INTRODUCTION

Successful hazard accommodation is an important aspect of maintaining a continuous walking pattern and avoiding slips and falls. Identifying and adapting to observed hazards is one component that leads to this success. Anticipatory locomotor adjustments (ALAs) have been previously investigated with respect to accommodating versus avoiding changes in surface levels (e.g. McFadyen and Carnahan, 1997) and during the circumvention of obstacles in the travel path (e.g. Vallis and McFadyen, 2003). Numerous studies have been completed documenting gait control and evaluating ALAs at the hazard or ‘target’ (e.g. Cham and Redfern, 2002), that is, the kinetic and kinematic features of step regulation at the time the contingency in the environment is negotiated. The question as to how gait is regulated during the approach is considerably less well documented.

Previous studies have examined approach characteristics in the sport of long jumping where there is a requirement to approach the target at maximum velocity (e.g. Hay, 1988). Fewer studies have examined adjustments while walking towards various types of targets (e.g. Buekers et al., 1999). Step length regulation upon approach appears to be an important feature of successful obstacle negotiation or target accommodation (Bradshaw and Sparrow, 2001). Minimal research, however, has focused on more complex gait adjustments that occur during multiple steps prior to a target or hazard.

METHODS

An experiment using a 2x2 repeated measures design incorporated two within-subject variables: walking velocity (normal and fast) and size of target (small-2cm x 2cm and large-33cm x 53cm). To minimize confounding influences related to ordering, the presentation of the conditions was randomly assigned after being blocked by walking velocity. Thirty-six participants (19 females, 17 males) completed this experiment. The means (sd) of ages, heights and weights of the participants were 41.7 (15.1) years, 168.4 (9.4) cm, and 72.5 (14.7) kg, respectively.

A straight runway of approximately 10m was used for all trials, with overhead lights projecting targets towards the end of the runway. Participants were fitted with uniform footwear (athletic shoes). After determining the walking velocities for the participant, each participant performed 50 walking trials at each of the two self-selected velocities to acquire a minimum of ten usable trials per condition. Participants were instructed to completely cover the small target with their foot and center their foot within the large target while walking. The color of the runway was dark gray to provide adequate contrast with the targets.

Kinematic data of the lower limbs were collected using a passice reflective
cinematographic motion tracking system (Eagle Digital camera system, Motion Analysis Corp, Santa Rosa, CA, USA). Position data was collected at 200Hz using 10mm diameter reflective markers placed according to the modified Helen Hayes marker set (Kadaba et al., 1990).

Kinematic data was processed to provide gait parameters for each step within the trials. The initiation of ALAs determined in the analyses were compared across participants to determine the onset of ALAs. ANOVAs were used to determine the effects of walking velocity and target size for each of the dependent measures. Post-hoc statistical analyses (Tukey’s HSD test) were used to determine the step at which significant changes were initiated within the trial. All statistical analysis used a significance level of p<0.05.

RESULTS AND DISCUSSION

Target size and gait velocity significantly affected adjustments of step length and step velocity but did not significantly affect step width or step duration. Generally, step length and step velocity decreased during adjustment phases to apparently provide better control of foot placement.

During normal walking velocities, participants made small changes in variables within multiple steps (three or four) while maintaining a relatively normal and uninterrupted gait pattern. This may be possible because visual control onset occurs earlier at lower velocities (Bradshaw and Sparrow, 2001). Adjustments during the faster trials were only made to the two steps prior to stepping on the target. This was similar to findings by Buekers et al. (1999) who found that excessive adjustments in stride length were required for the final step preceding a doorway opening.

Some of the variation in ALA onset can be attributed to the effect of target size. Larger adjustments over an additional step were required for smaller targets because stepping on the small target placed added constraints on foot placement. Similarly, Bradshaw and Sparrow (2001) showed a linear relationship between approach velocity of the whole body and accuracy of foot placement for various targets and obstacles.

SUMMARY/CONCLUSIONS

Goal-directed walking, represented by the targeting task, involves adjustments to gait parameters over multiple steps. Present findings indicate that future research regarding slips and obstacle negotiation should consider multiple steps during the approach of a hazard, not just the step immediately preceding it.

REFERENCES