INTRODUCTION

Hip fractures are a major health problem among the elderly, and 90% of fractures are caused by falls. Wearable hip protectors (Parker et al., 2006) represent a promising strategy for attenuating and redistributing the force applied to the hip region, and thereby reducing the risk for hip fracture during a fall. However, the protective effect of hip protectors should depend on the direction of the fall, and the amount of baseline soft tissue padding over the hip. In the current study, we tested these hypotheses through safe falling experiments in young adults.

METHODS AND PROCEDURES

Fourteen young women (aged 18-35) participated. Through initial screening, one-half of participants were selected to have a body mass index (BMI) greater than 25, and the other half had a BMI less than 18.5. Subsequent ultrasound measures confirmed that the high BMI group had considerably greater thickness of soft tissue padding over the greater trochanter (GT).

Sideways falls were simulated by releasing the participant (by means of a tether and electromagnet) from a height of 5 cm. Trials were acquired for pelvis orientations which produced direct lateral impact to the GT, with the pelvis tilted 20 degrees posterior to the lateral midline, and with the pelvis tilted 20 degrees anterior. For each configuration, three repeated measures were acquired in the unpadded condition, and while wearing a commercially available soft shell hip protector.

In each trial, an RSscan device (0.5 m model) mounted over the impact surface provided a measure of the pressure applied to the contact areas, at 500 Hz. The RSscan plate contains 4096 pressure sensors (each having a surface area of 7 mm x 5 mm) in a 64 by 64 cell array. The device has a measurement resolution of 1 kPa, range of 3 to 1270 kPa, and accuracy of 0.37 kPa based on in-house calibration.

The location of the greater trochanter (GT) and femoral diaphysis during impact were monitored at 250 Hz with an optical motion measurement system (Motion Analysis Corp, Eagle system), and custom routines were used to anatomically map the RSscan pressure record over the hip region (Figure 2).

Data were analyzed using RM ANOVA (with alpha=0.05), with BMI as a grouping factor, to determine whether the hip protector affected the magnitude and location of peak pressure over the hip region during impact.

RESULTS

ANOVA results indicated that normalized values of peak pressure associated significantly with hip protector condition (F=13.7, p=0.003), impact configuration (F=4.9, p=0.03), and BMI (F=6.7, p=0.024). Furthermore, there was a significant interaction between hip protector condition and BMI (F=7.8, p=0.016), reflecting a
greater protective effect for low BMI than high BMI participants. For example, in the lateral impact configuration, peak pressure decreased 77% (from 754 to 168 kPa) in low BMI participants, and 48% (from 369 to 180 kPa) in high BMI individuals (normalized pressures shown in Figure 1). Similar trends were observed in the posterio-lateral and anterior-lateral impact configurations.

The location of peak pressure (distance from the GT) also associated with hip protector condition (F=67.3, p<0.001 for absolute distance and F=7.3, p=0.02 for angle from the diaphysis), and with impact configuration (F=21.5, p<0.001 for angle). Furthermore, there was a significant interaction between protector and BMI (F=8.4, p=0.013 for distance and F=19.8, p=0.001 for angle), with the hip protector redirecting peak pressure, on average, from 53 mm to 71 mm away from the GT in low BMI individuals, and from 47 to 84 mm in high BMI individuals (Figure 2).

DISCUSSION

Previous studies indicate that peak force during a fall scales linearly with the thickness of soft tissues over the greater trochanter (Robinovitch et al. 1995), and that such tissues typically reduce fall impact force by 50% (Bouxsein et al. 2007). In support of these observations, we found that peak pressures in the baseline, unpadded condition were much greater in low BMI than high BMI individuals. Furthermore, hip protectors substantially attenuate peak pressure in low BMI but not high BMI individuals, largely removing the variation in pressure between these groups.

SUMMARY

The soft shell hip protector we tested substantially reduced peak pressure over the hip for low BMI participants, but had less protective effect for high BMI individuals.

REFERENCES


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