SAFE LANDING DURING A FALL: EFFECT OF RESPONSE TIME ON ABILITY TO AVOID HIP IMPACT DURING SIDEWAYS FALLS

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INTRODUCTION

Ninety percent of hip fractures in the elderly are due to falls (Grisso et al., 1991), and there is considerable evidence that fall severity, as defined by the configuration and velocity of the body at impact, is a stronger predictor of hip fracture risk than bone density (Greenspan et al., 1994). Of particular importance is whether impact occurs to the hip region, which increases fracture risk 30-fold (Schwartz et al., 1998).

We previously found that young women can avoid hip impact during a sideways fall by rotating forward or backward during descent, when instructed to do so before fall initiation (Robinovitch et al., 2003). However, during real-life falls, individuals rarely have the ability to plan their descent strategy before fall initiation. Under these circumstances, the effectiveness of a specific safe landing strategy may depend on time delays in initiating the response.

Our goal in the current study was to test whether the ability of young women to avoid hip impact during a sideways fall depends on the time instant during descent when the instruction (to rotate forward or backward) is provided. We hypothesized that a critical time window exists following the onset of the fall, beyond which pelvis rotation is ineffective in allowing for avoidance of hip impact.

METHODS

Participants consisted of 15 women ranging in age from 20 to 32 years (mean = 23 ± 4 (SD) yrs). In all trials, a sideways fall onto a gymnasium mat was initiated by suddenly releasing a tether, which supported the subject at a 10 deg lean angle (Figure 1). Subjects were instructed to respond to a visual cue (110 x 160 cm) projected on a wall in front of them, and first displayed either before tether release (by 300, 200, or 100 ms), at the exact instant of release, or after tether release (by 100, 200, or 300 ms). If an image appeared of a person landing on her front side, the subject was to rotate forward to land on her hands. If an image appeared of a person landing on her back side, the subject was to rotate backward to land on her buttocks. If no image was displayed, the subject was to fall sideways with no rotation and land on her hip (control trial). Each subject participated in a total of
53 trials presented in a random order: 15 practice trials, followed by two trials in each of the 14 combinations of rotation direction and cue delivery time, with 10 interspersed control trials.

In each trial, we acquired the 3D positions of 22 skin surface markers with a 60 Hz motion measurement system (Qualisys, ProReflex). From these data, we determined the pelvis impact angle. A value of zero deg in this parameter indicated direct impact to the hip, and 90 deg indicated impact to the anterior or posterior aspects of the pelvis. We used a 2-way repeated measure ANOVA to test whether the absolute value of pelvis impact angle was affected by direction of rotation and time of cue delivery.

RESULTS AND DISCUSSION

We observed significant main effects for time of cue delivery (p<0.001) and direction of rotation (p=0.003). Earlier cue delivery led to increased pelvis impact angles (Figure 2). Furthermore, pelvis impact angles were greater for backward than forward rotation. In addition, a significant interaction existed, with pelvis impact angles being greater in backward than forward rotation trials, for cue delays of 200 and 300 ms after release.

These results indicate that young women can avoid direct impact to the hip during unexpected sideways falls. However, rotation must be initiated within 200 ms after release in order for it to be effective. Our results also show that, when there is a substantial delay in initiating the response, backward rotation is more effective than forward rotation.

Our findings suggest that fall severity and risk for hip fracture during a fall may depend strongly on reaction time and cognitive factors, such as attention (Nevitt et al., 1991). These data may help to guide the design and evaluation of exercise programs to enhance safe landing responses in elderly participants.

Figure 2: Mean ± S.E. values of pelvis impact angle. Asterisks (*) show where impact angles were greater for backward rotation.

SUMMARY

We found that individuals can avoid hip impact during a sideways fall by rotating during descent. However, to be effective the response must be initiated within 200 ms after fall initiation.

REFERENCES


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