Biomechanical Evaluation of Patient Falls from Bed

Key Findings

1. A significant risk of skull and/or brain injury exists due to patient falls from bed onto a hard floor surface.

2. Risk of head and brain injury is directly proportional to bed height and patient mass.

3. As bed height increases the risk of head and brain injury increases.

4. It is recommended that hospitals utilize lowest height patient beds as well as bedside fall mats, to minimize the risk of serious head injury among vulnerable patients.

Background

Patient falls in healthcare institutions are a serious problem. Even though hospitals have devoted considerable time and resources to prevent falls, patient falls consistently compose the largest single category of reported incidents[1].

A reported 79.5% of falls occur in patient rooms.[2]Approximately 22% of all reported falls are falls from bed.[3] Falls are the most common cause of nonfatal injuries.[4] Serious injuries, such as fractures, sprains, lacerations, or concussions, occur in 10% of inpatients who fall.[5]

A blow or jolt to the head can disrupt the function of the brain and result in a concussion.[5] Falls also can cause bleeding in the enclosed cavity of the brain (subdural hematoma), a problem three times more common in older adults.[5] Head, neck, thorax, and lower-limb injuries are serious complications that can occur after a seemingly non-threatening, low-velocity fall from the same level or sitting position, especially in older adults.[5]

Empirical evidence shows that the height of typical patient beds in low position in acute care units are much higher than the average height of beds designed for residential use in the U.S. market. The height of patient beds might be an overlooked cause of patient falls.[2]

Objectives

The objective of this study was to determine how bed height effects fall injury risk. Data from this study is expected to provide useful information to hospital nursing staff considering using low-height hospital beds to help reduce patient injuries that result from bed falls.

Test Methods

Patient falls from bed were simulated using a CHG Spirit Plus® bed and a six-inch (6") thick CHG mattress. The mattress was placed on the bed's mattress deck and the bed height was lowered to a starting height of nine-inches (9"). Three different anthropomorphic test dummies were used to simulate a small, average and large patient falling out of bed. The dummy referred to as H5 represented a small female, 5ft tall and 115lbs. The mannequin referred to as H50 represented an average male 5ft-6" tall and 175lbs. The dummy

referred to as H95 represented a large male 6" tall and 235 lb.

The mannequins were used to simulate a patient falling from bed, both feet first and head first. Each configuration was repeated three times, then the mattress deck was raised by one-inch (1") increments, up to a maximum thirty-four-inch (34") deck height. Thus each of the three mannequins was used to simulate feet first and head first falls at twenty-six (26) different mattress deck heights, ranging from nine-inches to thirty-four-inches (9" – 34") onto hard flooring, representative of the flooring in a typical hospital room. Bedside fall mats were not used or evaluated in this particular study.

Data Collection

The data recorded included Linear Acceleration (g), Head Injury Criterion (HIC), a value used in the automotive industry to correlate acceleration with injury severity, and Impact Force (N). Lines of best fit along with the corresponding equation and R^2 (correlation) values were also included. Injury threshold values corresponding with Linear Acceleration of >250g and HIC >1000 are represented on the following graphs using horizontal red lines.

Data was captured to determine force of impact at the head and hip. Observed forces were then compared with known forces required for injury (injury thresholds).

Results

Two hundred successful trials were completed to satisfy statistical analysis. For feet first falls involving the small (H5) mannequin, injury threshold values based on linear head acceleration and HIC was met for falls from bed height of approximately 15.5 inches. Therefore, feet first falls from bed heights greater than 15.5 inches may cause significant head injury in patients corresponding in anthropometry to the small H5 (115lbs) dummy.
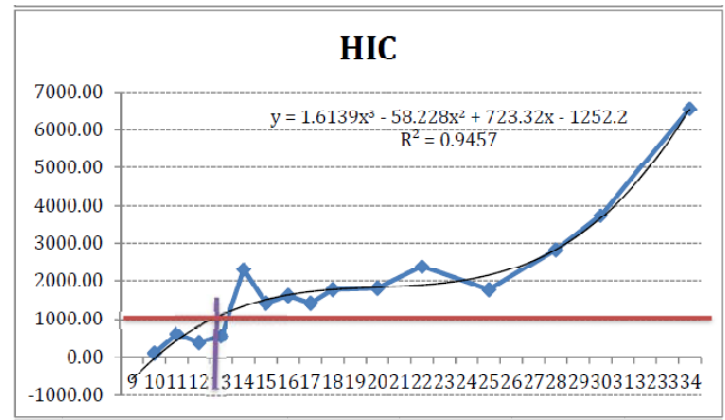
For feet-first falls involving the average (H50) mannequin, injury threshold values based on linear head acceleration and HIC correspond with a lower bed height of approximately 12.5 inches. Therefore, feet-first falls from bed heights greater than 12.5 inches may result in significant head injury in patients corresponding in anthropometry to the average H50 (172lb) dummy.
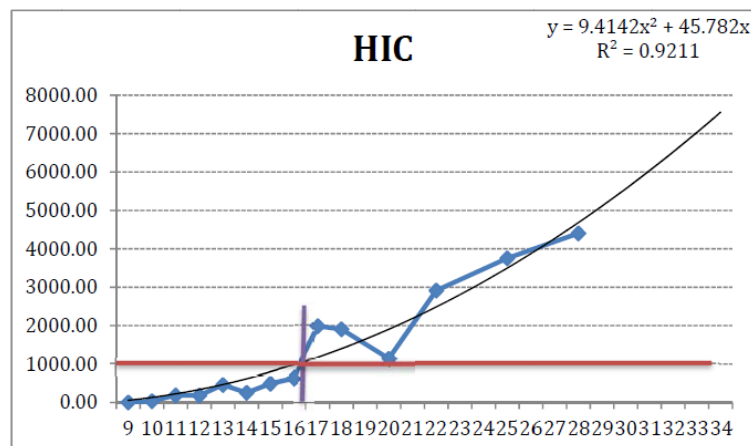
Conclusions

Findings from this study show that a significant risk of head injury exists due to patient falls from bed onto a hard floor surface, as determined by head impact acceleration and head injury criterion (HIC). A fall from bed base height of 16 inches could cause significant head injury in a small female patient (5ft, 115lb), whereas the same injury may be caused in an average size male patient (5ft-6", 175lbs) falling from a bed base height of 12.5 inches.

Recommendations

This study concludes that risk of head and brain injury is directly proportional to bed height and patient mass. That is, as bed height or patient weight increases, the risk of head and brain injury increases.

It is recommended that hospitals utilize the lowest height patient beds possible as well as other protective mechanisms, such as bedside fall mats, to minimize the risk of serious head injury in normal patients. Vulnerable patients are likely to be at heightened risk of injury and as such it is imperative that all available precautions be utilized.

Acknowledgements

This study was conducted by Dr. John Lloyd, who holds a PhD in Ergonomics from Loughborough University in England, and is Board Certified throughout the United States as a Certified Professional Ergonomist (No. 725). Dr. Lloyd is a federally-funded Researcher and Expert in the fields of Ergonomics and Biomechanics. John currently serves as Associate Director for the Tampa VA HSR&D/RR&D Center of Excellence on Maximizing Rehabilitation Outcomes. He is also an Assistant Research Professor in the Department of Biomedical Engineering at the University of South Florida.

For over 20 years, Dr. Lloyd has provided ergonomics and biomechanics-related consulting services. He has authored more than 80 book chapters, publications, open-literature articles and technical reports on both ergonomics and biomechanics.

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