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Basic research

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

Terumi Iuchi [a], Yukari Nakajima [a], Moriyoshi Fukuda [a], Junko Matsuo [b], Hiroyuki Okamoto [c], Hiromi Sanada [d], Junko Sugama [e,*]

[a] *Department of Clinical Nursing, Division of Health Sciences, Graduate Course of Nursing Science, Kanazawa University, Kanazawa, Japan*
[b] *Faculty of Nursing, Osaka Medical College, Osaka, Japan*
[c] *Department of Quantum Medical Technology, Institute of Medical, Pharmaceutical and Health Sciences, Kanazawa University, Kanazawa, Japan*
[d] *Department of Gerontological Nursing/Wound Care Management, Division of Health Science and Nursing, Graduate School of Medicine, University of Tokyo, Japan*
[e] *Department of Clinical Nursing, Institute of Medical, Pharmaceutical and Health Sciences, Kanazawa University, 5-11-80 Kodatsuno, Kanazawa, Ishikawa 920-0942, Japan*

KEYWORDS
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Abstract Bed sheets generate high surface tension across the support surface and increase pressure to the body through a process known as the hammock effect. Using an anatomical model and a loading device characterized by extreme bony prominences, the present study compared pressure distributions on support surfaces across different bed making methods and bed sheet materials to determine the factors that influence pressure distribution.

The model was placed on a pressure mapping system (CONFORMat®; NITTA Corp., Osaka, Japan), and interface pressure was measured. Bed sheet elasticity and friction between the support surface and the bed sheets were also measured.

* Corresponding author. Tel./fax: +81 76 265 2555.
E-mail address: junkosgm@mhs.mp.kanazawa-u.ac.jp (J. Sugama).

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For maximum interface pressure, the relative values of the following methods were higher than those of the control method, which did not use any bed sheets: cotton sheets with hospital corners (1.28, $p = 0.02$), polyester with no corners (1.29, $p = 0.01$), cotton with no corners (1.31, $p = 0.003$), and fitted polyester sheets (1.35, $p = 0.002$). Stepwise multiple regression analysis indicated that maximum interface pressure was negatively correlated with bed sheet elasticity ($R^2 = 0.74$). A statistically significant negative correlation was observed between maximum interface pressure and immersion depth, which was measured using the loading device ($r = -0.40$ and $p = 0.04$).

We found that several combinations of bed making methods and bed sheet materials induced maximum interface pressures greater than those observed for the control method. Bed sheet materials influenced maximum interface pressure, and bed sheet elasticity was particularly important in reducing maximum interface pressure.

Introduction

A pressure ulcer is a localized injury to the skin and/or underlying tissue that usually appears over a bony prominence as a result of pressure or pressure in combination with shear stress [1]. Pressure ulcers frequently occur among elderly bedridden patients with extreme bony prominences; therefore, it is important to use a support surface, such as a two-layer pressure air mattress, to redistribute the tissue load over bony prominences [2,3].

Bed sheets serve to protect patients from infection and maintain comfort. However, they often cause a phenomenon known as the hammock effect [4] in which the bed covers and sheets may generate high surface tension across the support surface [4] that leads to increased pressure; for example, if a patient's buttocks are not immersed, the contact area between the buttocks and the support surface is reduced, and pressure is increased (Fig. 1). Although the principle of the hammock effect is well-known, the methods to reduce this phenomenon remain unknown in clinical practice. Therefore, we investigated the potentials of different bed sheet-related methods to redistribute pressure across a patient's body.

Matsuo et al. [5] previously suggested that bed making methods influence the hammock effect on the support surface. Other studies have reported that bed sheet materials promote the hammock effect. For example, Iizaka et al. [6] found that the elasticities of cushion covers influences the hammock effect in wheelchairs, and Nagano et al. [7]. reported on the influence of friction on this phenomenon. Although these studies showed that the hammock effect can be aggravated by bed making methods and bed sheet materials, no studies have been conducted to determine the differences among bed making methods and bed sheet materials in terms of pressure distribution on the support surface. Therefore, using an anatomical model characterized by extreme bony prominences, we compared pressure distributions on the support surface across different bed making methods and bed sheet materials and identified the factors that influence pressure distribution. We hypothesized that bed making methods and bed sheet materials influence the maximum interface pressure on the support surface.

Materials and methods

Model

We employed an anatomical model and a loading device described and validated by Matsuo et al. [8]. The Matsuo model was developed to evaluate support surfaces and quantify the hammock effect. This model was created by attaching polyurethane gel and a film to a resin model of an adult female pelvis (female pelvis 1/1 scale model®; Nihon 3B Scientific Corp., Niigata, Japan) with an intercristal diameter of 25.0 cm and an interspinal diameter of 24.0 cm. Polyurethane gel was used to mimic the soft tissue of the buttocks at thicknesses of 80 and 210 mm and stiffnesses of 0.08 and 0.46 megapascals (MPa) at the sacral and hip regions, respectively. A polyurethane film (thickness, 0.3 mm) was used to mimic skin on the model (Fig. 2).

The loading device was composed of an aluminum frame (length, 100 cm; width, 60 cm; and height, 73 cm). A vertical load was applied to the sacral region using a weight attached to a vertical column erected at the center of the frame. A load of 11 kg was applied and the pelvis was tilted by 30°; these parameters were calculated based on contact areas and interface pressures of the buttocks from pressure redistribution maps of elderly bedridden patients [8]. A spring