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Whole Body Biomechanics When Egressing and Ingressing From a Bed

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Abstract

Falls when egressing and ingressing a hospital bed are common occurrences. The height of the bed may be one of the critical factors related to these falls, as it may result in non-optimal postures of the body, especially the lower extremities. The study evaluated individuals egressing and ingressing a bed using a motion capture system. Low bed height (25–39 cm) and high hospital bed height (63–87 cm) were shown to have greater flexion and abduction angles of the upper/lower arm, ankle, pelvis, knee, and head with more difficulty, less stability, and more slippery participant perception. Further, the results suggest that setting a hospital bed at mid-range height (39–63 cm) could significantly reduce the risk of patient falls.

Keywords

egress, ingress, hospital, falls

Introduction

Every year, more than 1 million patient falls occur in hospitals and long-term care facilities (LeLaurin & Shorr, 2019; Marcum et al., 2023). About two-thirds of patient's falls result from egressing and ingressing the bed (Fonda et al., 2006). Low bed height has been a common strategy by healthcare organizations to mitigate the risk of patient falls (Dykes et al., 2010). When egressing or ingressing a bed in a low bed height position, people may adopt lower back, knees, hip, and ankle postures that result in biomechanical disadvantages. These postures may require greater muscular effort to maintain an upright posture. This may increase the risk of falls during sit-to-stand transitions, particularly for individuals with muscle strength deficiencies and balance impairments (Hoffman et al., 2003; Sharkey et al., 2012; Tzeng & Chang-Yi, 2006). It was reported by Merryweather et al. (2015) that elderly individuals with age greater than 55 years old exhibited reduced hips, knees, and ankle flexion angles and more anteriorly shifted center of mass during bed egress through a stand-to-sit motion at low bed height compared to the standard hospital bed height. A rapid shift in the center of mass during egress requires adequate balance, including postural stability, which demands increased torque at the knee and hip joints (Usmani et al., 2023). The study's objective was to measure the body postures when egressing and ingressing a bed at different heights.

Table 1. Demographics of Participants.

Body Dimensions	Male (13)	Female (16)
Age (years)	27.4 (7.5)	26.7 (5.0)
Height (cm)	176.6 (7.6)	163.5 (8.5)
Weight (kg)	79.4 (14.7)	67.3 (11.1)
Hip height (cm)	94.7 (6.8)	88.2 (6.4)
Knee height (cm)	51.7 (3.8)	47.3 (4.7)

Methods

Twenty-nine participants (16 females and 13 males) completed the laboratory study after a University IRB-approved consent form was signed. The participants were a combination of students and the general university population. Complete demographics are in Table 1. The Xsens motion capture system with 17 sensors was utilized to capture the instantaneous postures of the neck, right and left shoulder, right and left elbow, low back, right and left hip, right and

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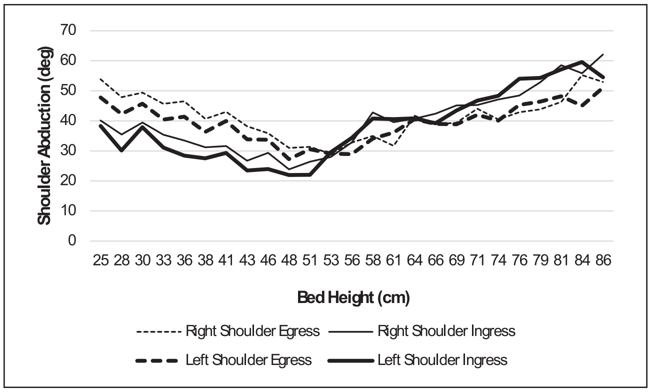

Figure 1. Peak Shoulder Abduction as a function of bed height.

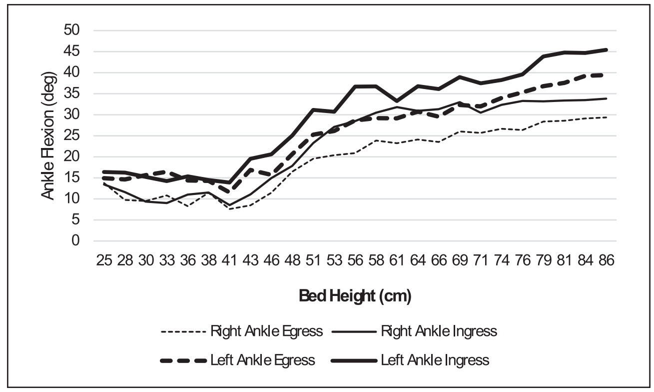

Figure 2. Peak Ankle flexion as a function of bed height.

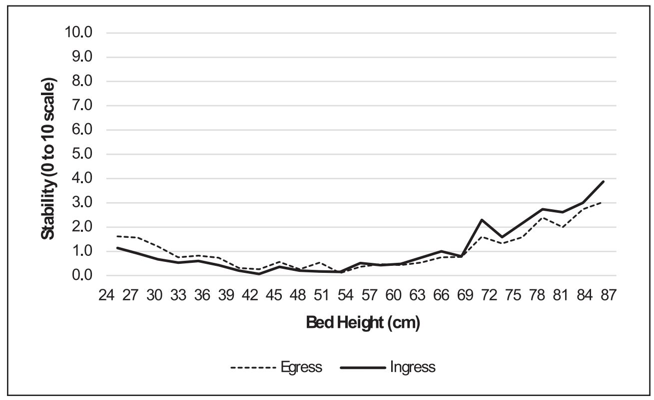

Figure 3. Perceived stability as a function of bed height.

left knee, and right and left ankles. The bed heights were randomized between 25.4 and 86.4 cm, with a small platform being utilized to obtain heights below 45.2 cm. Participants completed a set of ingress and egress trails at each bed height (a total of 100 trails, 50 egress, and 50 ingress). After each egress/ingress, researchers recorded perceptions of difficulty, slipperiness, and stability.

The Xsens MVN Software computed the three-dimensional postures of the joints of interest, with maximum values calculated in Excel. A one-way analysis of variance was utilized to evaluate whether differences existed for bed heights for each dependent variable. Tukey tests were used to determine the source of the significant differences.

Results

For most body parts, the postures were more neutral when bed heights were between 40.6 and 68.6 cm for both egress and ingress conditions (Figure 1 shows shoulder abduction). Bed height impacted the foundation of the body (e.g., ankles) where more ankle flexion occurred above 40.6 cm (see Figure 2). A couple of deviations from this trend were lateral bending of the lower back and head, and hip abduction for ingressing, where an increase of 2.54 cm about 48.3 cm resulted in about 2° more. Some body parts, such as knees (around 70° of flexion), elbows (around 55° of flexion), and wrists (around 35° and 40° of flexion of left and right wrists, respectively) were not impacted by the bed height. The perceptions of stability and difficulty followed similar trends of being lowest for the bed heights of 35.6 to 68.6 cm (Figure 3).

Conclusion

This study demonstrates that hospital bed height significantly impacts an individual's ability to ingress and egress a hospital bed, which may further impact patients experiencing muscle strength difficulties and balance impairment. Low bed height (25–39 cm) and high hospital bed height (63–87 cm) were shown to have greater flexion and abduction angles of the upper/lower arm, ankle, pelvis, knee, and head with more difficulty, less stability, and more slippery participant perception. These posture changes likely result in changes in the kinetics of the body, potentially increasing patient fall risk (Usmani et al., 2023). Further, the results suggest that setting a hospital bed at mid-range height (39–63 cm) could significantly reduce the risk of patient falls. However, future studies should explore a sub-optimal population as a more specific range of bed heights may produce the most neutral postures. Overall, this study lays the foundation for the broader implementation of appropriate hospital bed height to mitigate the risk of patient falls in healthcare facilities.

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Declaration of Conflicting Interests

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