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A Multidisciplinary Integrative Innovative Mattress Design to Prevent Pressure Injury for Palliative Care in the Community in Thailand

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Abstract: A pressure injury is a severe complication that causes excessive interface pressure on a bony prominence and usually occurs in palliative patients in the community. The article describes a new healthcare innovation, A lateral tilting mattress (LTM), based on the pressure injury pathophysiology principle. This modern nursing innovation, created by a multidisciplinary team that could adjust a patient's head and knee and rotate to the left and right, may decrease interface pressure over bony prominences in palliative patients. This experimental research design of 70 palliative home-based patients examined the effectiveness of LTM on pressure injury healing scores and family caregiver's quality of life levels over time from September 2019 to May 2020. We examined differences in patients' pressure injury healing scores and family caregivers' quality of life levels between the different groups: LTM versus no-LTM. Significant time by group interactions was found on patients' pressure injury healing ($F = 235.123$, $p < .01$) and family caregivers' quality of life ($p < .05$) in the LTM versus no LTM group. The results provide evidence for the effectiveness of LTM in improving pressure injury healing scores that may decrease interface pressure over bony prominences in palliative patients and the overall quality of life levels in family caregivers. The findings also suggest the need for further healthcare innovation to improve the quality of care for palliative patients, increase the quality of life (or decrease stress level) among family caregivers, and reduce workloads and danger for caregivers.

Keywords: Lateral tilting mattress, Quality of life, Palliative, Pressure injury, Pressure ulcer.

多學科綜合創新床墊設計，可預防泰國社區姑息治療時的壓力傷害

摘要：壓迫性損傷是一種嚴重的並發症，在骨突出部上引起過度的界面壓力，通常發生在社區的姑息患者中。由多學科團隊創建的橫向傾斜床墊（LTM）是一項現代護理創新，可以調節患者的頭部和膝蓋並向左和向右旋轉，可以減輕姑息患者骨骼突出時的界面壓力。這項針對 70 位姑息性家庭患者的實驗研究設計研究了 LTM 對 2019 年 9 月至 2020 年 5 月間壓力損傷癒合評分和家庭護理人員的生活質量的有效性。將姑息性家庭患者和家庭護理人員隨機分配給 LTM 或沒有 LTM。我們研究了 LTM 與不-LTM 在不同組之間患者的壓力損傷癒合得分和家庭護理人員的生活質量的差異。與沒有 LTM 組相比，在 LTM 組患者的壓力損傷癒合（ $F = 235.123$, $p < .01$ ）和家庭護理人員的生活質量（ $p < .05$ ）上，通過小組互動的時間明顯增加。結果為 LTM 在改善壓力損傷癒合評分方面的有效性提供了證據，該評分可能會減輕姑息患者的骨突起上的界面壓力，並降低家庭護理人員的整體生活質量。研究結果還表明，需要進一步的醫療保健創新，以改善姑息患者的護理質量，增加家庭護理人員的生活質量（或降低壓力水平），減少工作量以及護理人員的危險風險。

关键词：橫向傾斜床墊，生活質量，姑息性，壓傷，壓瘡。

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1. Introduction

Pressure injuries (PIs) are a severe complication that may occur in immobilized patients under palliative care in home-based care [1-3]. The limited movement results in a loss of muscle mass, thinning skin, loss of tissue elasticity, impaired pressure-distributing ability, tissue blood flow, and the tendency to develop PIs [2-3]. Interface pressure, shearing, and friction are significant factors in the occurrence of PIs. These factors contribute to tissue tearing, leading to wounds and obstructive subcutaneous capillaries, resulting in insufficient blood flow to tissues in pressure areas. As a result, the skin and tissues lack oxygen, and waste is accumulated in cells, eventually leading to skin and tissue death [4-9].

Turning/ repositioning is an essential and necessary activity in preventing PIs, especially in immobilized patients [1,11,12]. Studies have shown that a 30-degree lateral tilt reduces pressure, allowing oxygen to feed tissues and preventing PIs [10]. However, turning patients with limited movement requires proper techniques and may be complicated because of pathological conditions and chronic illnesses. Some family caregivers are reluctant to turn patients, whereas others may be negligent about turning at a minimum of two-hour intervals. It has explained why the incidence of home-acquired pressure injuries in home-based patients is increased [13-14].

Nowadays, the need for in-home care has been increasing among palliative patients, resulting in an increase in the families' responsibilities in taking care of patients. Therefore, inventing an innovative device is crucial to facilitate the turning or repositioning of patients, such as in the right lateral decubitus, so that the repositioning would become simpler and more convenient. Qualitative studies that involve innovative PIs have shown that most patients commonly sleep on a regular mattress placed on the floor that cannot adjust a patient's head and knee and rotate to the left and right. There are no innovative mattress designs that can help reposition patients on their left and right without other accessories involved. Therefore, the research team aimed to develop an inexpensive yet efficient mattress using domestic resources to reduce the repositioning burden.

1.1. Objective

To study the effectiveness of the lateral tilting mattress (LTM) by:

1.1.1 Comparing pressure injury healing scores between the experimental group using the lateral turning mattress (LTM) and the control group using conventional care

1.1.2. Comparing pressure injury healing scores before and after using the LTM

1.1.3. Comparing quality-of-life levels between the caregivers of the experimental group and the control group.

2. Methods and Materials

2.1. Participants

This experimental research design of 70 palliative home-based patients examined the effectiveness of LTM on pressure injury healing scores and family caregiver's quality of life levels over time from September 2019 to May 2020.

In this study, the sample size was calculated via the power analysis using the G*Power program [15]. Based on previous research [16] using $\alpha = 0.05$, power = 0.8, medium influence factor (w) = 0.6, and a single-tailed test, a sample size of 70 in total was obtained; 35 participants were assigned to the experimental group, and the other 35 were assigned to the control group. Physical characteristics of both groups – BMI, hematocrit levels, pressure ulcer risk scores, and albumin levels – were the same.

2.2. Research Method

The LTM, a new type of mattress in a double-layer steel frame, 90 cm wide, 200 cm long, and approximately 30 cm thick, was designed with two longitudinal planes to help turn patients on their left and right at 0 to 30 degrees. Turning patients on their left or right were accomplished by lifting the opposite-side steel frame, attached to four supporting hinged steel legs, at a 30-degree angle. The hinges allowed the legs to be folded under the mattress (as shown in Figure 1). This innovation has been designed by a researcher and created by the staff of the Faculty of Engineering at Thammasat University. With a guarantee of quality, the calculation of the bed-strength structure is performed along the horizontal and vertical axes during loading. The yield strength of the material is generally more significant than the standard yield strength (factor of safety = 2) and is certified to be 150 kg or 330 lb. The result of the safety factor of LTM is 2.0–3.6.

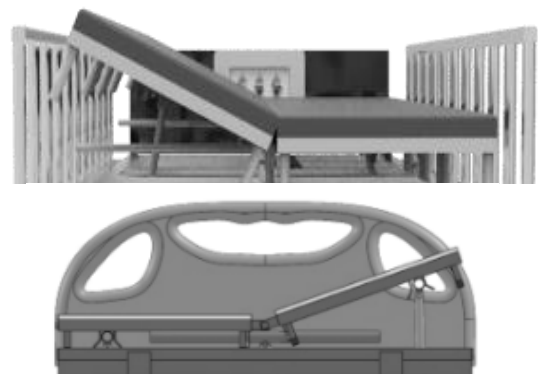


Fig. 1 Features of established LTM model

After designing the movement mechanism, it is necessary to calculate the material strength of various parts of the bed to meet the desired 100 kg weight-bearing ability of the LTM. The finite element method was applied for calculation through a three-dimensional

design program. The calculation of material strength was performed along with the different axes of the bed frame. The material stress was then predicted. The predicted stress value must be less than twofold of the material yield stress (factor of safety ≥ 2). The factor of safety of the LTM was more than 2 in all parts tested: in left- and right-side lifting = 3.1, x-axis = 3.6, and y-axis = 2.

This LTM was based on an engineering design principle on the movement of mattress parts, all of which were medical grade for use in medical equipment and tested per medical standards and technical safety in medical engineering.

The participants in the control group used standard thickness-type and single-plane mattresses that cannot adjust a patient's head and knee and rotate to the left and right.

2.2.2 The Pressure injury healing scores (Pressure Ulcer Scale for Healing-PUSH) were created by the National Pressure Ulcer Advisory Panel [17] to track the progress of the wound healing rate weekly. Based on the ulcer status assessment criteria, the maximum score of 17 indicates that the ulcer is severe, and a score of 0 indicates that the ulcer has healed.

The wound healing scores were assessed on Days 1, 7, 14, and 21 after the participation. Cronbach's alpha coefficient was 0.91, and inter-rater reliability was 1.00.

3. Data Collection Procedure

Seventy Community palliative participants were randomly allocated to the experimental group using the LTM ($n=35$) and the control group using a conventional mattress ($n=35$). The SPSS version 22.0 was used to generate random numbers of equivalent participants in each group.

In the intervention group, the researcher took the LTM, booklet, and DVD to the patients' homes to advise and teach the caregivers individually about the general nature of PIs, strategies of preventing PIs, skin assessment, patient positioning, the approximate two-hour repositioning, and how to use the turning mechanism. The researcher then demonstrated and re-demonstrated until the caregivers could use and manage the turning beds appropriately. For the control group, the researcher took the booklet and DVD to the patients' homes to advise and teach them individually about the same aspects as the intervention group, minus the LTM.

4. Results

Community palliative participants ($N = 70$; mean age = 54.48 years [standard deviation, $SD = 5.12$], range = 43–63 years) with the average body weight 48.83 kg (range 40–60 kg [$SD = 5.39$]), mean body height 1.56 ± 0.07 cm (range = 142–171 cm), mean body mass index 16.81 ± 1.72 kg/m² (range = 13.51–

20.47 kg/m²), and mean Braden scores 9.00 ± 1.01 (range = 7–11) were enrolled in this study. They were recruited through a referral from clinicians in the community hospital. The inclusion criteria included being community patients receiving palliative care at least three months after a medical condition. All the participants provided informed consent to the study. The Institutional Review Board approved the study at Thammasat University (065/2562). The 70 community palliative patients included 38 women and 32 men. Forty-five participants had a very high risk level (Braden Scale = 7–9), and 25 participants had a high risk level (Braden Scale = 10–12) of developing a pressure ulcer.

According to Table 1, there was a relationship between the pressure injury healing scores and the experimental group with a statistical significance, meaning that this group affected the mean scores each week ($F = 57.142$, $p < .01$). The mean pressure injury healing scores between the control and experimental groups in weeks 1, 2, and 3 were statistically significantly different ($F = 11.437$, $p < .01$), and the mean scores among weeks 1, 2, and 3 also were other with a statistical significance ($F = 235.123$, $p < .01$).

Table 1 compares pressure injury healing scores between experimental and control groups for Weeks 1, 2, and 3.

Table 1 Pressure injury healing scores between experimental and control groups for Weeks 1, 2 and 3

Source	SS	df	MS	F	p-value
Between-Subjects					
Group	68.90	1	68.91	11.44	.001*
Error	421.74	70	6.03		
Within-Subjects					
PUSH	128.51	1.59	80.79	235.12	.000*
PUSH *	31.23	1.59	19.63	57.14	.000*
Error	38.26	111.35	.34		

* $p < .01$

As for the third component – the comparison of the pressure injury healing scores before and after using the LTM in the experimental group in weeks 1, 2, and 3, using the repeated measure ANOVA – the analysis found that the scores were statistically significantly different at $p < .01$ ($F = 254.764$) as demonstrated in Table 2.

Table 2 Comparison of the pressure injury healing scores before and after using the LTM in the experimental group in Weeks 1, 2, and 3, using the Repeated Measure ANOVA

Gr	SS	df	MS	F	p-value
Push	143.02	1.45	98.59	254.76	.00*
Error	19.65	50.77	.39		

* $p < .01$

Regarding the analysis of the fourth component – quality-of-life levels of the family caregivers – the descriptive statistics revealed that their overall quality of life was moderate (77.17 ± 5.79) with scores

between 61 and 88. The quality of life was low in the physical health aspect (15.97 ± 1.35), moderate in the mental element (19.43 ± 2.28), average in the component of the social relationship (9.23 ± 1.38), and reasonable in the environmental aspect (24.90 ± 2.68) as shown in Table 3.

Table 3 Quality-of-life levels of the caregiving relatives – the descriptive statistics

WHO-QoLBref	Good		Fair		Poor	
	N	%	N	%	N	%
Physical health	0	0.00	9	30.00	21	70.00
Psychological	1	3.33	28	93.33	1	3.33
Social relationships	1	3.33	26	86.67	3	10.00
Environment	1	3.33	27	90.00	2	6.67
Global	0	0.00	30	100.00	0	0

6. Conclusion

The LTM in this research is a type of innovative mattress invented by the researchers, using techniques to employ mechanical loading to prevent PIs and to reduce the burden among caregivers. With a length of 200 cm and width of 90 cm, this mattress can turn patients on their left and right sides by being lifted to an angle from 0 to 30 degrees to the horizontal plane to reduce the pressure on the bony prominence (iliac spine, acromion process, and thigh). The findings from this study were similar to those studies in the past in that lateral decubitus at no more than 30 degrees can reduce the impact on the body and prevent tissue injury as well as PIs [10]. Unlike currently available conventional beds consisting of a single plane, these beds can be placed on the floor, but the plane level cannot be adjusted. There have not been inventions of mattresses of this nature in Thailand.

The LTM is also different from Alfa beds, pressure distributing devices, and weight-bearing mattresses. The Alfa bed can be used in conjunction with conventional beds to distribute stress on patients in all bodily movements. However, the combined use of air mattresses and traditional beds is costly to repair and maintain. Furthermore, studies have found that even if patients use particular mattresses, there is still pressure ulcer incidence [11-12, 18-20, 24]. Although there have been various innovations per the local wisdom in Thailand, such as water balloon mattresses and air balloon mattresses, there are some limitations in academic references, studies, and research of patients in communities. This group requiring care at home is considered one of the most vulnerable groups to develop PIs [5, 19, 21-24]. However, this mattress has limitations on patient material selection and weight restrictions which will develop in the future.

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