THE EFFECT OF BED-BACKREST ELEVATION SYSTEM COMBINED WITH HIP AND KNEE FLEXION ON LOWER EXTREMITY BODY-PRESSURE REDUCTION

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Abstract: Pressure sores are painful and needless complications of critical illness, and manifest as a localized area of ischemic necrosis of tissue caused by pressure. This study analyzed the bed-backrest elevation system combined with hip and knee flexion for lower extremity body-pressure reduction. Eight healthy adults aged 21 to 26 years were recruited. The Body Pressure Measurement Mat of the Tekscan system was used to measure the location and magnitude of the peak pressures on the body–bed interface. The SPSS statistical package was used to analyze the significance of differences between the general bed-backrest elevation system and the bed-backrest elevation system combined with hip and knee flexion using the paired t-test. The result showed that the body-pressure of the lower extremity was more significantly reduced for the bed-backrest elevation system combined with hip and knee flexion (26.6 ± 4.3 mmHg) than a general bed-backrest elevation system (37.3 ± 5.2 mmHg) (p<0.05).

1. INTRODUCTION

Pressure ulcers are the visible evidence of pathological changes in the blood supply to dermal tissues (Whittington et al., 2000). A localized pressure at the skin surface is believed to cause blockage of capillary blood flow and subsequent ischemic damage, and is common in patients being nursed in chairs or beds. The chief cause is pressure, or force per unit area, applied to susceptible tissues. Muscle tissue, subcutaneous fat, and dermal tissue are differentially affected in that order (Bates-Jensen et al., 2003). Prevalence studies have shown that 3% to 11% of all hospitalized patients have pressure-related skin ulcers (Allman et al., 1986). Although some patients are admitted to hospitals with preexisting ulcers and other patients develop them during their stay, pressure sores are a significant and increasing source of suffering and financial burden (Lake, 1999). Patients admitted to intensive care units (ICUs) are at a particularly high risk of developing pressure ulcers (Boyle and Green, 2001). These critically ill patients are generally not able to notice increased tissue pressure and to react accordingly because they receive sedation, analgesics, and/or muscle relaxants (Bours et al., 2001).

Preventive care must focus on decreasing the incidence of new ulcers; however, such care can be an expensive use of hospital resources. Thus, it is important to have the best possible definition of an “at-risk” population so that these resources can be focused (Fife et al., 2001). Programs aimed to improve pressure ulcer care were successful in nationwide projects (Lyder et al., 2002), specific healthcare institutions, and specific patient groups (Robinson et al., 2003). These projects are based on the idea that pressure ulcers are...
the result of pressure and/or shear forces (Gunningberg et al., 2001). Numerous studies have identified factors associated with an individual’s increased or decreased risk of developing a pressure ulcer, but many of these studies have one or more of the following limitations: small sample size, conducted at one long-term care or hospital facility, limited number of resident and treatment characteristics collected, and few health outcomes examined (Bergquist and Frantz, 1999; Brandeis et al., 1994; Gilmore et al., 1995).

Patient positioning is a key component of nursing care. The positioning of critically ill patients (i.e., patient position and backrest elevation) often has multiple rationales and may significantly affect (Evans, 1994). The determination of backrest elevation by nurses should be based on scientific knowledge and clinical evaluation, adjusting the intervention to the specific needs of the patient (Dillon et al., 2002). The backrest elevation, defined as the angle of the backrest height above the horizontal position, is an important nursing intervention (Dillon et al., 2002; Peterlini et al., 2006). This study analyzed the significance of differences between the general bed-backrest elevation system and the bed-backrest elevation system combined with hip and knee flexion for lower extremity body-pressure reduction.

2. METHODS

2.1 Subjects

Eight healthy and active young adults (3 males, 5 females) aged 21–25 years were recruited from the Yonsei University student population (height, 161.4±3.2 cm, mean±SD; weight, 55.3±6.5 kg). All subjects had been free of neck and back pain for a minimum of 1 year prior to the study, and had no pathologies such as rheumatologic or neurological conditions in the extremities or spine. All subjects signed informed consent forms approved by the Yonsei University Faculty of Health Sciences Human Ethics Committee prior to their participation.

2.2 Measurements

The TekScan system was used to measure the location and magnitude of the peak pressures on the body–bed interface for the different bed-backrest elevation system. A sampling rate of 60 Hz was achieved due to the extreme thinness and the relatively high spring constant of the sensor materials (a rise time of less than 20 microseconds). The software supplied with the TekScan system was used to locate areas of interest, and display temporal forces and pressures on a monitor during the elevation angle 0 ~ 90 degrees of the bed.

2.3 Procedures

All subjects were instructed to look straight ahead at a designated point on the ceiling whilst they were in the neutral supine position on a bed covered with the Body Pressure Measurement Mat of the Tekscan system. This mat was thin, and we were confident that incorporating the sensor in the application would not alter the characteristics of the support surface during bed-backrest elevation using the automatic control cylinder (Figure 1).

Using standardized instructions, the hip and knee joints of all subjects were positioned in a standardized position by the same investigator for all the trials. The reliability of the pressure measurements was confirmed in a pilot study involving five subjects undergoing two trials, for which the intraclass correlation coefficients were between 0.90 and 0.92. The peak contact pressures were calculated from the last 10 seconds of the 30 seconds of data recorded by the computer software supplied with the Tekscan system. A general bed-backrest elevation system was elevated by one-axe and two-segments elevation system; the bed-backrest elevation system combined with hip and knee flexion was elevated by two-axes and three-segments elevation system, which was at the flexed hip and knee during using two-axes backrest elevation and then is extended again (Figure 2). The test order was selected randomly. Subjects rested for 3 minutes between trials. All tests were performed by a single investigator.
2.4 Statistical Analysis

The Statistical Package for the Social Sciences (SPSS, Chicago, IL) was used to analyze the significance of differences between the general bed-backrest elevation system and the bed-backrest elevation system combined with hip and knee flexion using the paired t-test. The alpha level for statistical significance was set at 0.05.

3. RESULTS

The result showed that the body-pressure of the lower extremity was more significantly reduced for the bed-backrest elevation system combined with hip and knee flexion than a general bed-backrest elevation system (p<0.05) (Table 1). The peak contact pressure was 37.3 ± 5.2 mmHg on the general bed-backrest elevation system and 26.6 ± 4.3 mmHg on the bed-backrest elevation combined with hip and knee flexion system (Table 1).
Table 1. The Mean of Peak Contact Pressure of the Lower Body

<table>
<thead>
<tr>
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<th>General bed-backrest elevation</th>
<th>Bed-backrest elevation combined with hip and knee flexion</th>
<th>t</th>
<th>p</th>
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<tr>
<td>Peak contact pressure</td>
<td>37.3 ± 5.2 mmHg</td>
<td>26.6 ± 4.3 mmHg</td>
<td>7.596</td>
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4. DISCUSSION

Pressure is concentrated wherever weight-bearing points come in contact with surfaces. These weight-bearing points usually occur over a bony prominence. Tissues over a bony prominence may differ in resistance to hypoxia or pressure compared to “soft sites” away from bone (Thomas, 2006). This may explain the frequency of pressure ulcer development in these sites. About 95% of pressure ulcers occur in the lower part of the body. The sacral and coccygeal areas, ischial tuberosities, and greater trochanteric areas account for the majority of pressure ulcer sites (Bours et al., 2001). The sacrum is the most frequent site (36% of ulcers). The heel is the next most common site (30%), with other body areas each accounting for about 6% of pressure ulcers (Meehan, 1994).

In a previously reported study (Rithalia et al., 2000; Rithalia and Gonsalkorale, 2000), to evaluate the pressure-relieving effect of mattresses with pressure alternating function, a scale of Pressure Relief Index (PRI) was defined as the minutes per hour when the local interface pressure was below a certain level. Without dynamic pressure redistribution, these static cushions, when loaded to the “dense region,” eventually lose the ability to reduce the sitting load; therefore, the excessive load on soft tissue remains largely unrelieved (Maksous et al., 2003). During sitting, the head, arm, and trunk weight is carried mainly by the ischial tuberosities and surrounding tissues (Knight, 1988; Reuler and Cooney, 1981). High pressure at the tuberosities is closely associated with high load to the spine (Salzberg et al., 1998).

We analyzed the significance of differences between the general bed-backrest elevation system and the bed-backrest elevation system combined with hip and knee flexion for lower extremity body-pressure reduction. The body-pressure of the lower extremity was more significantly reduced for the bed-backrest elevation system combined with hip and knee flexion (26.6 ± 4.3 mmHg) than a general bed-backrest elevation system (37.3 ± 5.2 mmHg). The advantage of releasing buttock loading provided by the bed-backrest elevation combined with hip and knee flexion system can be dynamically extended into prolonged sitting by incorporating this posture into an alternate sitting protocol.

The exact interval for optimal repositioning in prevention is unknown. The interval may be shortened or lengthened by host factors. In healthy older volunteers, intervals of 1 hour to 1.5 hours rather than the traditional 2-hour schedule were required to prevent skin erythema on a standard mattress (Knox et al., 1994). Repositioning the patient to relieve pressure may be difficult to achieve despite best nursing efforts and is very costly. Despite commonsense approaches to repositioning, and improving passive activity, no published data support the view that pressure ulcers can be completely prevented by passive positioning (Clark, 1998). The theoretical goal is to reduce tissue pressure below capillary closing pressure of 32 mm Hg. Devices can be defined as pressure relieving or pressure reducing (Thomas, 2006). The majority of devices are pressure reducing. Pressure-reducing devices can be further classified as static or dynamic. Static surfaces are stationary and attempt to distribute local pressure over a larger body surface (Lyder et al., 2002). Dynamic devices use a power source to produce air currents and promote uniform pressure distribution over body surfaces (Thomas, 2006). The bed-backrest elevation system combined with hip and knee flexion was elevated by a two-axes and three-segments elevation system, which was flexed at the hip and knee during using two-axes backrest elevation and then is extended again. This system redistributed high interface pressure from the ischia almost entirely to the thighs during elevation of bed-backrest. This large-scale pressure repositioning has its own unique advantage: because it shifts most of the high interface pressure away from the entire ischial area to the thighs, the unloading time for ischia can remain long. Relieving the ischial support may make the pelvis rotate forward.

Several clear advantages to using Tekscan in bioengineering applications still exist. Tekscan has a smaller profile, has the ability to evaluate a wider range of loads with greater accuracy and reliability, and is capable of real-time data (Bachus et al., 2006). The main part of our study investigated the relative body pressure changes between bed-backrest elevation systems; this part of findings should not be showed by the group.
difference on body build and long-term changes. Also, we measured very few subjects. Future studies should require assessment of various groups and analysis of data for longer term changes in pressure.

5. CONCLUSION

The body-pressure of the lower extremity was more significantly reduced in the bed-backrest elevation system combined with hip and knee flexion than in a general bed-backrest elevation system. These results indicate that the use of a bed-backrest elevation system combined with hip and knee flexion reduces patients’ risk of pressure ulcers. We expected that the alternate bed backrest elevation mechanism evaluated in this study might be a better seating option for people sitting for a prolonged time.

6. REFERENCES


