A DESIGN GUIDELINE FOR MATTRESS SUPPORT PLATFORM OF ELECTRICAL ADJUSTABLE BED BASED ON UPPER-BODY SLIP ASSESSMENTS

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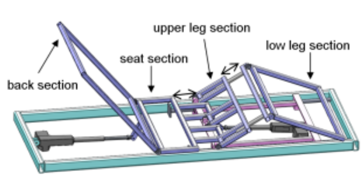
INTRODUCTION

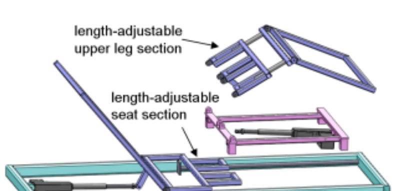
Electrically adjustable bed (EA-Bed) is a typical assistive product for home care. In Korea the public long-term care insurance system for elderly persons has been started in 2008, and the EA-bed is an essential item of the insurance benefits.

There are standards relating to the EA-Bed(IEC, 2009, JISC, 2009, KATS, 2012). The Korea standard(KATS, 2012) was revised two times since it was first published in 2007, and the last edition was published in 2012. In general a standard of product only defines basic requirements of safety and performance based on technology, but it generally does not consider usability and satisfaction of users. In a research report on usability test of EA-Bed published in 2011, users pointed out occurrence of body slip when upper body is raised. And some users had an uncomfortable feeling caused by the body slip.

It is known that the body slip is one of factors to develop pressure ulcer because the body slip causes shear force on the body trunk(Cook, A.M., & Hussey, S.M., 2002). When a shear force is loaded on the body, the pressure ulcer is easily developed even if the skin contact pressure is relatively low than the capillary vessel pressure. Therefore it is important to prevent body slip when upper body is raised on the EA-Bed. A simple method to prevent body slip is to lift up the upper leg section first before the back session is raised up. In addition to it, lengths of seat section and upper leg section would be concerned in the body slip.



(a) component of mattress support platform



(b) length adjustable sections

Figure 1: Design of sample bed.

In this study we investigated the effects on the body slip according to the lengths of upper leg section and seat section, and to the initial angle of upper leg section. For the assessment of body slip on EA-Bed we first developed a sample mattress support platform whose lengths of seat and leg sections are changeable. Then experiments were performed with six subjects. The initial position of human body was selected based on the thickness of upper body trunk. The initial angle of upper leg section was also set to 0 to 12 degrees. When a condition for the slip test is set, each experiment was performed three times at the same condition. Then the experimental results were verified by a statistics method. From the experimental results we propose ideal lengths of the mattress support platform and a guideline to care the elderly persons at home.

METHODS

<u>Design of sample bed</u>

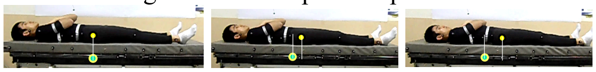
The designed sample EA-Bed for test was composed of four sections: back section, seat section, upper leg section and low leg section. The lengths of seat section and upper leg section were adjustable in the range 190 mm to 400 mm for seat section and 200 mm to 400 mm for upper leg section. The lengths were selected based on the SizeKorea data(KATS, 2010). The mechanism of upper leg section was put on the lifting mechanism for upper leg section in order to be movable the upper leg section. Fig. 1 shows the design of sample bed and the developed sample bed is shown in Fig. 2.

<u>Experimental setup</u>

We set the initial position of users, the angle of upper leg section, and lengths of seat section and upper leg section to three levels.

Fig. 3 shows the initial position of user. The first level fits the position of user's hip joint to the center of rotation of back section. The second level sets the position of hip joint

Figure 2: Developed sample bed.



(a) (b) (c)

Figure 3: Initial position of hip joint: (a) fit to the center (b) moved by a half of trunk thickness (c) trunk thickness.

(a) (b) (c)

Figure 4: Initial angle of upper leg section: (a) 0 degree (b) 6 degree (c) 12 degree.

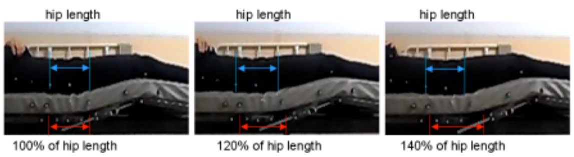


Figure 5: Initial length of seat section.

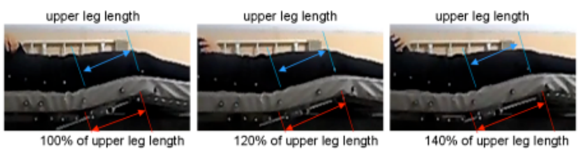


Figure 6: Initial length of upper leg section.

Figure 7: 3D motion capture system.

Figure 8: Measuring position of body slip.

to the position moved by a half of body trunk thickness from the center of rotation of back section. The third level sets the position of hip joint to the position moved by body trunk thickness as shown in Fig. 3(c). The initial angle of upper leg section is set to 0, 6, and 12 degree because the upper leg section should be adjustable 12 degree at least [1]. Fig. 4 shows the initial angle of upper leg section. The lengths of seat and upper leg section are set to 100%, 120%, and 140% of the hip length and upper leg length, respectively (see Fig. 5 and 6).

The upper body slip is measured by 3D motion capture system (see Fig. 7). The markers for measuring body slip are attached on shoulder and hip joint as shown in Fig. 8.

Experiment procedure

Six subjects who are all healthy male participated in the experiments. Experiment procedures are determined

Table 1: Comparison of WK and SD

Condition	Procedure
Hip joint position	1. Set the angle of upper leg section to 0 degree 2. Set the hip joint position to one of the initial position of hip joint in Fig. 3 3. Lift up the back section and measure body slip 4. Repeat three times 5. Move the hip joint position to other position
Angle of upper leg section	1. Set the length of upper leg section to 100% of upper leg length 2. Set the length of seat section to 100 % of hip length 3. Set the hip joint position to a position moved by a half of trunk thickness from the center of rotation of back section 4. Set the angle of upper leg section to one of the initial angle of upper leg section in Fig. 4 5. Lift up the back section and measure body slip 6. Repeat three times 7. Change the angle of upper leg section to other initial angle
Length of seat section	1. Set the angle of upper leg section to 12 degree 2. Set the length of upper leg section to 100 % of the upper leg length 3. Set the hip joint position to a position moved by a half of trunk thickness from the center of rotation of back section 4. Set the length of seat section to one of the initial length of seat section in Fig. 5 5. Lift up the back section and measure body slip 6. Repeat three times 7. Change the length of seat section to other initial length
Length of upper leg section	1. Set the angle of upper leg section to 12 degree 2. Set the length of seat section to 100 % of hip length 3. Set the hip joint position to a position moved by a half of trunk thickness from the center of rotation of back section 4. Set the length of upper leg section to one of the initial length of upper leg section in Fig. 6 5. Lift up the back section and measure body slip 6. Repeat three times 7. Change the length of upper leg section to other initial length

according to effective conditions in body slip: hip joint position, lengths of seat section and upper leg section, and the angle of upper leg section (see Table 1).

EXPERIMENTAL RESULTS

In experiments we measured two data, and of Fig. 8 by the motion capture system, but only used for assessment of body slip because body slip was mainly occurred in the hip joint area.

Body slip by hip joint position

Fig. 9 shows the measured results of body slip according to the initial position of hip joint. When the hip joint position is set to the same position of center of rotation of back section, the slip was occurred higher that others, but two positions of which hip joint is not on the same center position did not show a significant effectiveness in subject 1, 2 and 5. Certainly the body slip was shown in the same position of hip joint as the center for rotation of back section.

Body slip by length of seat section

Fig. 10 shows the results of body slip affected by the length of seat section. The results show a tendency that longer seat section causes higher body slip. However some subjects did not show such tendency in Fig. 10 (a) and (d).

Body slip by length of upper leg section

In Fig. 11 the results of body slip affected by the length of upper leg section is shown. Though subject 2 and 5 showed a significant effectiveness, the other data did not show the effectiveness by the length of upper leg section.

Body slip by angle of upper leg section

Fig. 12 is the results of body slip affected by the angle of upper leg section, and it shows that higher angle of upper leg section helps to prevent body slip even though subject 4 showed a different result.

DISCUSSIONS AND CONCLUSION

In this study we investigated the effects on the body slip according to the lengths of upper leg section and seat section, and to the initial angle of upper leg section. From the experimental results for assessment of body slip we can lead the following results.

First, the length of upper leg section was not effective to slip prevention. But the fitted length to user's upper leg length must be better to keep posture stability.

Second, the higher angle of upper leg section helps to prevent body slip when back section lifts up. Therefore to set the relatively high angle of upper leg section is recommended when caregivers perform care service for the elderly persons at home.

Third, the initial position of user on EA-Bed is important factor in body slip. Thus the recommendation for caregivers is that the hip joint position on bed should be separated from the center of rotation of back section, and at least the position moved by a half of trunk thickness is recommended.

Finally the length of seat section to be fitted to user's hip length is better to prevent body slip.

From these results, we can recommend an optimal size of mattress support platform. Because the average lengths of hip and upper leg of 60 to 69 years old in Korea are 240mm and 265mm respectively. If the lengths of seat section and upper leg section of EA-Bed are designed by the average

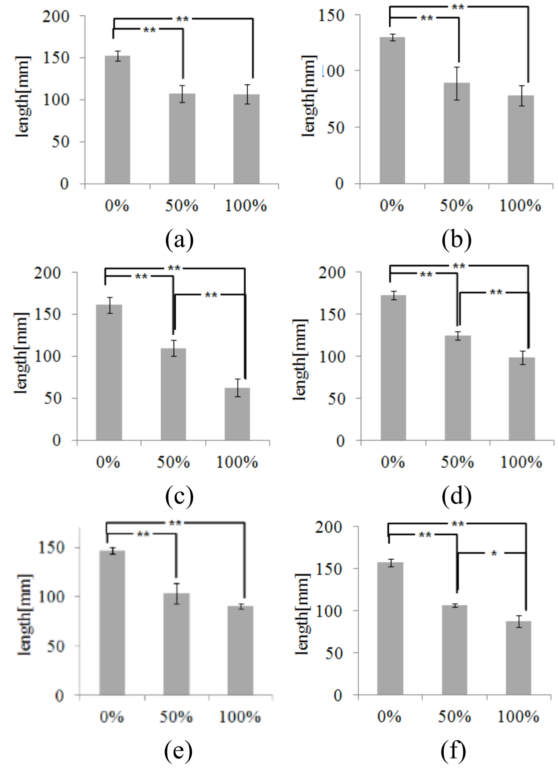


Figure 9: Results of body slip by hip joint position.

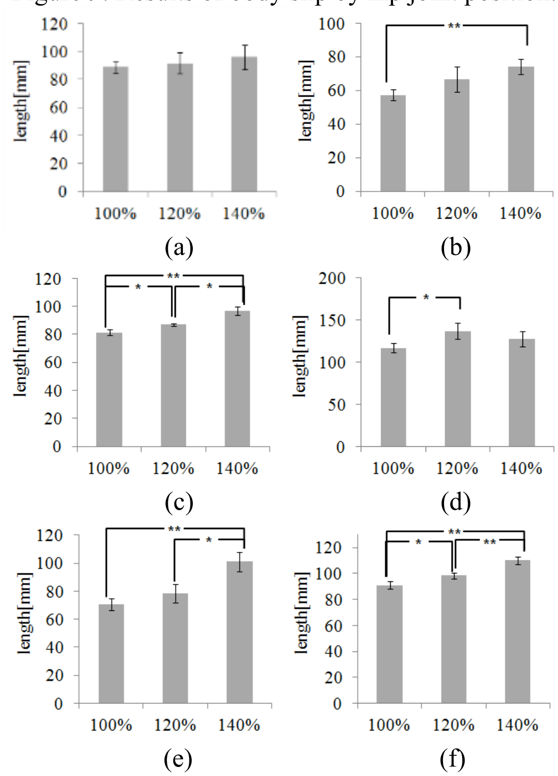


Figure 10: Results of body slip by length of seat section.

length of user, the possible users to use the designed bed to prevent body slip are persons with hip length 240~288 mm and upper leg length 265 ~ 318 mm.

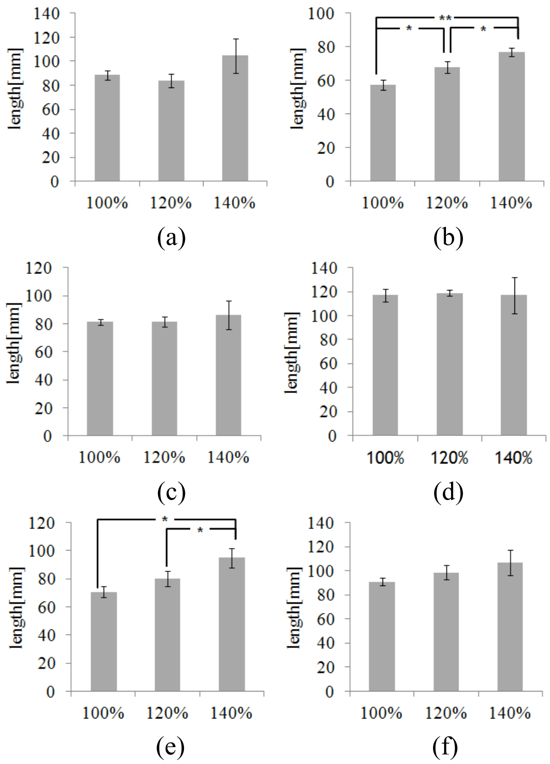


Figure 10: Results of body slip by length of seat section.

We are trying to perform usability test with elderly person. Using the results, we will propose an optimal design guideline. This is the next study.

ACKNOWLEDGEMENT

This study was supported by a grant of the Korea Healthcare technology R&D Project, Ministry for Health & Welfare Affairs, Republic of Korea. (A120125).

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