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The Effect of a 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 ㎜Hg) ($p<.05$).

Key Words: Backrest elevation; Body weight distribution; Peak contact pressure; Pressure ulcer.

Introduction

The chief cause of pressure ulcers is constant or consistent pressure (Bates-Jensen et al, 2003). 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. Prevalence studies have shown that 3% to 11% of all hospitalized patients have pressure-related skin ulcers (Allman et al, 1986; Land, 1995).

The treatment cost of pressure ulcers exceeds more than $1 billion annually in the US (Ennis and Meneses, 1997). Management of pressure ulcers can cost lots of money and pressure sores are a significant and increasing source of suffering and financial burden (Lake, 1999). There are numerous pieces of literature revealing that it is much more cost-effective to focus on prevention of pressure ulcers than on their treatment (Gunningberg et al, 2001; Lyder et al, 2002; Robinson et al, 2003).

Preventing the major causes of pressure ulcers is the best way to manage a compromised patient (Bours et al, 2001). Preventive care must focus on decreasing pressure and on the incidence of new ulcers (Fife et al, 2001). Patient positioning is a key

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component of nursing care. Usually, critically ill patients are generally not able to notice increased tissue pressure and to react accordingly because they receive sedation, analgesics, or muscle relaxants (Bours et al, 2001). Therefore, these can be prevented by any equipment for proper positioning (Harada et al, 2002).

Once a pressure ulcer has started, the sore is extremely hard to reverse without specialized care. Specialized care can include, load reducing surfaces such as air beds, specialty beds, and surface deliver. The beds generally used for proper positioning in hospitals and nursing homes are the type that allows the head of the bed to be raised (Dillon et al, 2002).

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 (Peterlini et al, 2006). The general bed-backrest system, raising the head of the bed, needs to be used carefully and the head should be raised no more than 30 degrees to prevent the patient from sliding down in the bed (Evans, 1994).

To reduce pressure, it is important to use equipment that is the most adjustable for body positioning because patients lay for a long period of time (Gilmore et al, 1995). The use of the bed-backrest system combined with hip and knee flexion and the other type of adjustable bed, also relieves soreness and gives a lot of comfort. 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.

Methods

Subjects

Eight healthy and active young adults (3 males, 5 females) aged 21 to 26 years were recruited from the Yonsei University student population (mean height±SD, 161.4±3.2 ㎝; mean weight±SD, 55.3±6.5 ㎏). 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.

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 ㎐ 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.

Procedures

All subjects were instructed to look straight ahead at a designated point on the ceiling while 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.

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 .90 and .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 1). The test order was selected randomly. Subjects rested for 3 minutes between trials. All tests were performed by a single investigator.

Statistical Analysis

The Statistical Package for the Social Sciences (SPSS, Chicago, IL, U.S.A.) 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 .05.

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 ($p<.05$) (Table 1). The peak contact pressure was 37.3±5.2 ㎜Hg on the general bed-backrest elevation system and 26.6±4.3 ㎜Hg on the bed-backrest elevation combined with hip and knee flexion system (Table 1).

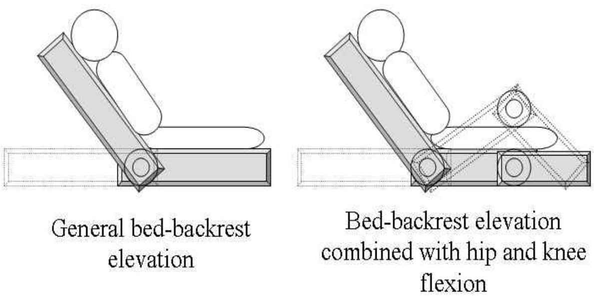

Figure 1. Bed-backrest elevation system.

Discussion

Pressure is concentrated wherever weight-bearing points come in contact with surfaces. These weight-bearing points usually occur over a bony prominence (Thomas, 2006). 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). Of all these sites, the sacrum is the most frequent ulcer location (36% of ulcers) (Meehan, 1994).

A previous study, to evaluate the pressure-relieving effect of mattresses with pressure alternating functions, reported that the local interface pressure was below a certain level (Rithalia and Gonsalkorale, 2000; Rithalia et al, 2000). Without dynamic pressure redistribution, these static cushions, when loaded to the "dense region," eventually lose the ability to reduce the load; therefore, the excessive load on soft tissue remains largely unrelieved (Makhsous et al, 2003).

To relieve and distribute the pressure, out of the ordinary equipment is needed and used for confined patients. This study investigated the differences between a general bed-backrest elevation system and a bed-backrest elevation system combined with hip and knee flexion for lower extremity body-pressure relief. Different types of beds were selected in this

Table 1. The mean of peak contact pressure (CPpeak) of the lower body

	General bed-backrest elevation	Bed-backrest elevation combined with hip and knee flexion	t
CPpeak	37.3±5.2 ㎜Hg	26.6±4.3 ㎜Hg	7.596*

*$p<.05$

study; the general bed-backrest elevation system only raises the upper segment, and is compromised of a one-axe and two-segment system the bed-backrest elevation system combined with hip and knee flexion simultaneously moves the upper and lower segments and is compromised of a two-axe and three-segment elevation system.

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).

When using a two-axe backrest bed, the upper body was raised and the hip and knee were simultaneously flexed. The peak body-pressure on the coccyx and buttock areas was significantly reduced with the bed-backrest elevation system combined with hip and knee flexion compared with a general bed-backrest elevation system. This result demonstrated that effective pressure relief and pressure redistribution may occur on the combined bed.

On a general bed-backrest bed, while raising the backrest, upper body weight was loaded down or pressurized by the subject's weight (Harada et al, 2002). However, while raising the backrest of a combined bed, the upper body weight might be supported and distributed by the flexion of the hip and knee segments. Adjustable body support by simultaneously flexed segments of the combined bed may have resulted in the increase of body-bed interface, especially in the coccyx and buttock areas.

It is thought that an increase in the body-bed interface leads to effective local pressure distribution. This combined elevation system may redistribute high interface pressure from the ischia to the thighs during elevation of the bed-backrest. Because most of the high interface pressure shifts away from the ischial area to the thighs, there is a long unloading time for the ischia.

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 the bed-backrest elevation systems; this part of the findings could not show the long-term changes of pressure on the beds. Also, we obtained our measurements from a small sample size and did not take pressure measurements at various angles. Future studies should require the assessment and analysis of various angles and changes in pressure over longer durations and from a larger sample size.

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.

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