

EFFECTS OF BACKWARD WALKING ON BALANCE AND LOWER EXTREMITY WALKING KINEMATICS IN HEALTHY YOUNG AND OLDER ADULTS

Janet S. Dufek, John A. Mercer, Jennifer M. Aldridge, Geoffrey G. Melcher and Philana-Lee Gouws
Department of Kinesiology and Nutrition Sciences, University of Nevada, Las Vegas, Las Vegas, NV, USA
email: jdufek@unlv.nevada.edu, web: <http://kinesiology.unlv.edu>.

INTRODUCTION

Falls are a leading cause of morbidity in the United States, especially among the older adult population. More than one-third of adults in the U.S. who are 65 years of age and older experience a fall each year [1]. Among older adults, falls are the leading cause of injury deaths and the most common cause of nonfatal injury and hospital admission for trauma [2]. We questioned whether a backward walking intervention would augment stability and enhance range of motion of the lower extremity joints during forward walking, thus potentially leading to fall reduction. The purpose of the study was to compare overall system balance and lower extremity kinematic patterns during walking between healthy younger and healthy older adults following a four-week intervention of backward walking. We hypothesized that the intervention would significantly improve balance for the older adult population. We further hypothesized that lower extremity kinematic patterns (range of motion values) would more closely approximate patterns exhibited by young adults following the intervention.

METHODS

Ten healthy young adults (21.9±2.8 yrs; 175.3±10.5 cm; 70.4±11.5 kg) and 10 healthy, non-faller older adults (69.8±7.7 yrs; 167.8±11.8 cm; 70.7±15.2 kg) volunteered to participate. After providing institutionally approved written informed consent, all participants completed a balance pre-test which consisted of five stability tests performed on a balance platform (Bertec; 3000 Hz): 1) normal stance, eyes open (N-EO), 2) normal stance, eyes closed (N-EC), 3) perturbed stance, eyes open (P-EO), 4) perturbed stance, eyes closed (P-EC), and 5) limits of stability (LOS). The perturbed stance condition was defined as that obtained while standing on a 3 cm thick piece of foam. The average

of three balance trials for each test was used for subsequent analysis. Participants were instrumented with 16 lower body reflective markers (Plug-in-Gait model). A 12-camera motion capture system (Vicon, 120 Hz), calibrated per manufacturer's instructions, was used to obtain kinematic data during both forward (n=5) and backward (n=5) walking trials at preferred velocity (pre-test). A four-week backward walking exercise intervention (10-15 min/day; 3 days/wk) followed. At the end of the second (mid) and fourth (post) week of backward walk training, balance tests were repeated following the same procedures as during the pre-test. Kinematic assessment was conducted during pre and post testing sessions only. Five dependent variables (individual balance test scores) were evaluated using 2 (group) x 3 (session) mixed model analyses of variance ($\alpha=0.05$). A low pass Butterworth filter ($f_c=6$ Hz) was used to smooth the kinematic position data prior to calculation of derivatives. Seven kinematic dependent variables including sagittal plane lower extremity joint range of motion (ROM), maximum lower extremity joint angular velocity and knee joint coronal plane (varus-valgus) ROM values were evaluated during the support phase of forward and backward walking using 2 (group) x 2 (session) mixed model analyses of variance ($\alpha=0.05$).

RESULTS AND DISCUSSION

There were no significant group x session interactions observed for any of the balance variables. Group (young vs. old) was significantly different for P-EO ($F_{1,18}=6.02$; $p=0.0246$), P-EC ($F_{1,18}=10.15$; $p=0.0051$) and LOS. Session (pre, mid, post) was significantly different ($F_{2,18}=5.02$; $p=0.0102$) for P-EC. Balance test results are summarized graphically in Figures 1-2.

There were no significant group x session interactions observed for any of the kinematic

parameters. There were no significant differences between groups in lower extremity kinematics during the support phase of forward walking. Both groups significantly increased backward walking velocity across the intervention period ($F_{1,18}=33.22$; $p<0.0001$). During backward walking, older adults exhibited significantly greater ROM at the ankle ($F_{1,18}=7.36$; $p=0.0143$) vs young adults. In addition, there was a significant difference observed between groups for knee joint varus-valgus ROM, with older adults exhibiting greater ROM ($F_{1,18}=11.51$; $p=0.0032$). Maximum angular velocity of the ankle joint was observed to be different between test sessions ($F_{1,18}=14.33$; $p=0.0014$) with both groups exhibiting increased maximum angular velocity of the ankle following the intervention.

significantly improved stability following backward walking. Older adults also exhibited a trend toward improvement in balance for P-EO (Figure 2). We also sought to determine if differences in lower extremity forward walking kinematic characteristics would exist for older adults following the backward walking intervention. Since there were no observed differences in lower extremity kinematics during forward walking between groups, results can speak only to the potential benefits of backward walking on improving balance characteristics.

Observed differences in ankle joint kinematics following the intervention for both young and older adults does deserve greater attention. It is known that toe clearance during the swing phase of gait decreases with age [3]. A change in ankle joint kinematics that might be induced as a result of walking backward could be of benefit relative to reducing fall occurrence for older adults and other populations at risk for falls and deserves further study. In addition, additional exercise prescriptions may induce differential responses.

CONCLUSIONS

Results of the study suggest that backward walking may enhance stability during a challenging balance task for healthy younger and older non-faller populations. The implications of this intervention for those at risk for falls may be even more remarkable. Additional research is warranted to examine this possibility.

REFERENCES

1. Hausdorff, JM et al. Gait variability and fall risk in community-living older adults: A 1-year prospective study. *Archives of Phys Med Rehabil.* **82**, 1050-1056, 2001.
2. Centers for Disease Control and Prevention (CDC). Falls among older Adults: An overview. <http://www.cdc.gov/ncipc/factsheets/adultfalls.htm> Retrieved on April 12, 2007.
3. Mills PM et al. Toe clearance variability during walking in young and elderly men. *Gait & Posture* **28**, 101-107, 2008.

ACKNOWLEDGEMENTS

Partially funded by Bertec Corporation, Columbus, OH and the President's Research Award, University of Nevada, Las Vegas, Las Vegas, NV.

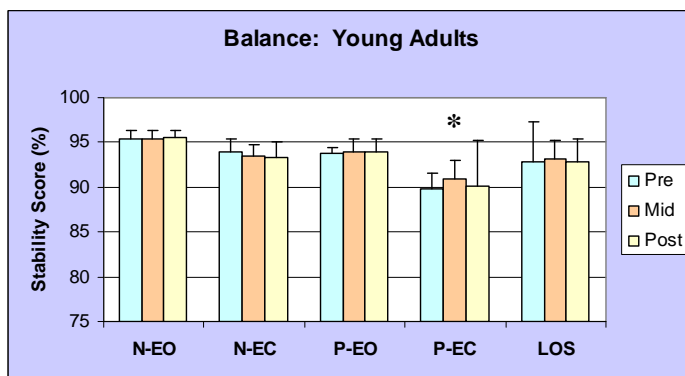


Figure 1. Balance scores for young adults across test sessions. * $p<0.05$ among test sessions.

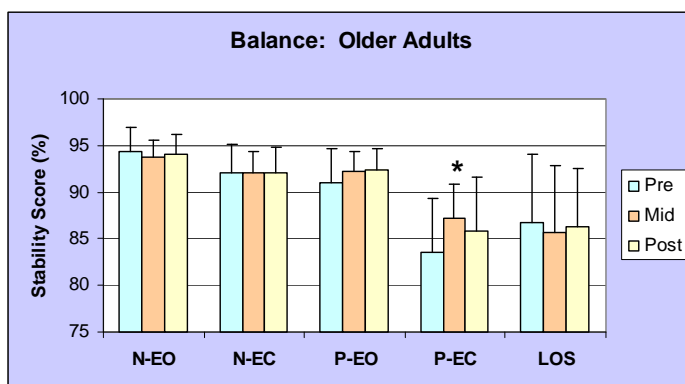


Figure 2. Balance scores for older adults across test sessions. * $p<0.05$ among test sessions.

We anticipated differences between groups in balance and kinematic measures. Results refuted our hypothesis that there would be differences in forward walking kinematics between groups. We did observe differences in balance outcomes as a result of the backward walking intervention. Differences were observed for the most challenging balance task (P-EC) with both groups exhibiting