GAIT ADAPTATION: LEAD TOE CLEARANCE CONTINUALLY DECREASED OVER MULTIPLE EXPOSURES WITH AND WITHOUT ON-LINE VISUAL INFORMATION

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INTRODUCTION

Reduced vision of the lower limbs is a common occurrence in activities of daily living. Carrying a laundry basket up stairs reduces vision of both the lower limbs and the obstacle (stair). Patla [1] has shown that absence of vision of the lower limb relative to an obstacle changed the trajectory of the swing limb. Rietdyk et al. [2] found that similar visual interference did not change the trajectory of the swing limb when accomodating an elevated surface, and suggested that the lack of change may have resulted from increased exposure. The purpose of this research was to determine if increased exposure to an obstacle with visual interference and full vision modified toe clearance of the lead limb during gait.

METHODS

The lower limb kinematics of six subjects (23.8 yrs) were examined while stepping over a 10 cm obstacle. Subjects performed 50 blocked trials with full vision and 50 blocked trials with visual interference which were randomized so half of the subjects received full vision first. Goggles blocked the view of the lower limb and the obstacle two steps prior to stepping over it. Lead toe clearance was examined. A 2x2x3 (vision x order x trials (grouped as first, middle, and last five trials)) ANOVA was run.

RESULTS AND DISCUSSION

Subjects tripped on 1% of the obstacle crossing trials, all trips occurred with the trail limb. A significant interaction was observed for lead toe clearance (vision x order x trials, $p < 0.0001$). Post hoc analyses for the full vision trials revealed that toe clearance decreased 12.1% over the first 50 trials (solid line in figure 1). While the initial large margin (17.3 cm) reduced the risk of tripping with the lead limb, the proactive strategy would require an increase in energy consumption and also reduced stability [3]. Therefore, an ideal toe clearance should be high enough to prevent tripping, but low enough to maintain stability and reduce energy costs. With increased exposure, and without specific instructions or external feedback from the experimenters, the subjects reduced their toe clearance. This indicates that subjects were attending to 'internal' feedback to decrease the toe clearance during this dynamic task. Visual feedback, presumably from view of the knee in the periphery [1], would allow the subject to continually reduce the limb elevation.

Toe clearance was 19.9 cm for the first five trials with visual interference, an increase of 2.5 cm (14%) relative to the full vision condition, consistent with Patla [1]. Due to visual interference, feedback would not be received from the view of the knee in the periphery. Generally, spatial estimates with vision are considered to be less variable than other sensory modalities [4]. As only kinesthetic information could provide the feedback, limb elevation increased to compensate for variability. Subjects reduced toe clearance by 23.4% during the first 50 trials, the reduced toe clearance values were not different from the full vision group after 20 and 50 exposures.

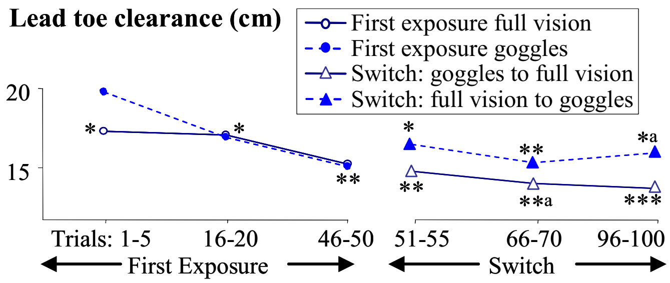

Figure 1: Lead toe clearance across 100 trials for full vision (open circles and triangles) and goggles (closed circles and triangles). Asterisks indicate significantly different responses, *a indicates the response was not different from * or **; **a was not different from ** or ***.

Following 50 exposures with full vision, subjects who received visual interference for the first time showed an increase in toe clearance (dotted line in right half of Fig. 1), which did not decrease over 50 trials. However, the subjects who received visual interference first did not demonstrate a decrement in performance when vision was provided. These findings are consistent with the motor control literature where motor learning during aiming tasks has been shown to be specific to the sources of afferent information used to optimize performance during practice [5]. These findings are especially interesting as we did not specifically instruct subjects or provide feedback regarding toe clearance.

It is important to note that the toe clearances observed here were slightly higher than those observed in the literature [e.g. 1]. This between subject difference may affect the overall magnitude of the decrease, but we would still expect to see a decrease with repeated exposures. Further analyses will examine clearance of the trail limb and toe clearance variability during this task.

CONCLUSIONS

During initial exposure, toe clearance decreased for both full vision and visual interference conditions, and after 20 trials the toe clearance was not different across the visual conditions. However, when subjects switched to another visual condition, those with initial visual feedback showed a decrement in performance, which was not observed when the initial trials were without visual feedback.

REFERENCES

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