INTRODUCTION

Our study was motivated by the serious problem of falls in the elderly. Tripping over obstacles has been cited as a frequent cause of falls in the elderly (Campbell et al., 1990). Previous studies on obstacle crossing of the trailing limb have examined the effects of toe-obstacle distance and obstacle height, but not the effect of gait speed on this activity (Chou and Draganich, 1997; Chou and Draganich, 1998). Our objective was to investigate the effect of walking speed on the biomechanics of the trailing limb during obstacle crossing. Gait speed is important because of the range of speeds commonly used in everyday life and the fact that in healthy adults, average gait speed peaks in the 30s and then decreases with age (Bohannon, 1997). Decreased gait speed has been associated with decreased muscular strength and falling in the elderly (Whipple et al., 1987). To obtain baseline data, we examined the trailing limb during obstacle crossing of 10 healthy young adults. We hypothesized that increased gait speed would significantly increase the motions and moments of the trailing limb while crossing an obstacle. If this is true, then the elderly should be careful not to walk too fast.

PROCEDURES

Gait analysis was performed on 10 healthy young adults (5 females, 5 males), having a mean age of 25 years (range, 22-39 years), an average height of 171 cm (range, 155 cm to 187 cm), and a mean weight of 643 N (range, 463 N to 904 N). All of them were right hand dominant. Subjects wore low-heeled shoes for the experiment. The obstacle was a white wooden rod 37 in. (94 cm) long and 0.03 in. (0.5 cm) in diameter, held 8 inches high (204 cm) by grooves in the two vertical arms of an aluminum frame. Subjects were asked to walk along the 9.5m long walkway, step over the obstacle with their right legs first and their left legs (trailing limbs) second, and continue walking to the end of the walkway. Each subject crossed the obstacle at a self-selected normal speed, self-selected slower than normal speed and self-selected faster than normal speed. The order of the slow and fast trials was random.

Ground reaction forces were measured with a multicomponent force platform in the center of walkway. Clusters of six or eight infrared light-emitting diodes were attached to the foot, shank, and thigh of the left lower limb and pelvis of the subject with elastic straps. Kinematic parameters were collected with the OPTOTRAK optoelectronic, three-dimensional digitizing system. Kinematic and force parameters were sampled at a rate of 100 Hz. The overall accuracy of the system was better than 0.5 mm.

The mean of three trials for each walking speed was used in formulating the results. SYSTAT was used to perform the statistical analysis. The effects of walking speed on the motions and moments of the trailing limb were tested using one-way analysis of variance with repeated measures. To account for multiple comparisons, an α level of 0.01 was used to determine statistical significance. If a significant difference was detected, the polynomial test was performed...
at an α=0.05 level of significance to determine the trend (linear, quadratic, or cubic). The flexion-extension angles and external moments for the joints of the trailing limb are reported here.

RESULTS

When stepping over an obstacle in a self-selected manner, increasing gait speed significantly increased crossing velocity (p≤0.0001). Gait speed was not found to affect the flexion-extension angles of the joints. The peaks of five external flexion-extension moments about the hip, knee, and ankle increased linearly with gait speed (Fig 1). The largest increases from slow to fast speeds were 100% for hip flexion moment (p≤0.0001), 47% for knee flexion moment in late stance (p≤0.0001), and 63.3% for ankle plantarflexion moment (p≤0.0001).

DISCUSSION

Gait speed did not significantly affect the flexion-extension angles of the hip, knee or ankle of the trailing limb. Thus, flexion-extension angles are not key factors to crossing obstacles at increased gait speeds. However, five flexion-extension moment variables increased significantly with increased walking speed, so muscle strength is important to crossing obstacles at increased speeds. Studies have shown that muscle strength begins to diminish from the 5th decade until the 9th decade by 12-15% per decade, and that ankle and knee flexion-extension strengths are significantly weakened in a subset of elderly who suffer frequent falls (Whipple et al., 1987; Wolfson et al., 1985). The implication is that in frail older adults, the risk of tripping over obstacles is increased with faster gait.

Figure 1. Hip, knee and ankle moments that increased linearly from slow to fast.

REFERENCES