Effects of Mattress Material on Body Pressure Profiles in Different Sleeping Postures

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ABSTRACT

Objectives: This study compared the body contact pressure profiles of 2 types of mattresses: latex and polyurethane.
Methods: Twenty participants were required to lie down on the different mattresses in 3 different postures for 6 minutes, and their body contact pressure profiles were recorded with a pressure mat sensor.
Results: The data indicated that the latex mattress was able to reduce the peak body pressure on the torso and buttocks and achieve a higher proportion of low-pressure regions compared with the polyurethane mattress.
Conclusions: Latex mattress reduced peak body pressure and achieved a more even distribution of pressure compared with polyurethane mattress across different sleeping postures. (J Chiropr Med 2016;xx:1-9)
Key Indexing Terms: *Posture; Supine Position; Sleep; Beds; Pressure Ulcer*

INTRODUCTION

Annually, sleep disorders affect up to 40% of the US adult population and are often associated with morbidity and mortality.[1,2] Sleep quality plays an instrumental role in the overall wellness of our lives, whereby a good sleep can help facilitate a normal circadian rhythm and thus lessen fatigue and improve physical regeneration.[3,4] Poor sleep quality can be attributed to a variety of environmental factors, which include temperature, light, noise, and mattress quality.[5,6] Addison et al[7] reported that 7% of sleep problems were due to uncomfortable mattresses, which affect the loading of the spine during sleep.[4]

Several previous studies have suggested that mattress material can affect sleep quality.[8-10] Dickson[11] noted increased sleep quality of human participants sleeping on natural wool. Okamoto et al[12] further reported that body temperature was higher in participants sleeping on an air mattress than on a futon mattress. Moreover, Tonetti et al[13] found that expanded polyurethane-viscoelastic mattresses exhibited improved actigraphic sleep parameters of sleep onset latency and sleep efficiency, compared with traditional spring mattresses.

In addition, effective heat loss through the use of a high-rebound breathable mattress may facilitate restorative sleep.[14] An electromyography-based human-mattress compatibility study by Park et al[15] reported significantly lower muscle activities, together with greater participant relaxation rating, for the spring mattress compared with the Tempur mattress, during tossing and turning.

However, it is difficult to compare the result of these prior studies because different types of mattress were investigated. Furthermore, it is important to note that these studies adopted different methods, such as actigraphy, body temperature, polysomnography, contact pressure profile, and questionnaires.

Body contact pressure is a measure of the distribution of the body weight across the surface of the body in contact with the mattress.[16] A well-designed mattress often possesses the ability to minimize high-pressure points applied onto the body.[17,18] However, if the mattress is not suited for the person, pressure sores may develop at body regions where the pressure is concentrated.[19] The regions affected by higher pressure often include the buttocks, shoulder, and back,[17,20] which may consequently affect the quality of sleep and result in lethargy or body stiffness throughout the day.[21] A recent study by Bae and Ko[22] compared the bed positions of hospital mattresses and found that the head-foot angle of 30° was the best position to mitigate the possibility of decubitus ulcers occurring in patients at the high-pressure-risk regions.

In view of these previous studies, there is still a lack of research that specifically compares latex mattresses to polyurethane foam mattresses, considering that both mattress types are common mattresses used in hospital beds.[20,23] A biomechanical comparison of these mattresses

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across different sleeping postures will allow us to provide new insights into their pressure-distributing capabilities. Therefore, the objective of this study was to evaluate the effect of different types of bed material (latex and polyurethane foam) on the body contact pressure profiles in various sleeping postures, using peak body pressure and pressure distribution as outcome measures.[17,24,25] We hypothesized that the latex mattress would perform better in reducing the body contact pressure profiles across different sleeping profiles, compared with polyurethane foam mattress. The purpose of this study was to evaluate the performance of different mattress materials in order for hospitals to determine the type of mattress best suited for patients by reducing risk of pressure sores.[26,27]

Methods

Participant Recruitment

Twenty young healthy participants (10 men, 10 women; height: 1.67 ± 0.07 m, weight: 59.8 ± 11.1 kg) were recruited in this study. Informed consent was obtained in accordance with approval from the National University of Singapore's Institutional Review Board before commencement of the trials. The participants had no history of back, shoulder, or neck pain for the past month and were instructed to put on their usual sleepwear during the conducting of the sleep experiments.

Test Protocol

All trials were conducted at a motion analysis laboratory at the local university. The participants were required to lie down on 2 different mattresses (latex foam, Sofzsleep, model Delight, and high-density polyurethane foam, Masterfoam, model Masterfoam 1000), where the sequence of mattress conditions was randomized. A standard pillow was provided throughout the trials. The purpose of the pillow was to allow the participants to lie comfortably on the beds, and a similar pillow was used throughout the trials.

For each mattress, the participants were instructed to adopt 3 different postures[1]: lying on the back (in the soldier posture),[2] lying on the side, and[3] lying on the front (in the freefaller posture). The participants were asked to lie down comfortably on the mattress for 6 minutes for each posture. A single-blind approach was adopted, whereby the participants did not know the material of the mattress that they were lying on.

A pressure mat sensor (Pressure Mapping Sensor 5400N, Tekscan, Boston, MA) was first calibrated on the different mattresses using fixed weights and then used to capture the body contact pressure profiles in a video format for 6 minutes for each posture at a sampling rate of 4 Hz. The collected data were then converted to a compatible format in Matlab (MathWorks, Natick, MA) for further processing (Fig 1).

Data Processing

For the back posture, the back torso and buttocks regions were identified for pressure comparison. For the side posture, the regions were the side torso (inclusive of the upper arm and shoulder) and the buttocks. For the front posture, only the front torso (chest and stomach region) was identified. Two outcome measures were evaluated to compare the latex and polyurethane foam mattresses, namely the average peak body contact pressure in each region and the average body contact pressure distribution based on the pixelated data captured from each region. For the video, 6 frames were processed for each posture at each minute interval from 1 minute to 6 minutes, where the average peak body contact pressure were over an average of 6 frames. For the average pressure distribution, the threshold was set at 3 psi, whereas the pressure data were categorized into 10 distinct bands that identified the pressure distribution.

Statistical Analysis

A paired t test was used to compare the mean peak body contact pressures between the 2 mattresses in each posture. All significance levels were set at $P < .05$.

Results

Our mean body contact pressure distribution data (Figs 2-4) indicated that the latex mattress had a higher proportion of body surface area (90.9%-96.1%) in the range of 0 to 0.6 psi across all 5 identified regions compared with the polyurethane foam mattress (82.1%-91.8%). On the other hand, the polyurethane foam mattress had a higher proportion of body surface area (7.4%-14.9%) in the range of 0.6 to 1.2 psi compared with the latex mattress (3.7%-9.5%).

In terms of the mean peak body contact pressure for the back posture, the peak pressures at the back torso and back buttocks were significantly lower, by 26.1% ($P < .001$) and 28.4% ($P < .001$), respectively, for the latex mattress compared with the polyurethane foam mattress (Fig 5). For the side posture (Fig 6), the mean peak body contact pressures at the side torso and side buttocks were significantly lower, by 35.1% ($P < .001$) and 28.2% ($P < .001$) for the latex mattress, relative to the polyurethane foam mattress. For the front posture (Fig 7), the mean peak body contact pressure at the front torso was significantly lower, by 30.9% ($P < .001$) for the latex mattress, comparison with the polyurethane foam mattress.