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Analysis of the Body Pressure-related Sensory Changes in the Static Supine Position for Healthy Science Research: a Randomized Controlled Pilot Trial

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Abstract

The aim of this study was to analyze body pressure-related sensory changes after being in a static supine position to the head, shoulder, right and left arms, low back, pelvic girdle, and right and left legs. To analyze body pressure, a Body Pressure Measurement System was used. Body pressure sensors were attached to existing mattresses and pressure was monitored beneath the ten subjects (five male and five female). The level of pain was evaluated using the pain scale before, at 1, 5, 10, and 15 min, and in total of the head, shoulder, right and left arms, low back, pelvic girdle, and right and left legs after being in the static supine position. Head pressure intensity was significantly higher than other body part measures, and the head had the highest pain score, almost showing a similar tendency. However, the low back was not too high in body intensity, while it had the second highest total pain score. As well, the low back and pelvic girdle showed a significant difference between the pain scores of males and females. The pain appeared after 10 min on all measuring parts. As well, as time progressed, the level of pain became more increased. These results suggest that when performing physical therapy and healthy science research, the properties of time, posture, and gender need to be carefully considered.

Keywords: Body pressure, Static supine position, Pain

Introduction

In human life, body pressure always occurs due to the effect of gravity. Hence, proper body pressure distribution is essential in all postures for a comfortable life. However, comfort is a very complex concept[1], and the perception of comfort is clearly related to firmness, pressure distribution[2], and pain. Therefore, a previous study considered some ergonomic aspects of design, including body pressure and subjective rating of comfort on various mattress types[3]. In particular, regarding improving patients' quality of life, body pressure distribution in mattresses has been widely studied for the prevention of pressure sores[4]. Regarding the human posture, the supine position has advantages, including ease of positioning and more comfort[5]. In addition, when concentration is needed, such as in a physical therapy situation, people usually select the supine position. Hence, an analysis of body pressure-related sensory changes in the static supine position is very important. As well, pain is subjective and subjectively experienced[6], and it is known to hyper-sensitize nociceptors in tissues, leading to lower sensory thresholds both peripherally and centrally[7]. Furthermore, acute pain sometimes transitions into disabling chronic pain[8]. Therefore, an analysis of pain is also very important for a comfortable life. However, regarding the static supine position, no studies have focused on body pressure-related sensory changes. In the static supine position, moreover, in relation to body pressure and the temporal change in pain, an identification of the relationship between physical therapy situations has not been performed. The purpose of this study was to analyze body pressure-related sensory changes after being in the static supine position in the head, shoulder, right and left arms, low back, pelvic girdle, and right and left legs. Furthermore, we evaluated body pressure using a Body Pressure Measurement System and the pain score was evaluated using the visual analogue scale (VAS), faces pain rating scale (FPRS), and Iowa pain thermometer (IPT).

Results

Body pressure measurement screenshots showed a difference between the body pressures of males and females (Figure 1A), where males and females were different in terms of pressure distribution and intensity. After digitizing these images, head pressure intensity (1297.2 ± 77.0) was demonstrated to be significantly higher than other body parts (Figure 1B-a). The second highest pressure intensity body part is in the low extremity (710.6 ± 51.0), and this part was significantly higher than other body parts, except the head. To investigate more objectively, we divided the upper limbs into three parts: the shoulder and the right and left arms. As well, we divided the lower limbs into three parts: the pelvic girdle and the right and left legs (Figure 1B-b). A similar tendency was almost shown; however, the shoulder (866.7 ± 38.4) among the upper limbs, in particular, had the second highest pressure intensity. This part was significantly higher than the low back (296.8 ± 35.7) and both arms (Right: 175.7 ± 28.1, Left: 146.0 ± 39.0). Furthermore, to show another perspective, we divided the data into male and female (Figure 1C), and there was no significant difference in all body parts. To confirm body pressure-related pain and sensory changes in the static supine position, we used three pain scores: the VAS, FPRS, and IPT. Three total pain scores showed a similar tendency. Similar to the pressure intensity result, on the head, the total pain score was significantly higher than on other parts (Figure 2A-a, 2B-a, and 2C-a). However, the low back was not too high in relation to body intensity, while it had the second highest total pain score. In particular, according to the VAS, the low back total pain score (1.7 ± 0.3) was significantly higher than other parts, except the head (1.9 ± 0.2) and both legs (1.3 ± 0.2). To investigate more objectively, we divided the total pain score into male and female total pain scores (Figure 2A-b, 2B-b, and 2C-c), which almost showed a similar tendency. However, the low back and pelvic girdle showed a significant difference between the pain scores of males and females. As well, to show another part, we investigated the temporal change in pain after being in the static supine position on the body parts (Figure 3). Overall, the upper limb pain score increased in 5-10 min, while other pain scores increased in 1-5 min (Figures 3 and 4). In addition, the upper limb pain score was significant lower than the others were. For pain intensity, to investigate more objectively, we divided the upper limbs into three parts: the shoulder and the right and left arms. As well, we divided the lower limbs into three parts: the pelvic girdle and the right and left legs. In particular, both arms had low pain scores. This result

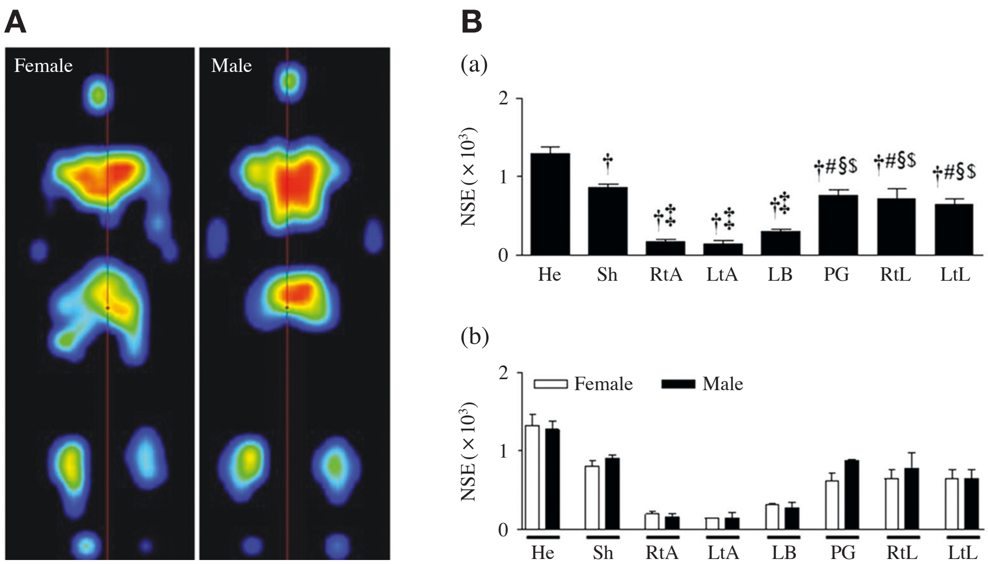

Figure 1. Differences in the body pressure after being in the static supine position of healthy subjects. Each bar represents the mean ± SE. NSE, number of sensing element; He, head; sh, shoulder; RtA, right arm; LtA, left arm; LB, low back; PG, pelvic girdle; RtL, right leg; LtL, left leg. *$p < 0.05$. Statistically significant differences exist in He vs. Sh, RtA, LtA, LB, PG, RtL, and LtL (†$p < 0.05$), in Sh vs. RtA, LtA, and LB (‡$p < 0.05$), in RtA vs. PG, RtL, and LtL (#$p < 0.05$), in LtA vs. PG, RtL, and LtL (§$p < 0.05$), and in LB vs. PG, RtL, and LtL ($$p < 0.05$).

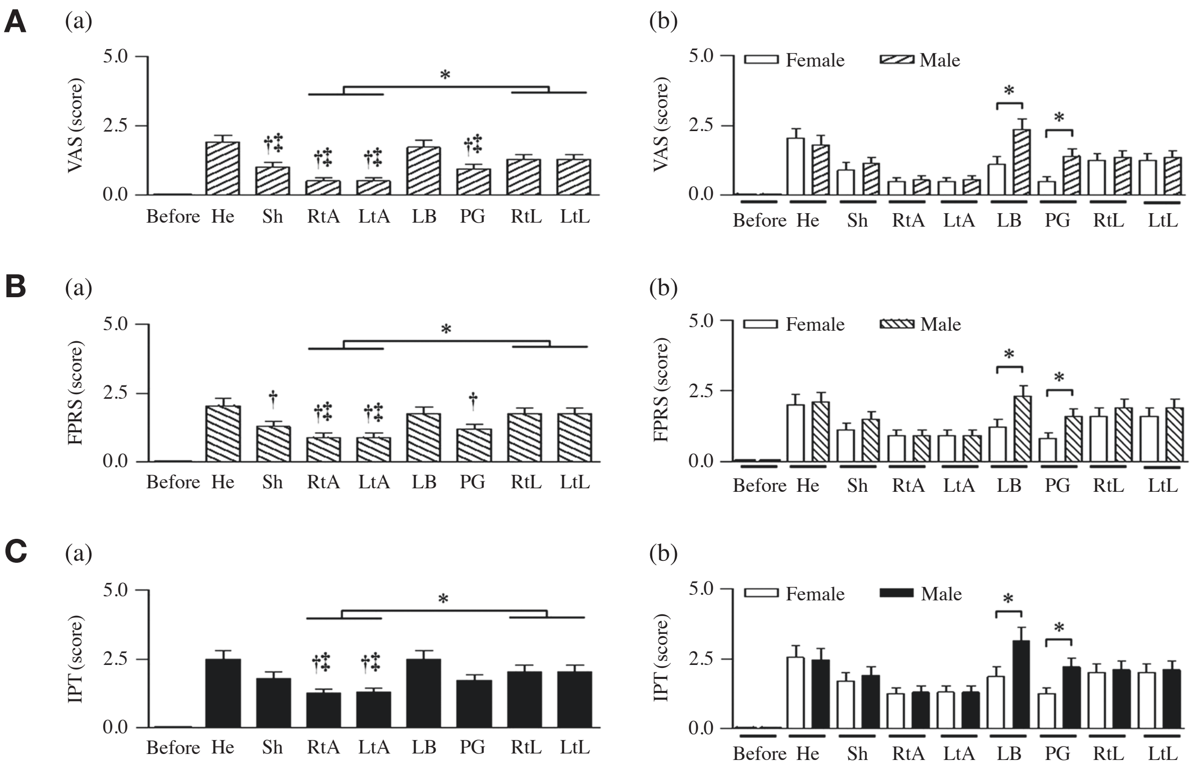

Figure 2. Differences in the pain scale after being in the static supine position of healthy subjects. Each bar represents the mean ± SE. VAS, visual analogue scale; FPRS, faces pain rating scale; IPT, Iowa pain thermometer; He, head; sh, shoulder; RtA, right arm; LtA, left arm; LB, low back; PG, pelvic girdle; RtL, right leg; LtL, left leg. *$p < 0.05$. Statistically significant differences exist in He vs. Sh, RtA, LtA, and PG (†$p < 0.05$), and in LB vs. Sh, RtA, LtA, and PG (‡$p < 0.05$).

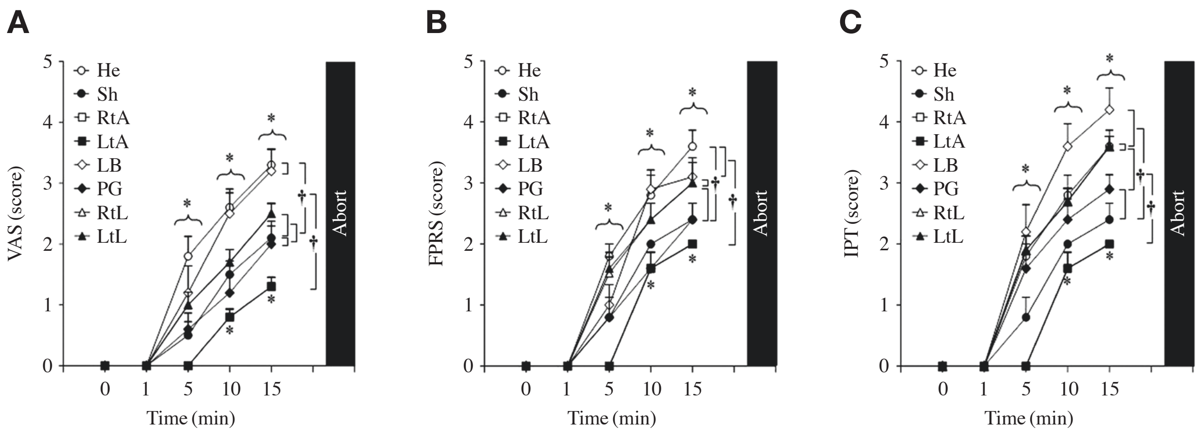

Figure 3. Changes in the time-dependent pain scale of the static supine position from healthy subjects. VAS, visual analogue scale; FPRS, faces pain rating scale; IPT, Iowa pain thermometer; He, head; sh, shoulder; RtA, right arm; LtA, left arm; LB, low back; PG, pelvic girdle; RtL, right leg; LtL, left leg. *Significant differences exist between the control (0 min) and time-dependent pressure groups. †$p < 0.05$, ANOVA for repeated measurements.

is related to both arms' low-pressure intensity. Furthermore, the pain scores (VAS, FPRS, and IPT, respectively) of male groups were significantly increased at minutes 5 and 10 after static supine position compared with female groups (Figure 4).

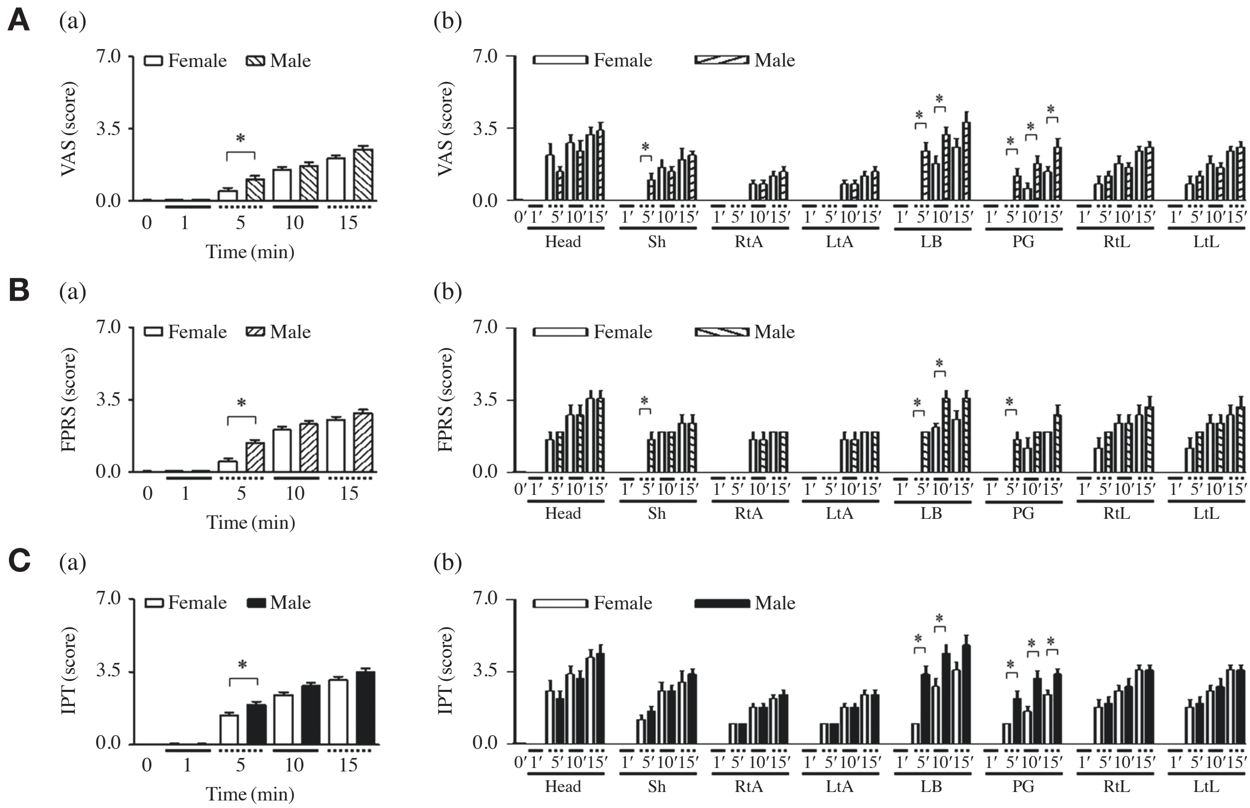

Figure 4. Differences in the time-dependent pain scale of the static supine position between the both groups. Each bar represents the mean ± SE. VAS, visual analogue scale; FPRS, faces pain rating scale; IPT, Iowa pain thermometer; He, head; sh, shoulder; RtA, right arm; LtA, left arm; LB, low back; PG, pelvic girdle; RtL, right leg; LtL, left leg. *$p < 0.05$.

Discussion

Postural medicine studies the effects of gravity on human body functions and revealed that physiological adaptations are mainly due to the effect of gravity[9]. One is body pressure distribution, which is very important because most cell deaths from pressure occurred between 1 and 4 h post-loading, and greater tissue deformations from pressure led to faster tissue damage[10]. In addition, people do body repositioning even during sleep[11]. Hence, research that is more objective is needed about body pressure distribution. Among them, monitoring is a good tool because it has become a typical practice in preventative strategies for many diseases and conditions[12]. In particular, regarding body pressure, static supine monitoring is very important for patients, as an immobile posture for a period could affect a patient's body condition. As well, in relation to this, pain is an important concept. Pain is defined as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage"[13]. Furthermore, pain is individual, and physical and psychosocial factors should be addressed simultaneously[14]. Clinical pain is not simply the consequence of a "switching on" of the "pain system" in the periphery by a particular pathology, but it instead reflects to a substantial extent the state of excitability of the central nociceptive circuits[15]. As noted above, neuro inflammation and the associated release of pro-inflammatory cytokines contribute to the transition from acute to chronic pain[8]. In addition, chronic pain is a frequent component of many neurological disorders[16]. Thus, pain management is a high priority in patient care[17]. In a previous study, a mattress comfort classifying investigation study was conducted using an analysis of pressure distribution for certain parts of the body[4,18,19]. However, many authors point out the high variability of these data[4,20-22]. In a previous study, the static supine position was investigated to prevent bedsores. However, many studies suggested a link between pressure intensity and pain sensory changes. We focus on this point. Therefore, in this study, we conducted an analysis of body pressure-related sensory changes from being in the static supine position. In our study, the pressure intensity and total pain score showed almost a similar tendency. However, a different result for the low back was shown. This part showed low pressure intensity, despite a high total pain score. We suspected these results related to our body structure. Because our body has a spinal curve, this curve has seriously affected low back pain in the static supine position. In addition, males felt more pain than females, and we suspected this result was related to male body flexibility. The pain appeared after 5 min on all measuring parts, except both arms. As time progressed, the level of pain became more increased on all measured body parts. This result is full of suggestions for physical therapy situations. The goal of physical therapy is to relieve pain and restore function. The supine position has advantages, including ease of patient positioning and greater patient comfort. As well, most physical therapy is done in the supine position for quite a long time, and most patients hold themselves to focus on treatment. In the absence of these protective sensations, patients are unaware of potential tissue damage[12]. In other words, in the static supine position, even though physical therapy took the pain away from the treatment region, there are fears it could lead to other pain due to body pressure. Therefore, it is necessary to consider the proper time and posture for physical therapy. Although our results have great implications for living a healthy life, more studies are needed. A major limitation of this study is the lack of measurements of other postures. However, as few studies have been performed on other postures, we consider the present results to be meaningful for physical therapy. Furthermore, further systematic and scientific studies in the fields of neurorehabilitation and others are needed to confirm the effects of therapy[23-25]. In summary, we studied the analysis of the body pressure-related sensory changes from being in the static supine position for healthy science research. Therefore, when performing physical therapy, the properties of time and posture must be carefully considered.

Methods

In total, ten healthy young subjects (five men, five women) participated in these measurements. Their mean age, height, and body mass were 29.1 ± 3.2 years, 169.3 ± 10.5 cm, and 63.5 ± 16.2 kg. They had no pain in the measuring site (head, shoulder, right and left arms, low back, pelvic girdle, right and left legs) that affected this measurement. The level of pain was evaluated using the visual analogue scale (VAS), faces pain rating scale (FPRS), and Iowa pain thermometer (IPT) before, at 1, 5, 10, and 15 min, and in total of the head, shoulder, right and left arms, low back, pelvic girdle, and right and left legs after being in the static supine position, respectively[7,26,27]. The VAS is a measurement instrument that aims to measure a characteristic or attitude that is believed to range across a continuum of values and that cannot easily be directly measured. For example, the amount of pain that a patient feels ranges across a continuum from none to an extreme amount of pain. From the patient's perspective, this spectrum appears continuous; their pain does not take discrete jumps, as a categorization of none, mild, moderate, and severe would suggest. It was to capture this idea of an underlying continuum that the VAS was devised. Operationally, the VAS is usually a horizontal line 100 mm in length, which is anchored by word descriptors at each end[7]. The patient marks on the line the point that they feel represents their perception of their current state. The VAS score is determined by measuring in millimeters from the left-hand end of the line to the point that the patient marks. It must be explained to the patient that each face represents a person who feels happy because he or she has no pain (no hurt) or sad because he or she has some or much pain. Face 0 is very happy because he or she does not hurt at all, face 1 hurts just a little bit, face 2 hurts a little more, face 3 hurts even more, face 4 hurts very much, and face 5 hurts as much as you can imagine, although you do not have to be crying to feel this level of pain[7]. The person is asked to choose the face that best describes how he or she is feeling. The pain thermometer is an adaptation of the traditional verbal descriptor scale that aligns a thermometer alongside the options of words that represent varying levels of pain severity. The thermometer facilitates the understanding and communication of pain severity, particularly by those with diminished cognitive capacity and difficulty with abstract thinking. Patients are shown the scale and asked to think that as the temperature rises in a thermometer, pain also increases as you move to the top of the scale. The original pain thermometer was evaluated in earlier research[1] and a revised version of the tool, the IPT, has been shown to be a good choice for both younger and older patients. These combined verbal and thermometer scales have been shown to be the most preferred and easiest to understand tools for assessing pain in older persons and they are recommended by national and international guideline panels on pain in older persons[7]. Furthermore, none of the subjects had any skin or musculoskeletal disorders that affected being in the supine position. Body pressure was measured using a Body Pressure Measurement System (Tech storm, Korea). In total, 3,000 sensing elements are available and the sensor size on the cell is 20×20 mm. The sensor system attaches to existing mattresses beneath the subjects. The monitor shows low pressures as blues and greens and high pressures as oranges and reds. In addition, the measured values of each site (head, shoulder, right and left arms, low back, pelvic girdle, and right and left legs) were shown. Data were expressed as the mean ± standard error (SE) of the measurement, and a p value of <0.05 was considered statistically significant. SPSS Version 18.0 (International Business Machines, Armonk, USA) for Microsoft Windows was used for data analysis in this study. In addition, the differences in pressure and sensory changes were estimated by the Student's t-test for the comparison of pairs of groups and with the analysis of variance (ANOVA) for multiple comparisons.

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