ADAPTIVE CHANGES IN STEPPING UP ONTO LATERALLY-COMPLIANT STRUCTURES: AGE DIFFERENCE IN HEALTHY MALES

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INTRODUCTION

Falls from laterally-compliant structures, such as stepladders, cause injuries in industry and at home across the age spectrum; however, fall-related injuries become more frequent and more serious in older populations [1,2]. Healthy adults, especially the elderly, have been shown to take significantly more time to complete a single step-up movement onto a raised structure with unexpected structural compliance [3]. The purpose of this study was to investigate whether subjects demonstrate practice or learning effects in this behavior. We therefore tested the null hypotheses that there are (a) no significant practice effects in stepping up onto a laterally-compliant structure in repeated trials and (b) no age effects on this behavior between healthy young and older men.

METHODS

Twenty healthy male subjects, 10 young males (YM) aged 26±3 years and 10 older males aged 72±3 years, were asked to stand bare-foot on firm ground, and then step forward and up onto a 7" (0.178 m) -high structure at a self-selected comfortable speed. The mediolateral compliance of the structure could be covertly adjusted to one of three different values (measured at the structural top surface): rigid ($C_0 < 10^{-5}$ m/N), smaller compliance ($C_1 = 1\times10^{-4}$ m/N), and larger compliance ($C_2 = 2\times10^{-4}$ m/N). Six stepping trials were performed with each compliance. Trial order was C_0, C_1, and C_2, interspersed by different numbers of blocks of six C_0 trials to prevent subjects knowing when a compliance change occurred. Adaptive changes in the stepping movements were examined by comparing data from the first to sixth trials in each compliance condition.

The primary parameter investigated was the total time each subject used to complete the step-up movement normalized by the time used from initiating weight transfer till the lead foot contacting the raised structure (Ts). Kinematic and kinetic data were recorded and analyzed, but for brevity are not reported in this abstract. Repeated measure analyses of variance (rm-ANOVA) were performed to examine the effects of practice, structural compliance, and age on Ts. Post-hoc rm-ANOVA were used to examine the effects of structural compliance and age on stepping movements after practice (in the sixth trial). Additional post-hoc rm-ANOVA were performed to compare movement parameters of the first trial of YM with those of the sixth trial of OM. $P<0.05$ (with Bonferroni correction) was considered statistically significant unless otherwise noted.

RESULTS AND DISCUSSION

Practice significantly ($p<0.001$) reduced the stepping duration (Ts) needed for completing a single step-up movement, especially for older males stepping onto the laterally-compliant structures (C_1 and C_2) (Figure 1). The largest

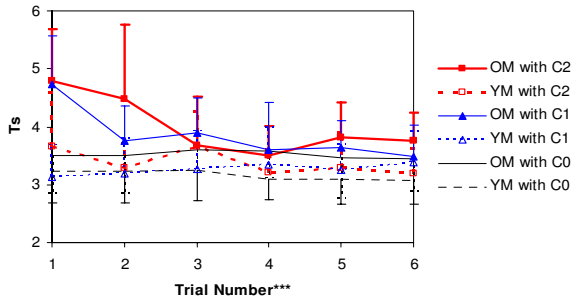

Figure 1: Mean values (error bars: 1SD) of total duration (Ts) of one stepping movement onto the raised structure with three values of structural compliance (C_0, C_1 and C_2) in six consecutive trials each (***: $p<0.001$). For six trials: age effect: $p<0.01$; interaction effect between age and practice: $p<0.01$. In the sixth trial: compliance effect: $p=0.15$; age effect: $p<0.018$.

practice effect appeared within the first three trials. Ts for OM decreased 21% from the first to second trials on C_1 and 23% from the first to the third trials on C_2, while YM showed relatively smaller amounts of decrease (15%) in Ts from the first to sixth trials on C_2, but no significant changes on C_1. In contrast to results from the first trial only [3], after five repeated trials, the structural compliance did not affecte the total duration of the stepping movements. Although the difference in stepping duration between the two age groups decreased over six consecutive trials, it remained significant, especially on the most compliant structure (Ts for OM was 18% longer than for YM on C_2). By their sixth stepping trial, OM no longer differed significantly from YM in their first trial in either stepping duration or peak lateral structural displacement ($p=0.23$).

Within a small number of practice trials, healthy male adults (both young and older) were able to significantly adjust their stepping movements to adapt to the lateral structural compliance. Older males were able to compensate for the age difference after two or three practice trials.

CONCLUSIONS

Elderly men require more time to adapt to the presence of unexpected lateral ladder compliance than do younger men.

REFERENCES

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