts of the body (such as the head, shoulder, and leg). In this regard, the model used was considered to be appropriate to achieve the purpose of this study based on the evidence presented in the Introduction. In addition, the oval buttocks model[7] used in this study was based on the jig [JIS standard: JIS T9256-3] designed by the National Institute of Technology and Evaluation to standardize methods for testing the pressure dispersion performance of mattresses. It is therefore reasonable to assume that the buttocks model[7] represents the pelvis and reflects the contribution of load distribution from other parts of the body simply by applying loads to the buttocks.

As shown in Figure 6, it can be considered that in all MIAPs, the low interface pressure areas (white areas in the diagram) are identified based on the formation of irregularities on the surface of the air cell. In other words, the results indicate that physical envelopment is not observed in all MIAPs. At the lower MIAPs (13–18 mmHg), the contact area increases (Figure 6 and Table 2) as the buttocks model[7] is immersed in the air cell (Figure 5). This may have resulted in the pressure redistribution. However, at the higher MIAPs (22–25 mmHg), the expansion rate of the air cell was even greater, resulting in the formation of irregularities on the air cell surface, which were used to identify the low interface pressure areas (white areas in the diagram). At all MIAPs, stress concentrations were identified at the edge of the buttocks model.[7] These stress concentrations are considered as a general stress load on the edge of metal flats. Figure 6 shows two critical findings. Firstly, the stress concentration at the pelvic edge tends to decrease as the MIAP increases. Secondly, as the MIAP increases from 22 to 25 mmHg, more white areas of low interface pressure appear, suggesting that each air cell supports the buttocks model[7] independently. These new findings support our claim that “increasing the

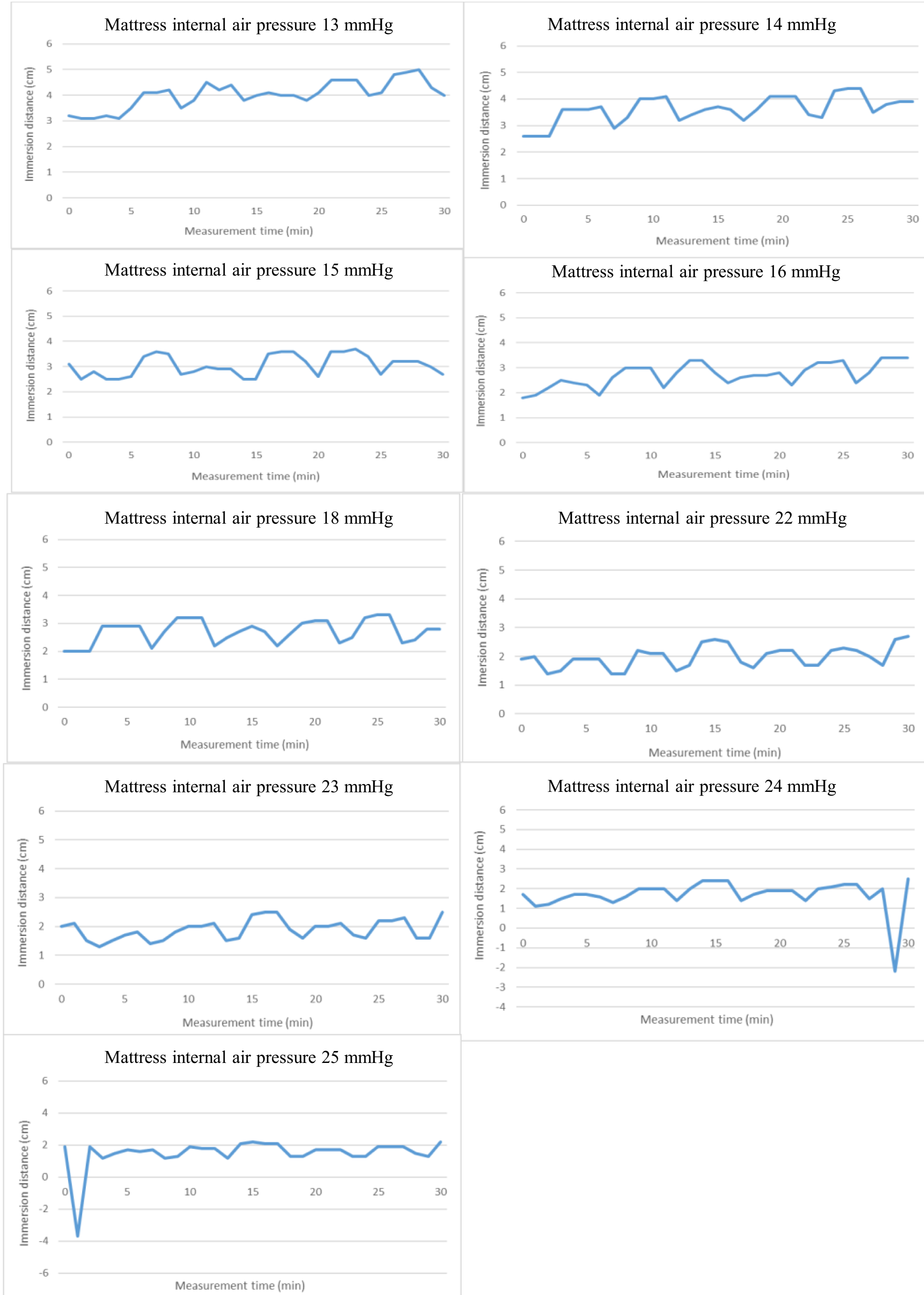

Figure 5 Change in immersion over time.

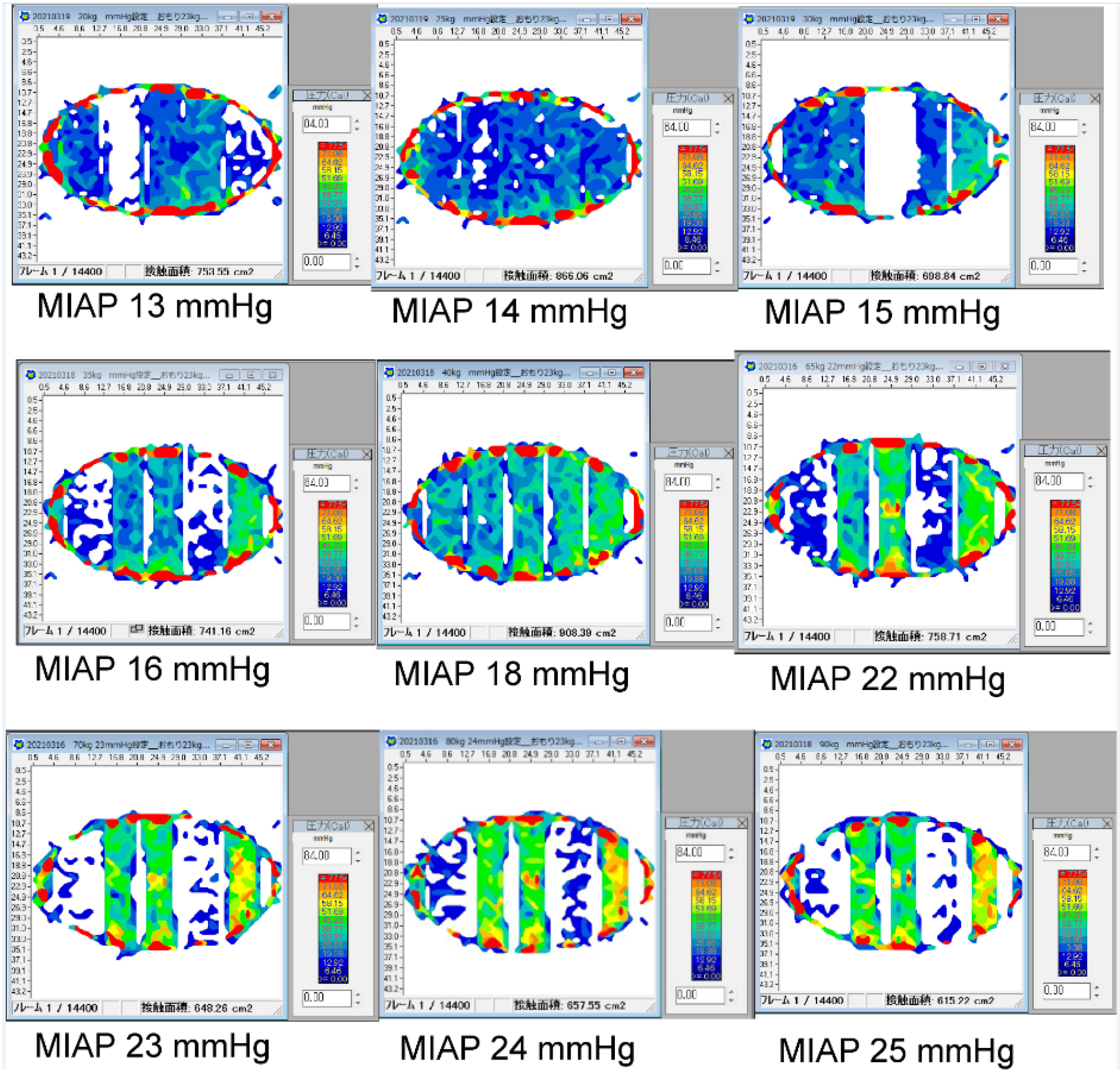

Figure 6 Distribution of interface pressure and contact area between the buttocks model and active air mattress.

internal air pressure in the air mattress is more effective for minimising the maximum interface pressure when changing position from the supine to the lateral position".[4]

Figure 7 presents two findings: 1) Pressure redistribution is achieved at low MIAPs ranging from 13 to 18 mmHg but not at high MIAPs between 22 to 25 mmHg, indicating that air cells expand and contract consistently at low MIAPs, whereas their behaviour is unclear at high MIAPs. 2) The maximum interface pressure is lower at high MIAPs (22–25 mmHg) than at low MIAPs (13–18 mmHg), supporting the effectiveness of the air cells operating at high MIAPs.

Table 2 Relationship Between MIAPs and Contact Areas

High internal air pressure (mm Hg)	13	14	15	16	18	22	23	24	25
Contact area (cm^2)	753.55	866.06	698.84	741.16	908.39	758.71	648.26	657.55	615.22

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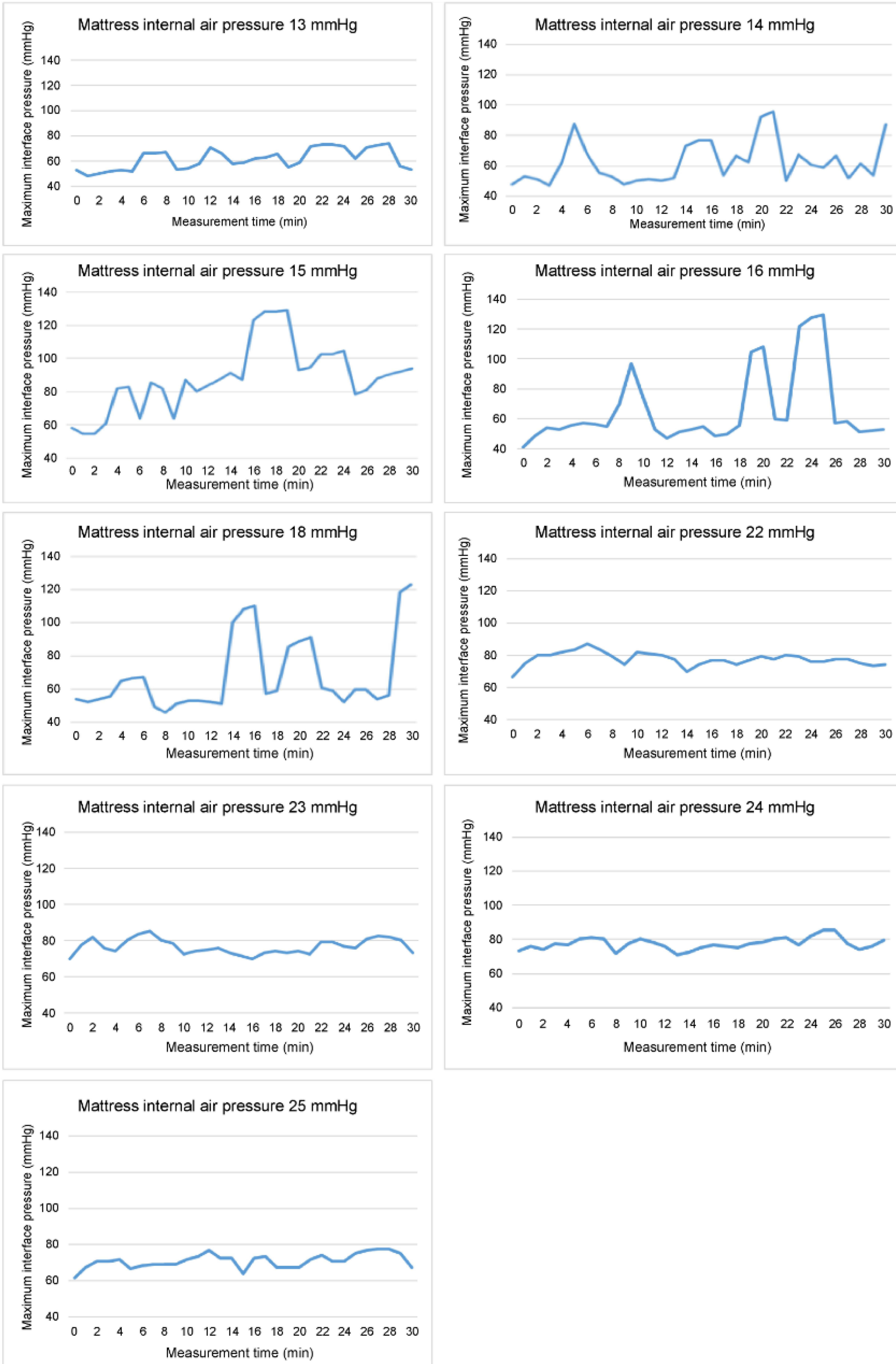
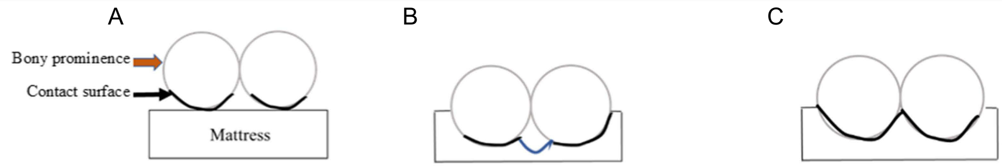


Figure 7 Change in maximum interface pressure over time at various mattress internal air pressures.



Immersion	None	Certain	Certain
Envelopment	None	None	Certain
Contact area and Interface pressure	Pressure concentrated on small contact areas.	Sufficient contact area is not achieved and interface pressure is high.	Adjusts to body irregularities, provides sufficient contact area and maintains low interface pressure.

Figure 8 Pressure redistribution property. **A**: Supported state at a point. **B**: A state in which there is an unsupported part in the irregularities of the body. **C**: Adjusted state to body irregularities. Reprinted from Matsuo J, Fukuda M, Iuchi E, et al. Effects of differences in bed-making methods on air mattress pressure redistribution. *J. Jpn. WOCM*. 2013;17 (1):33–39.[14]

Figure 8[14] shows a visual and organized representation of the pressure redistribution properties. The gold standard for pressure redistribution in the supine position, recommended in clinical care, is the state observed in Figure 8C[14] where the three properties of immersion, envelopment, and change in contact area over time are fulfilled. However, in clinical settings, it is recognized that the supine gold standard cannot be achieved in the lateral position because of the small contact area. In this study, we investigated the gold standard for the lateral position by examining the results of the three properties regarding pressure redistribution. It is evident from the findings presented in the immersion and envelopment that the model shown in Figure 8B[14] is the optimal pressure redistribution for the lateral position, as it provides sufficient immersion without causing the envelopment of a patient.

Table 3 summarises the results of this study. In the lateral pressure redistribution, increasing the MIAP from 16 mmHg to 25 mmHg decreased the maximum interface pressure to approximately 60%, from 129.8 mmHg to 77.7 mmHg, with a statistically significant difference ($P<0.01$). Comparisons of the maximum interface pressure between the MIAP of 16 mmHg and those of 22, 23, and 24 mmHg also revealed statistically significant differences ($P<0.01$). In the lateral position, the degree of immersion decreased with an increase in the MIAP. In addition, complete envelopment was not observed. These resulted in a sixfold decrease in the rate of interface pressure change. Therefore, it may be essential to increase the frequency of changing position when lying in the lateral position. Furthermore, Table 3 highlights that maintaining the MIAPs above 22 mmHg can suppress the maximum interface pressure in the lateral position because of the "unenvelopment" phenomenon, which induces pressure dispersion, as reported by Iizaka et al[15] and Iuchi et al.[16] Their study[15] demonstrated that the hammock effect increased with greater immersion depth, indicating that the immersion influenced not only an ability of cushion to redistribute pressure but also the length of bony prominence. Iuchi et al[16] compared pressure distributions on a support surfaces across different bed-making methods and bed sheet materials using an anatomical model and a loading device characterised by extreme bony prominences. They identified factors influencing pressure distribution and demonstrated a statistically significant negative correlation between the maximum interface pressure and immersion depth.[16] A previous study by Oette et al, which addressed the dynamics of pressure redistribution from a different perspective, showed that repeated pressure measurements using a commercially available pressure mat did not vary significantly over time, even among participants who could reposition themselves in a wheelchair.[17] They concluded—similar to the present study—that pressure relief activities must be frequent and sufficiently long to promote adequate blood flow to the tissues.[17] Therefore, we recommend that the MIAP should be increased above 22 mmHg in the lateral position to suppress the maximum

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Table 3 Evaluation Attributes of the Interface Pressure Distribution in the Lateral Position

MIAP (mmHg)	13.0	14.0	15.0	16.0	18.0	22.0	23.0	24.0	25.0
Maximum Interface Pressure (Ave.±SD)	61.8±8.1	62.4±13.9	88.2±20.2	66.3±25.5*	68.2±22.6	77.7±4.1*	76.8±4.1*	77.6±3.5*	71.0±3.9*
Maximum Interface Pressure (mmHg)	74.3	95.6	128.9	129.8	122.9	87.1	85.4	85.4	77.7
Minimum Interface Pressure (mmHg)	48.7	47.0	54.6	41.0	46.1	66.6	70.0	70.9	61.5
Rate of Interface Pressure Change	1.7	3.2	5.0	5.9	5.1	1.4	1.0	1.0	1.1
Range (mmHg)	25.6	48.7	74.3	88.8	76.8	20.5	15.4	14.5	16.2

Notes: *denotes statistical significance at $P<0.01$. Unpaired two-tailed t-tests comparing MIAP=16 with MIAP=22, 23, 24, and 25 yielded $P=4.31\times10^{-6}$, 1.37×10^{-5}, 8.69×10^{-6}, and 1.07×10^{-5}, respectively.

interface pressure. However, increasing the MIAP decreases the rate of interface pressure change, which requires more frequent repositionings.

A limitation of this study is that the relationship between the pressure redistribution in the lateral position and shear stress at the common pressure ulcer sites has not yet been quantitatively analysed, leaving this interaction insufficiently understood to date. A clearer understanding of this relationship may enable the establishment of more precise criteria for managing interface pressure in the lateral position. Moreover, another limitation may partly be attributable to specific properties of the air mattress used, such as its fully independent dual-layer air cells, sequential tri-zonal inflation and deflation system, and the materials used for the support surface.

Conclusion

This study examined the effectiveness of interface pressure management using the oval buttocks model[7] in the lateral position. The findings showed that increasing MIAPs above 22 mmHg in the active air mattress could effectively suppress the maximum interface pressure in the lateral position. However, decreasing the rate of interface pressure change in the lateral position requires more frequent repositioning. These findings provide valuable insights into patient repositioning for healthcare professionals and underscore the importance of careful interface pressure management.

Key Messages

- The purpose of this study was to determine the amount of increase in the MIAP of the active air mattress that can minimise the maximum interface pressure during repositioning from the supine to lateral position using the oval buttocks model.[7]
- The results of this study showed that increasing the MIAP of the active air mattress improved pressure redistribution in the lateral position and decreased the maximum interface pressure to 60%.
- In the lateral position, the degree of immersion decreased as the MIAP increased. In addition, complete envelopment was not observed. These factors resulted in a sixfold decrease in the rate of interface pressure change. Consequently, it is essential to increase the frequency of repositioning when lying in the lateral position.

Funding

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Disclosure

The authors report that the oval buttocks model[7] was borrowed free of charge from the Molten Corporation for this study. The authors report no other conflicts of interest in this work.

References

1. Sanada H, Sugama J, Inagaki M, et al. Relationship between internal cushion pressure of air mattress and interface pressure in the bed ridden elderly. *Jpn Soc Med Instrum*. 1995;65:419–427. In Japanese.
2. Sasaki N, Nakagami G, Sakai K, et al. Determining the optimal inner air cell pressure for the effective reduction of interface pressure. *J Tissue Viability*. 2012;21(2):47–53. doi:10.1016/j.jtv.2012.03.002

3. Matsuo J, Sugama J, Sanada H, et al. Development and validity of a new model for assessing pressure redistribution properties of support surfaces. *J Tissue Viability*. 2011;20(2):55–66. doi:10.1016/j.jtv.2010.12.002
4. Kawabata T, Sugama J. Relationship between mattress internal air pressure and interface pressure distribution in the lateral position. *Int Wound J*. 2022;19(8):2115–2123. doi:10.1111/iwj.13817
5. Reddy NP, Patel H, Cochran GV, Brunski JB. Model experiments to study the stress distributions in a seated buttock. *J Biomech*. 1982;15(7):493–504. doi:10.1016/0021-9290(82)90003-3
6. Bain DS, Ferguson-Pell MW, Davies P. An instrument for in-service testing of mattresses. *J Tissue Viability*. 2001;11(4):161–165. doi:10.1016/S0965-206X(01)80004-8
7. Hirose H, Takeda K. Efforts to standardize bedsore prevention equipment. *J Clin Rehabil*. 2002;11:1088–1091. In Japanese.
8. Nawata A, Fukushima T, Igarashi M, et al. Study on deformation of cushions by a simple buttock model. *Jpn J P U*. 2003;5:1–9. In Japanese.
9. Heule EJ, Goossens RH, Mugge R, Dietz E, Heule F. Using an indentation measurement device to assess foam mattress quality. *Ostomy Wound Manage*. 2007;53(11):56–62.
10. Tissue Viability Society. Laboratory measurement of the interface pressures applied by active therapy support surfaces: a consensus document. *J Tissue Viability*. 2010;19(1):2–6. doi:10.1016/j.jtv.2009.11.010
11. National Pressure Ulcer Advisory Panel, Support Surface Standards Initiative. Terms and Definitions Related to Support Surfaces. 2024;4(18):1–3.
12. Yamamoto Y, Nakagami G, Mori T, Sakai K, Sanada H. Evaluation of preventive effect on buttocks immersion of independently controlled inner air cell pressure in air mattress. *J. Jpn. WOCM*. 2011;15(3):239–249. doi:10.32201/jpnwocm.15.3_239
13. Ogawa Y, Mori T, Noguchi H, Nakagami G, Sanada H. Development and evaluation of an air mattress structure and function for reducing discomfort when elevating the head-of-bed. *Disabil Rehabil Assist Technol*. 2015;10(1):81–88. doi:10.3109/17483107.2013.836689
14. Matsuo J, Fukuda M, Iuchi E, et al. Effects of differences in bed-making methods on air mattress pressure redistribution. *J. Jpn. WOCM*. 2013;17(1):33–39. In Japanese.
15. Iizaka S, Nakagami G, Urasaki M, Sanada H. Influence of the "hammock effect" in wheelchair cushion cover on mechanical loading over the ischial tuberosity in an artificial buttocks model. *J Tissue Viability*. 2009;18(2):47–54. doi:10.1016/j.jtv.2008.08.001
16. Iuchi T, Nakajima Y, Fukuda M, et al. Using an extreme bony prominence anatomical model to examine the influence of bed sheet materials and bed-making methods on the distribution of pressure on the support surface. *J Tissue Viability*. 2014;23(2):60–68. doi:10.1016/j.jtv.2014.01.003
17. Oette C, Müller R, Schreff L, Abel R. How Do Everyday Life Activities Affect Seating Pressure Measurements? *Int J Spine Surg*. 2023;17(5):698–705. doi:10.14444/8530