BRITISH JOURNAL OF HOSPITAL MEDICINE

ARTICLE

Preventing postoperative moderate- and high-risk pressure injuries with artificial intelligence-powered smart decompression mattress on in middle-aged and elderly patients: a retrospective cohort analysis

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Abstract

Aims/Background Artificial intelligence technology has attained rapid development in recent years. The integration of artificial intelligence applications into pressure reduction mattresses, giving rise to artificial intelligence-powered pressure reduction mattresses, is expected to provide personalised intelligent pressure reduction solutions, through automatic user's data-based adjustment of the patient's local pressure condition to prevent pressure injury. The purpose of this study was to investigate the effectiveness of artificial intelligence-powered smart decompression in the prevention of postoperative medium- and high-risk pressure injury in middle-aged and elderly patients.

Methods A total of 400 middle-aged and elderly patients admitted to our hospital from June 2021 to December 2023 were selected as study subjects. Patients were categorised into observation and control groups according to the medical record system. General demographic data of the patients were collected. The propensity score matching method was used to balance the baseline data of the two groups of patients. The incidence, severity, complications and sleep quality in the matched study subjects were also compared.

Results After matching, there were 96 patients in the two groups, and the differences in baseline data between the two groups were not statistically significant. Pressure injury and the total incidence of complications in the observation group were significantly lower than those in the control group ($p < 0.05$). Before treatment, there was no difference in the scores of all aspects of the Richards Campbell Sleep Questionnaire between the two groups ($p > 0.05$). After treatment, the scores of all aspects of Richards Campbell Sleep Questionnaire in the observation group were significantly lower than those in the control group ($p < 0.05$).

Conclusion The artificial intelligence-powered smart decompression mattress can significantly prevent moderate- and high-risk pressure injury, effectively reducing the incidence of pressure injury and complications in postoperative long-term bedridden patients, alleviating the severity of pressure injury, relieving the pressure on various parts, and improving the sleep quality of patients.

Key words: Artificial intelligence cloud platform; Pressure injury; Risk of occurrence; Smart decompression mattress

Submitted: 31 March 2024; Revised: 05 June 2024; Accepted: 07 June 2024

How to cite this article: Yang F, Chen H, Shan Y, Che L, Tang Q, Hu F. Preventing postoperative moderate- and high-risk pressure injuries with artificial intelligence-powered smart decompression mattress on in middle-aged and elderly patients: a retrospective cohort analysis. Br J Hosp Med. 2024. https://doi.org/10.12968/hmed.2024.0112

Introduction

Pressure injuries (PIs), also known as pressure sores, are necrosis and ulceration of soft tissues caused by pressure from bony prominences and external hard surfaces. Postoperative PI represents a common yet perilous complication affecting surgical patients, causing considerable distress. Factors such as surgical incisions, changes in body positioning, and prolonged bed rest often contribute to an increased risk of PI in postoperative patients. Pressure injury is caused by a combination of different factors, such as mechanical pressure, friction, shear force, and humidity. Pressure injury occurs mostly in the sacrum, ischial tuberosity, trochanter of the femur, ankle, heel, and sometimes other parts, most often in

hospitalised patients (Aljezawi, 2021; Binsuwaidan et al, 2023). The susceptibility factors of PI mainly include advanced age, tissue perfusion and blood circulation obstruction, malnutrition, etc. Skin erythema is usually the initial symptom of PI, manifesting as extensive necrosis of soft tissue and full-thickness skin damage with the development of the disease, posing huge psychological, economic and social burdens to patients (Niemiec et al, 2020; Kim et al, 2022; Vecin and Gater, 2022). Therefore, how to effectively prevent the occurrence of PI is a common problem confronted by health care personnel worldwide.

At present, the risk of PI is mainly assessed using scales, which have subjective limitations and do not take into account the changes in patients' conditions. The existing treatment methods are not clinically effective, and the PI wounds are typically not managed with reasonably allocated time. Therefore, more effective treatment measures should be selected (Aghdam et al, 2019).

Artificial intelligence is a technology that simulates human intelligence and is applied to smart mattresses to analyse user sleep data, automatically adjust comfort, monitor health status and enable intelligent interaction to provide a better sleep experience. The artificial intelligence (AI) cloud platform can receive the full set of data regarding the smart mattresses in a hospital area, predict the actual situation of each bedridden patient in real time, and identify areas at risk of PI occurrence. At the same time, the smart decompression mattress leverages the powerfulness of cloud medical sleep data and AI technology to meet the individual needs of each patient, helping with the development of personalised treatment plans. Smart decompression mattress can provide assistance with turning over and fluctuation massage executed through pressure sensing to accelerate blood circulation, thus effectively preventing the occurrence of PI, reducing unnecessary waste of medical resources, and thus decreasing medical costs (Bates et al, 2021; Yang et al, 2023).

In the current study, we analysed the clinical data of a retrospective cohort to assess the efficacy of an AI-based smart pressure-relief mattress in preventing postoperative PI. The anticipated findings hold the potential to enhance the quality of care for postoperative patients and to propel the advancement of intelligent medical technologies in clinical applications.

Methods

General information

The clinical data of 400 postoperative patients in geriatrics, rehabilitation medicine, intensive care unit (ICU), orthopaedics, neurology and neurosurgery wards admitted to Affiliated Hospital of Shaoxing University from June 2021 to December 2023 were retrospectively analysed. This cohort included 200 cases in the control group and 200 cases in the observation group. The patients in the control group were given standard air cushion beds, whereas the patients in the observation group were given smart decompression mattress. This was a single-blinded study, and all participants gave verbal informed consent before joining the study. This study was reported to and approved by the ethics committee of Affiliated Hospital of Shaoxing University (Approval No.: 2022research-066-01). The study was conducted in compliance with the Declaration of Helsinki and in strict adherence with the relevant ethical principles, laws and regulations to ensure the rights and dignity of the participants. The general data of patients were collected, including gender, age, weight, education level, Braden score (Kottner et al, 2020), department distribution, and bed rest status.

Only participants meeting the inclusion criteria were included in this study: (1) patients with Braden score ≤16; (2) patients with vital signs that were relatively stable or fluctuating within the normal range; (3) patients with complete medical records and relevant examination data; (4) patients weighing less than 180kg; and (5) patients aged ≥18 years old.

Individuals exhibiting the characteristics below were excluded: (1) patients with PI in the iliac or sacrococcygeal region; (2) patients suffering from serious infectious diseases; (3) patients with mental disorders; (4) lactating or pregnant women; (5) patients with severe heart, liver, lung, kidney dysfunction; (6) patients with spinal or pelvic instability injury; and (7) patients who had just undergone skin grafting in the sacral area.

After careful selection, 400 patients were eligible for inclusion, and the included subjects in the observation and control groups were matched based on the calculated propensity

score (PS), to balance the baseline data of the two groups of patients based on gender, age, length of hospitalisation, and risk of PI occurrence. Eventually, 96 patients from the two groups were properly matched.

Methods

Control group

The control group received routine treatment.

(1) Patients in this group used the standard air cushion available in the hospital (Equipment No. 20000051, Shanghai San He Medical Device Co., Ltd., Shanghai Food and Drug Supervision, Shanghai, China).

(2) Preventive skin treatment was applied to this group. The utilisation of alkaline soaps and cleaners was avoided. Isolation products were gently applied onto the skin to protect it from moisture. It is recommended to use highly absorbable incontinence products, textiles with low friction coefficient, and silicone foam dressings to protect the skin areas that are at risk for PI.

(3) Patients with moderate and high risk for PI were given well-formulated meals catering to their nutritional needs so as to avoid malnutrition.

(4) All subjects were scheduled for a daily 2-hour turnover, and the turnover frequency was determined by the individual's activity level, flexibility, ability to make position changes independently, skin and tissue tolerance, general health, overall treatment goals, comfort, and pain. For bedridden patients, a 30° lateral position is better than a 90° lateral position. The patient's head should ideally lie on the bed as flat as possible, and they were encouraged to assume a 20–30° lateral sleeping position. Caution should be exercised not to elevate the position higher than 30° when the patients need to raise the head to prevent ventilator-associated pneumonia.

(5) According to the Guidelines for the Prevention and Treatment of PI (2019 version) formulated by the American Pressure Injury Advisory Committee (NPUAP) (Stefanopoulos et al, 2023), there are six PI stages ranked in terms of their severity:
   (i) Stage I: The epidermis is intact and there is non-tanning erythema.
   (ii) Stage II: Local epidermal exposure or damage to the dermis, which may be manifested as blisters, wear, etc.
   (iii) Stage III: PI involves full-thickness skin, resulting in loss, and adipose tissue can be seen without fascia, tendon, and cartilage being exposed.
   (iv) Stage IV: The whole cortex and tissue were damaged, and the fascia, tendon, and cartilage were exposed.
   (v) Deep tissue involvement: Due to pressure, deep tissue damaged by shear force can develop into eschar, resulting in a local persistent colour change of intact skin from purple to maroon.
   (vi) Unstageable: Obscured by debris, carrion, or eschar, the extent of tissue damage cannot be determined.

   Targeted treatment was carried out according to different stages of PI.
   (i) Treatment for stage I patients: The local skin was cleaned with warm water and then dried. Subsequently, the hydrocolloid dressing was directly attached to the affected area, which was changed once every 5–7 days.
   (ii) Treatment for stage II patients: After cleaning the affected area, Meibao moist burn ointment (40 g/each; Shantou Meibao Pharmaceutical Co., Ltd., Guangdong, China; Chinese Medicine approval no.: Z20000004) was applied directly twice a day, and then covered with sterile gauze.
   (iii) Treatment for stage III to IV patients: After saline irrigation, oxygen blowing therapy was applied once a day, 20 min each time, with an oxygen flow of 6–8 L/min. Meibao moist burn ointment was applied to the wounds following the same procedure described in the above, and the dressing was changed once a day.
   (iv) Treatment for patients deep tissue involvement or who were unstageable: After 2 to 3 days, vascular forceps and sterile scissors were used to separate and cut off the necrotic tissue, and then debridement glue (about 5 mm thick) was applied to the necrotic tissue area, and normal saline-soaked gauze was applied as wet

compress, and debridement is performed while lysing the necrotic tissue to avoid pain and bleeding.

Observation group

The patients in the observation group were instructed to use AI-powered smart decompression mattresses.

(1) The patients were briefed by the medical staff through the mobile phone app or tablets to carry out mattress binding operation. In the app, the participants could instantly log in through a pop-up window, which is convenient for quick authorisation. After logging in, 'Bind now' was selected, and the same device was used to scan the two-dimensional code on the mattress in order to connect the device for binding operation. Subsequently, the medical staff introduced the basic operations such as how to view the pressure map and heat map, rename, share information, connect to the Bluetooth network, and view the information status of the mattress.

(2) The main functions of the smart mattress were introduced and explained to the patients by the medical staff. The main contents were as follows:

(i) Precise control of pressure function. The smart mattress can transmit the pressure signals received by the mattress surface to the cloud intelligent control system, and then the cloud control system will calculate and analyse the pressure exerted onto various parts of the human body according to the pressure distribution signals, height, weight and other parameters to generate a pressure map. The integration of the pressure map and heat map gives rise to the real time image of the specified mattress and the airbag pressure, based upon which the key parts and airbag can be selected for treatment accordingly (Figure 1).

(ii) Cloud medical sleep data + AI function. By leveraging the powerfulness of the combination of cloud medical sleep data with AI, a corresponding sleep plan

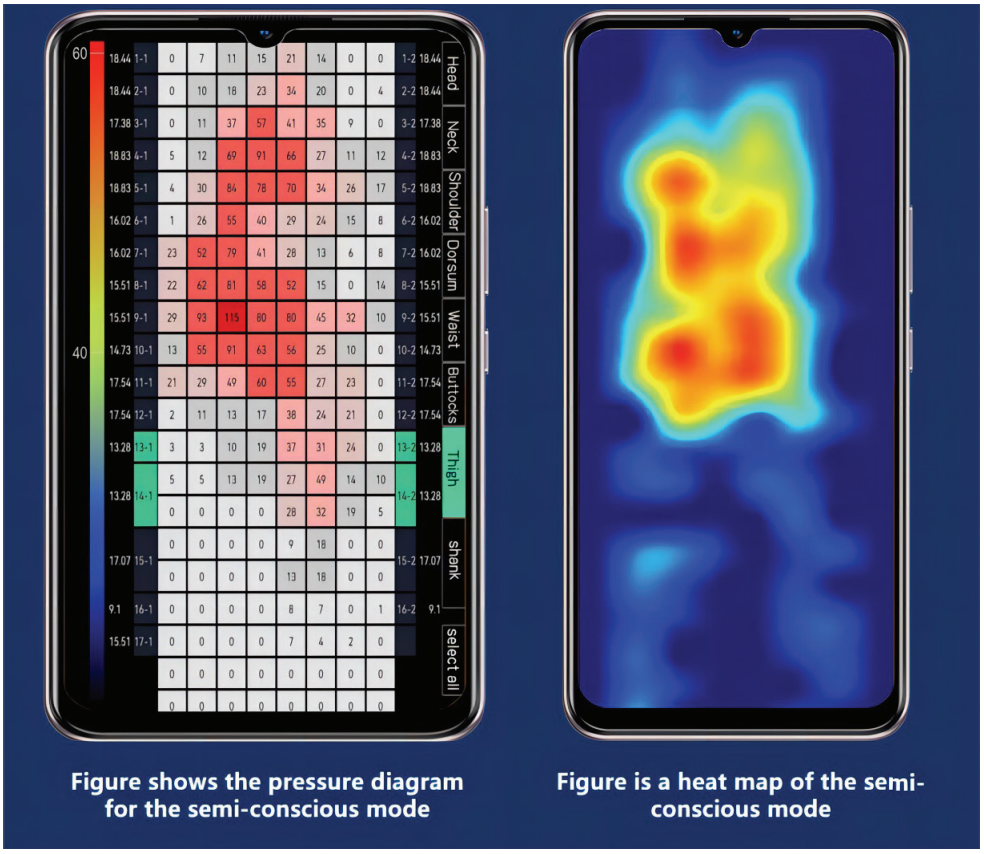

Figure 1. Digital data of pressure exerted onto different body parts of a patient (left panel) and their visualisation as a heat map (right panel). The colour intensity is a measure of pressure: the darker the colour, the higher the pressure.

can be formulated for each patient using the mattress, since the whole bed is designed to sense and register the changing pressure exerted onto the body. The mattress can actively adapt to the body curve, and the fluctuating massage and auxiliary turning-over features of the mattress can facilitate comfortable sleep and avoid the risk of PI.

(iii) Intelligent function of the hospital. The cloud management platform can fully access the data of all smart decompression mattresses in the hospital, and display the dynamic situation of bedridden patients in real time.

(3) The medical staff also explained and demonstrated the switch between manual operation and automatic mode for the patients. The mattress can be automatically adjusted after being integrated with to a patient's pressure data. After leaving the bed, the mattress will automatically return to its flat state in a short period of time, and the automatic mode can be turned off by pressing a button. The manual operation can be manoeuvred on eight disparate parts, corresponding to the head, neck, shoulder, back, waist, hip, thigh, and calf, which can be adjusted by lifting operation.

(4) The smart decompression mattress is available into four different modes, namely comfort mode, awake mode, semi-awake mode, and pressure ulcer prevention mode. Medical staff can guide patients on using the right mode according to their own physical conditions. These four modes of the smart pressure-reducing mattress are described as follows:

(i) Comfort mode: It is suitable for most patient groups with low risk for PI who would like to pursue comfortable mode.

(ii) Awake mode: It is suitable for the patient group with clear cognition, smooth communication, low risk for PI, weakened activity due to disease, and high comfort needs, as well as requiring long-term rest in bed. The operation steps of the awake mode are as follows: Maintain full body support and body swings for 60 minutes, then maintain rest for 60 minutes, then maintain rest for 60 minutes, then maintain full body support and body swings for 60 minutes, then maintain rest for 60 minutes, then maintain rest for 60 minutes, then maintain rest for 60 minutes, then maintain rest for 60 minutes, then maintain rest for 60 minutes.

(iii) Semi-awake mode: It is suitable for those with clear cognition, slight responsiveness to questions, high risk for PI, inability to communicate smoothly, and significantly weakened mobility, as well as needing assistance from others to turn over. The operation steps of semi-awake mode are as follows: The whole-body support and body fluctuation are conducted for 30 minutes, then held still for 30 minutes. Next, the body is turned to the right and held for 30 minutes, then held still for 30 minutes. Finally, the body is turned to the left and held for 30 minutes. The steps described above constitute a cycle.

(iv) Pressure ulcer prevention mode (default mode): It is suitable for comatose patients, those who are completely bedridden due to paraplegia, disease, and major surgery, or those who cannot take care of themselves independently. The operation steps of this mode are the same as those of the awake mode, but mainly based on the pressure value of the skin vulnerable to damage, as well as the state of the skin and consciousness of the patient. With these factors taken into consideration, various turning modes can be adjusted and selected. Adjustment times for rolling over and lying down vary, for example, after 20 minutes of holding steady exercise, hold the right side for 20 minutes after rolling over, and after 60 minutes of holding steady exercise, hold the left side for 20 minutes after rolling over, and then lie down.

(5) If the smart mattress used by the patient fails to deliver its function, the medical staff should timely report, adjust and replace the faulty mattress. Before the smart mattress is replaced, the patient should be manually turned over every 2 hours to avoid causing or aggravating PI.

Observation indicators

The incidence and severity of PI, complications and sleep quality were compared between the two groups. The parameters below were collected on admission and at 15 days of hospitalisation.

(1) The incidence and severity of PI of the study subjects determined according to the NPUAP criteria were compared. The pressure in various body parts of the study subjects in the observation group was recorded, including sacrococcygeal region, heel region, scapular region, leg region, and occipital region. There were six stages of PI, including stage I, stage II, stage III, stage IV, deep tissue involvement, and unstageable (Zhao et al, 2023). Finally, the total incidence of PI was determined.
(2) The incidence of PI complications, including abscess, infectious arthritis, necrotising fasciitis, combined osteomyelitis, and sinus tract, was statistically recorded, and the total incidence was calculated.
(3) Richards Campbell Sleep Questionnaire (RCSQ) Scale (Zhang et al, 2020) was used to evaluate the sleep quality of the subjects. The RCSQ scale consists of sleep depth, awakening frequency, the difficulty of falling asleep, difficulty of falling asleep again, and overall sleep quality. The full score of each item was 10, and the lower the score, the better the sleep quality of the patients. Pre-treatment data refer to those collected at the time of admission, and post-treatment data represent the mean of sleep quality over 15 days.
(4) The activity of daily living (ADL) Scale was utilised to evaluate the level of patients' self-care. According to this scale, 100 points refer to self-care; 60 points or more denote basic self-care; 40–60 points indicate living with assistance; 20–40 points denote living with a great deal of assistance; and 20 points or less refer to living with total dependence (Tramontano et al, 2022).
(5) The National Institute of Health Stroke Scale (NIHSS) was used to assess the level of consciousness (including level of consciousness questions and level of consciousness commands), gaze, visual field, facial palsy, upper limb movement, lower limb movement, limb ataxia, sensation, speech, dysarthria, and neglect. This scale has a total score of 42 points, with a higher score indicating more severe neurologic damage (Yamal and Grotta, 2021).

Statistical analysis

IBM SPSS Statistics for Windows, version 27.0 (IBM Corp., Armonk, NY, USA) was used for statistical analysis. Categorical data are expressed as percentages and were analysed using the Chi-squared test. When $1 \leq$ theoretical frequency < 5, the correction formula of the Chi-squared test was used. Quantitative data conforming to the normal distribution were expressed as mean ± standard deviation ($\bar{x} \pm s$) and those not conforming to the normal distribution were transformed into the normal distribution before statistical analysis. *t*-test was used to analyse the quantitative data. $p < 0.05$ was considered statistically significant. The gender, age, weight, education level, Braden score, department distribution, and bed rest status were selected as covariates, which were the independent variables, with treatments as dependent variables. The PS was calculated by logistic regression analysis, and the observation group and the control group were matched according to the 1:1 ratio nearest neighbour matching method. The absolute difference in PS between the two groups was taken to be 0.02; Calliper values were taken at 0.02.

Results

Comparison of general data of subjects

Before matching, there were differences in body weight, Braden score and bed rest status between the observation group and the control group ($p < 0.05$). After matching, there were 48 cases in each group, and the general data such as gender, age, weight, education level, Braden score, department distribution, and bed rest were not significantly different between the two groups ($p > 0.05$), as shown in Table 1.

Comparison of the incidence and severity of pressure injury

The total incidence of PI in the observation group (16.67%) was lower than that in the control group (35.42%) ($p < 0.05$), as shown in Table 2.

Table 1. Comparison of general data between the observation and control groups

Indicators		Before matching				After matching			
		Observation group (n=200)	Control group (n=200)	χ^2/t	*p*	Observation group (n=48)	Control group (n=48)	χ^2/t	*p*
Age (years)		68.25 ± 7.63	67.84 ± 7.46	0.543	0.587	69.33 ± 7.52	68.67 ± 7.60	0.428	0.670
Gender (n, %)	Male	126 (63.00)	121 (60.50)	0.265	0.607	30 (62.50)	27 (56.25)	0.389	0.533
	Female	74 (37.00)	79 (39.50)			18 (37.50)	21 (43.75)		
Body weight (kg/m^2)		24.62 ± 3.86	22.27 ± 3.54	6.345	< 0.05	23.44 ± 2.43	23.81 ± 2.78	0.694	0.489
Level of educated (n, %)	Below high school	139 (69.50)	144 (72.00)	0.302	0.583	31 (64.58)	34 (70.83)	0.429	0.513
	High school and above	61 (30.50)	56 (28.00)			17 (35.42)	14 (29.17)		
Braden score		12.23 ± 1.46	11.34 ± 1.24	6.571	< 0.05	11.37 ± 1.51	11.26 ± 1.45	0.364	0.717
Department distribution (n, %)	Department of Geriatrics	89 (44.50)	85 (42.50)	1.267	0.938	22 (45.83)	20 (41.67)	1.752	0.882
	Department of Rehabilitation Medicine	76 (38.00)	74 (37.00)			19 (39.58)	16 (33.33)		
	ICU	9 (4.50)	12 (6.00)			2 (4.17)	4 (8.33)		
	Department of Orthopaedics	10 (5.00)	9 (4.50)			2 (4.17)	3 (6.25)		
	Department of Neurology	6 (3.00)	6 (3.00)			1 (2.08)	2 (4.17)		
	Department of Neurosurgery	10 (5.00)	14 (7.00)			2 (4.17)	3 (6.25)		
Bed rest status (n, %)	Stay in bed before enrolment	143 (71.50)	123 (61.50)	4.489	< 0.05	35 (72.92)	32 (66.67)	0.445	0.505
	Not in bed before enrolment	57 (28.50)	77 (38.50)			13 (27.08)	16 (33.33)		

Note: Data are presented as count (percentage). ICU, intensive care unit.

Comparison of complications

The total incidence of complications in the observation group (8.33%) was lower than that in the control group (25.00%) ($p < 0.05$), as shown in Table 3.

Comparison of sleep quality

Before treatment, there was no difference in the scores of all aspects of RCSQ between the observation group and the control group ($p > 0.05$). After treatment, the scores of all aspects of RCSQ in the observation group were significantly lower than those in the control group ($p < 0.05$), as shown in Table 4.

Comparison of activity of daily living and National Institute of Health Stroke Scale scores

There was no difference in the ADL scores between the observation group and the control group before treatment ($p > 0.05$). However, the patients in the observation group had significantly higher ADL scores than those in the control group after treatment ($p < 0.05$). Before treatment, there was no difference in the NIHSS scores between the observation group

Table 2. Comparison of the occurrence and severity of pressure injury between the observation and control groups

Group	n	Stage I	Stage II	Stage III	Stage IV	Deep tissue involvement	Unstageable	Overall incidence
Observation group	48	4 (8.33)	2 (4.17)	1 (2.08)	1 (2.08)	0 (0.00)	0 (0.00)	8 (16.67)
Control group	48	6 (12.50)	3 (6.25)	4 (8.33)	2 (4.17)	1 (2.08)	1 (2.08)	17 (35.42)
χ^2	-	-	-	-	-	-	-	4.381
p	-	-	-	-	-	-	-	0.036

Note: Data are presented as count (percentage).

Table 3. Comparison of complications between the observation and control groups

Group	n	Abscess	Infectious arthritis	Necrotising fasciitis	Osteomyelitis	Sinus tract	Overall incidence
Observation group	48	1 (2.08)	1 (2.08)	1 (2.08)	0 (0.00)	1 (2.08)	4 (8.33)
Control group	48	4 (8.33)	2 (4.17)	3 (6.25)	1 (2.08)	2 (2.08)	12 (25.00)
χ^2	-	-	-	-	-	-	4.800
p	-	-	-	-	-	-	0.029

Note: Data are presented as count (percentage).

and the control group ($p > 0.05$). After treatment, the NIHSS scores of the observation group were significantly lower than those of the control group ($p < 0.05$), as shown in Table 5.

Discussion

Pressure injury is the disabling consequence of long-term immobility, marked by complex aetiology. At present, the occurrence of PI shows an ageing trend, influencing the morbidity and mortality of affected individuals. Among patients who need to be hospitalised for 1 year, the global mortality rate of PI has exceeded 60% (Arora et al, 2020; Ting and Garnett, 2021; Tesfa Mengist et al, 2022). In foreign countries, PI is rated as one of the five adverse events, affecting the physical and mental health of patients, although it is largely considered to be preventable (Sutherland-Fraser et al, 2012). Conventional treatment is essentially preventive in nature, involving regular turnover and skin cleaning. However, the current obstacles facing most medical staff are the lack of PI treatment knowledge and the severe shortage of nursing manpower; having said that, conventional treatment can no longer meet the current clinical needs (Lau et al, 2022). The smart decompression mattress operating based on the AI cloud platform entails the covering of the whole bed with sensors and high-efficiency air exchange components and achieves 99% fit with the human body curve through 33 elastic air units, representing a new and effective treatment method.

According to Tak et al (2023) and Bai et al (2020), the occurrence of PI can be significantly reduced through the use of the smart mattress, which is highly auxiliary, easy to use and highly acceptable, and can effectively improve the sleep quality of patients, enhance the comfort of patients and reduce the risk of PI. These studies were consistent with the results of this study, which showed that the total incidence of PI in the observation group was significantly lower than that in the control group. After treatment, the scores of all aspects of RCSQ in the observation group were significantly lower than those in the control group. Therefore, the sleep quality of the observation group was significantly higher than that of the control group, and the incidence of PI was lower than that of the control group. According to Xu et al (2016) sleep position is an influencing factor in sleep quality and is instrumental to PI prevention. There are four modes of smart decompression mattresses, based upon which

Table 4. Comparison of sleep quality in the observation and control groups

Group	Sleep depth (min)		Number of awakenings (min)		Difficulty in falling asleep (score)		Difficulty in falling asleep again (score)		Overall sleep quality (score)	
	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
Observation group	6.37 ± 1.23	3.51 ± 0.77	6.26 ± 1.35	2.67 ± 0.64	5.93 ± 1.18	2.88 ± 0.59	6.12 ± 1.24	3.79 ± 0.71	6.84 ± 1.51	3.67 ± 0.71
Control group	6.42 ± 1.31	4.02 ± 0.83	6.23 ± 1.23	3.74 ± 0.76	5.88 ± 1.22	3.26 ± 0.73	6.05 ± 1.29	4.23 ± 0.84	6.79 ± 1.42	4.21 ± 0.86
t	0.193	3.121	0.114	7.461	0.204	2.805	0.271	2.772	0.167	3.355
p	0.848	0.002	0.910	< 0.001	0.839	0.006	0.787	0.007	0.868	0.001

Note: Data are presented as mean ± standard deviation. n=48.

personalised treatment plans can be tailored for different individual conditions. These scientifically proven modes can aid in sleeping, ensure at least two times of rest in each cycle by increasing the turning step, accurately obtain the pressure data of various parts of the body to guide position changing at a regular time, and moderately reduce the pressure exerted onto the body. These measures, which can be achieved by the smart mattress can help prevent local skin problems faced by patients due to the lack of understanding of PI and its prevention among the medical staff (Ilyas and Rathore, 2020; Guo et al, 2023). Some studies (Saegusa et al, 2018; Ruan et al, 2023) have shown that the use of air cushion treatment can reduce the occurrence of PI. In this study, the whole-bed fluctuation massage was utilised, achieved using a wavy bed surface to promote blood circulation, thereby replacing manual massage and removing the need of manual turnover and massage, which is a burdensome endeavour for family members and medical staff. Using the smart decompression mattress can also prevent the occurrence of PI and reduce hospitalisation time and accompanying costs. Moreover, with the auxiliary turning function, the mattress can automatically adapt to the body curve, reducing the risk of PI due to improper sleep posture (Heo et al, 2022). At the same time, it can reduce the frequency of night disturbance and awakening, create a quiet and comfortable sleep environment, improve overall sleep quality and physical and mental health, and hence reduce the incidence of PI.

According to Nixon et al (2019) and Marshall et al (2019), by using a smart mattress, local pressure can be adjusted so as to prevent the occurrence of adverse events attributable to equipment, thereby preventing PI and ultimately reducing the complications of PI. The above studies were consistent with the results of this study, which showed that the total incidence of complications in the observation group was lower than that in the control group ($p < 0.05$). This indicates that the treatment of AI-powered smart decompression mattresses can relieve the pressure on various body parts of the patient, thereby reducing the incidence of complications. While applying the conventional treatment, medical staff mostly use manual scale to analyse the physical condition and pressure burden of patients at the present stage. Such a method is time-consuming and less efficient, and yields data that are inconsistent with the patient's actual condition—a typical situation leading to untimely treatment and increased pressure burden. The smart decompression mattress has four modes to customise the pressure on each part of the human body according to the pressure requirements of different body parts, which vary from person to person, so as to achieve pressure equalisation and relieve pressure. The sensors covering the whole bed are used to collect and record pressure data, which are reflected through the pressure map and heat map in real time. Thus, this would be convenient for effectively reducing the pressure burden on indicated body parts, decreasing the time and effort spent on manual treatment, improving the quality of life of patients, and preventing complications caused by improper protection (Manley and Mitchell, 2022). On the other hand, the smart decompression mattress can achieve a high-end treatment: For patients who are inconvenient to move, the mattress can automatically identify the parts affected by high pressure, and adjust the air in the high-flow air exchange module connected to the air elastic unit to automatically disperse pressure and prevent pressure build-up, while altering the mattress's horizontal position within the range of 15° to 25° to assist with turning over.

Table 5. Comparison of activity of daily living and National Institute of Health Stroke Scale scores

	ADL scores		NIHSS scores	
Group	Before treatment	After treatment	Before treatment	After treatment
Observation group	48.35 ± 3.43	62.33 ± 5.20	32.63 ± 2.97	19.42 ± 1.82
Control group	47.93 ± 3.49	59.16 ± 5.09	31.98 ± 2.71	20.65 ± 2.01
t	0.561	2.835	1.062	–2.984
p	0.576	0.006	0.291	0.004

Note: Data are presented as mean ± standard deviation. ADL, activity of daily living; NIHSS, National Institute of Health Stroke Scale.

To foster rapid rehabilitation, the level of intelligent treatments available in the hospital should be improved, and a comfortable and intelligent rehabilitation environment should be constructed for patients with moderate and high risk of PI. The smart mattress under investigation can also perform intelligent decompression and pressure adjustment on local parts affected by high pressure while the patient is still at rest, so as to relieve the pressure burden attributed to the body weight after a long time of inactivity and help the patient get adapted to the standard mattress, thereby reducing the length of hospital stay and medical expenses. The effective use of medical resources can relieve psychological pressure, prevent the risk of nosocomial infection, promote the rehabilitation process of patients, and reduce the occurrence of complications, which is worthy of clinical promotion (Montoya and Mody, 2011; Han et al, 2023).

Maintaining the same posture for a long period of time can lead to persistent pressure on local tissues and impeded epidermal sweat and heat release, making pressure ulcers more likely to occur. In order to address this pressure ulcer trigger, it is especially important to adjust the patient's posture considering the patient's condition. Pressure equalisation and pressure relief can effectively prevent pressure ulcers from occurring by changing the main stress areas. In this study, the incidence rate of pressure ulcers in the observation group was 35.42%, and the incidence rate of pressure ulcers in the control group was 16.67%, indicating that intelligent pressure relief can effectively prevent the occurrence of pressure ulcers. Compared with traditional mattresses, smart pressure-reducing mattresses can alleviate local pressure and reduce the incidence of pressure ulcers, a result that aligns well with the findings by Shi et al (2021). However, due to the high cost of production and implementation, smart pressure-reducing mattresses have not yet widely adopted by most hospitals, although studies have proven that they can prevent and mitigate complications in patients with moderate to high risk for pressure ulcers.

This study used the PS matching (PSM) method to reduce the interference by confounding factors. Several limitations of this study should be highlighted. Firstly, this study used a small sample, in which inter-individual physical differences among the participants might exist, and the participant recruitment process may present selection bias. Future studies should appropriately increase the sample size, reduce the impact of individual factors on the investigation, and increase the validity of the study. Secondly, the population included in this study is middle-aged and elderly patients. Thus, further study should consider including teenage patients to diversify the age groups of the sample. Finally, all participants in this study were recruited from the same hospital. Hence, a multicenter clinical study is warranted to increase the generalizability of the findings obtained.

Conclusion

In conclusion, the treatment utilising AI-powered smart decompression mattresses for postoperative long-term bedridden patients is beneficial to reduce the risk of PI and improve sleep quality. Therefore, the AI-powered smart decompression mattress should be advocated for clinical application.

Key points

- This study showed that the total incidence of PI and complications in the observation group were significantly lower than those in the control group, and the quality of sleep and ability to perform daily life in the observation group improved and the degree of nerve damage was reduced after the intervention.
- Combining the application of AI with pressure-reducing mattresses to enable the personalisation of pressure-reducing solutions that help deter the occurrence of pressure damage is the innovative highlight of this study.
- This study found that the AI-powered smart pressure-reducing mattress can effectively prevent postoperative pressure injury among middle-aged and elderly patients.
- This study adopted a retrospective cohort analysis, a rigorous research design that reduces the impact of interventions on patients and also provides more realistic and reliable findings.

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Availability of data and materials

The datasets used and/or analysed during the current study were available from the corresponding author on reasonable request.

Author contributions

FYY and HYC designed the study. All authors conducted the study. QT, FLH, YJS and LPC collected and analysed the data. QT and FLH participated in drafting the manuscript, and all authors contributed to the critical revision of the manuscript for important intellectual content. All authors gave final approval of the version to be published. All authors participated fully in the work, take public responsibility for appropriate portions of the content, and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or completeness of any part of the work are appropriately investigated and resolved.

Ethics approval and consent to participate

All participants gave verbal informed consent before joining the study. This study was reported to and approved by the ethics committee of Affiliated Hospital of Shaoxing University (Approval No.: 2022research-066-01).

Acknowledgement

Not applicable.

Funding

This research was funded by Zhejiang Province Medicine and Health Science and Technology Programme (2023KY370).

Conflict of interest

The authors declare no conflict of interest.

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