DEVELOPMENT OF AN INFLATABLE HIP PROTECTION SYSTEM: DESIGN FOR HIP FRACTURE PREVENTION AND INCREASED COMPLIANCE

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INTRODUCTION

Hip fractures are debilitating and the leading cause of injury deaths among persons 65 and older. Over 350,000 hip fractures occur annually in the United States, totaling $18 billion in healthcare costs (Cummings, 1990). Developing an effective means of protection against hip fracture could prevent premature death, increase livelihood among the elderly, and reduce healthcare costs.

Most hip fractures occur due to direct trauma to the hip from falling. The use of energy shunting and/or absorbing materials to divert impact forces away from the bone has been shown to prevent the occurrence of hip fractures. Although studies have proven that the use of external hip protector pads have reduced the incidence of hip fractures by nearly 50%, non-compliance has been an issue with compliance rates of 24% (Lauritzen, 1993). In addition to the issue of non-compliance, the current commercially available hip protectors are ineffective in reducing the impact forces below the hip fracture threshold of 2100 N (Lotz, 1990). The purpose of this study to develop a hip protection system which targets the issues of force attenuation and non-compliance.

METHODS

Two new designs were modeled after an inflatable airbag and utilized an energy shunting method to dissipate the fall energy away from the hip and into the surrounding soft tissue. Once a fall is detected, the hip bags will rapidly inflate with carbon dioxide gas. The first design, Prototype A, is a garment mounted hip protection system. The hip bag is designed to be concealed within pockets which are sewn onto the user's garments and pre-positioned over the greater trochanter. The second design, Prototype B, consists of an enclosure containing a hip bag that can be clipped onto a belt. When a fall is detected, the enclosure opens and the hip bag unfolds and inflates, to protect the greater trochanter.

A vertical drop tower was used to simulate a fall in which the hip was directly impacted. Since 80% of hip fracture patients are women, it was desirable to recreate the typical fall conditions for a female. The drop tower was constructed from an impactor assembly traveling on four reciprocating roller bearings that were attached to two linear shafts. A Hybrid III dummy hip was mounted to the impactor assembly with a load cell mounted inside. The load cell was mounted on a simulated greater trochanter, so that the measured load accurately represented the force on the hip. A drop height of 0.35 m was used with an effective mass of 20 kg. This is a similar design to that presented by Robinovitch (1995).

Baseline impact tests were performed without any protective measures in place. The new hip protector designs and commercially available hip protectors were compared to the baseline tests. The peak impact forces, or greater trochanter forces, measured with the drop tower for each test condition are compared.

RESULTS AND DISCUSSION

A plot of the measured forces on the hip from the drop tests is shown in Figure 1. A peak impact force of 8000 N was measured for an unprotected hip (no pad). This peak impact force falls within the range of average peak impact forces during a fall (Robinovitch, 1995). Although the commercial hip pads were effective in reducing the peak impact force, they were unable to reduce the force below the fracture threshold of 2100 N. In comparison, both of the new hip pad designs were able to reduce the impact force well below the fracture threshold. The peak impact forces for the garment mounted and belt mounted hip protection system were 1190 N and 1250 N, respectively. This results in a force reduction of approximately 85% for the garment mounted device and 84% for belt mounted device.

CONCLUSIONS

The proposed hip protector designs were effective in reducing the peak impact forces below the fracture threshold. The hip bags utilize an energy shunting method to protect the hip, which has been shown to be more effective than energy absorbing hip protectors (Robinovitch, 1995). With further development, the new hip protection devices proposed in this study have the potential to significantly reduce the number of hip fractures that occur annually in the United States.

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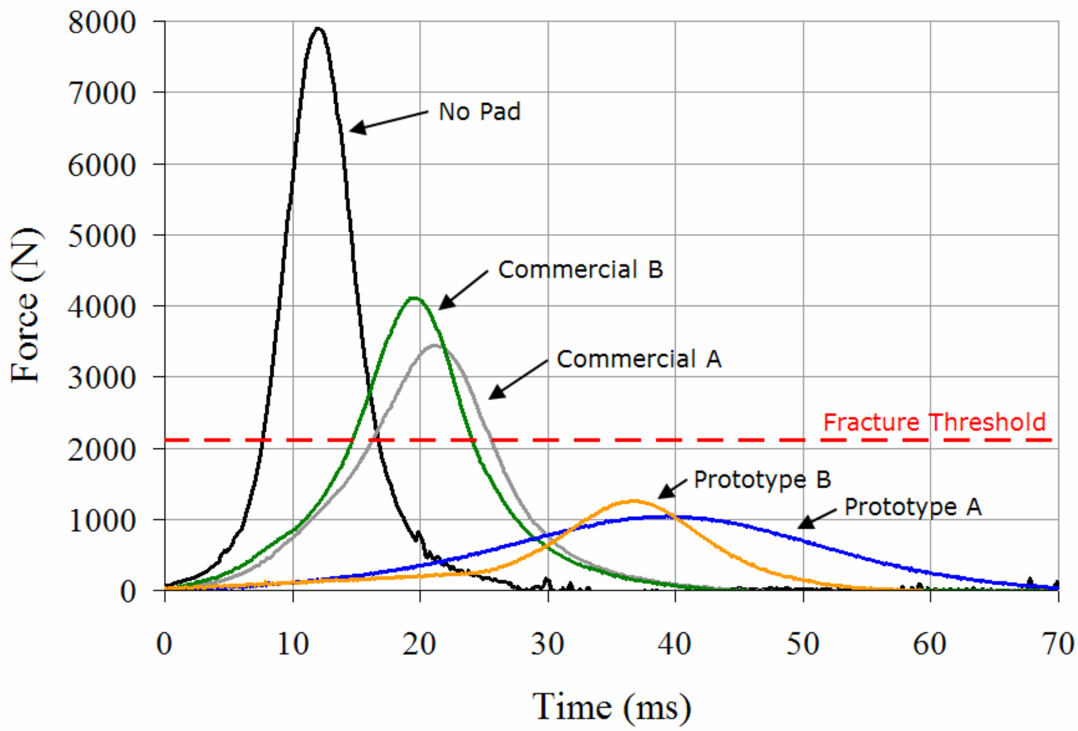

Figure 1: Greater trochanter force versus time curves for all hip pad tests from experimental falls. Note that impulse values are different given increased load sharing with the prototype pads.