

# POSTURAL CONTROL OF SELF-INITIATED WEIGHT SHIFTS IN CHILDREN AND ADULTS

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## INTRODUCTION

The development of postural control has been evaluated using quantitative measures, such as quiet standing and perturbations (Forssberg and Nashner 1982). This work focuses on self-initiated weight shifts, which have been used for balance training in individuals with neurologic injuries (Ledebt et al 2005, Haart et al 2005), and may be a better indicator of postural performance during activities of daily living.

## METHODS

*Subjects:* Healthy subjects were recruited into 3 groups: adults (AD, n=14, 8 males, age range 18-30, mean age 23.2), young children (YC, n=5, 2 males, age range 8-10, mean 9.2), and old children (OC, n=5, 4 males, age range 12-14, mean 13.1). Informed consent was given by the adults and the parents of the children.

*Protocol and Data Collection:* Subjects participated in a series of self-initiated weight shifts. For testing, subjects stood on a force plate (Bertec, Columbus OH) with their feet side-by-side, a hips width apart. Center of pressure (COP) was calculated and displayed as biofeedback (a cursor) on a computer monitor at eye-level, ~2.5 feet in front of the subject.

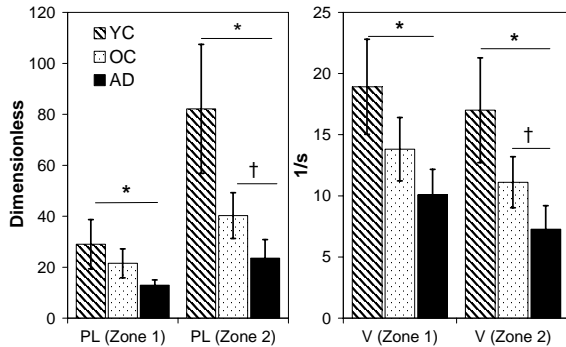
For each of 3 trials, subjects were presented with 10 targets (5 outer, 5 center). Outer targets were located E, NE, N, NW and W of the center target. Subjects were instructed

to move the cursor to the target center as quickly as possible by shifting their weight. After the subject maintained the cursor in the target for 2 seconds (or the 10-second time limit was reached) the next target appeared. All outer targets were followed by the presentation of the center target. The distance from the center to the outer targets and the target size were scaled (40% and 10%, respectively) by each subject's theoretical limit of stability, which was calculated as an 8° anterior rotation of the navel about the ankle (Hamman et al 1992). Data were collected at 500 Hz and stored on a personal computer for post-processing. Subjects practiced moving the cursor before data collection began.

*Data Analysis:* COP data were low-pass filtered at 20 Hz with a dual-pass 4<sup>th</sup> order Butterworth filter. Data were divided into 2 zones, zone 1 ( $Z_1$ ) - target presentation to entry point for the target, and zone 2 ( $Z_2$ ) - entry point to completion of the target. The following measures were calculated: *error* ( $Er$ )-mean distance from the target center ( $Z_2$ ); *unsteadiness* ( $UnST$ )-standard deviation of the distance from the target center ( $Z_2$ ); *path lengths*  $PL_1$  ( $Z_1$ ) and  $PL_2$  ( $Z_2$ ); *mean velocity*  $V_1$  ( $Z_1$ ) and  $V_2$  ( $Z_2$ ); *reentry count* ( $RC$ )-number of times subject reentered the target; and *total time per target* ( $T_T$ ). All measures, except  $RC$  and  $T_T$ , were normalized by ankle to navel height. An ANOVA with a Dunnett T3 post-hoc analysis (accounting for unequal variances) was used to compare the groups.

## RESULTS

Significant differences ( $p < 0.05$ ) were found for all measures. The post-hoc analysis indicated that YC had significant increases in all measures compared to AD, while OC had significant increases in  $PL_2$ ,  $V_2$ , and  $RC$  compared to AD (Table 1). Decreasing  $PL$  and  $V$  measures with age are demonstrated in Figure 1.



**Figure 1:**  $PL$  and  $V$  decrease with age. Error bars are  $\pm 1$  SD. Differences ( $p < 0.05$ ) between AD and YC and AD and OC are indicated with \* and †, respectively.

## DISCUSSION & CONCLUSIONS

During self-initiated weight shifts, YC demonstrated increased movement velocities and  $Er$ . This is similar to increased COP velocity during quiet standing. It has been suggested that children utilize larger, faster corrections (a ballistic postural control strategy) that results in less accurate movement (Riach & Starkes 1994). Increased  $V_2$  was also seen in OC. Differences between the OC and AD were unexpected since other studies have shown adult-like postural responses in 7-10 year olds (Shumway-Cook & Woollacott 1985).

However, this may be due to the difficulty of the task utilized in this study. Furthermore, it has been suggested that subtle changes in neuromuscular control continue throughout childhood (Sparto et al 2006).

Future studies will expand the number of healthy children and include children with disabilities, as well as compare this postural task to results of quiet standing trials. This functional postural task may increase the understanding of the development of postural control in healthy children as well as the impact of disability on the posture control system.

## REFERENCES

- Forsberg H. and Nashner L.M. (1982). *J. Neuroscience*, **2**, 545-52.  
 Haart M. et al. (2005). *Arch Phys Med Rehabil*, **86**, 755-62.  
 Hamman, R.G. et al. (1992). *Arch Phys Med Rehabil*, **73**, 738-44.  
 Ledebt, A. et al. (2005). *Motor Control*, **9**, 459-68.  
 Riach, C.L., Starkes, J.L. (1994). *Gait & Posture*, **2**, 167-72.  
 Shumway-Cook, A., Woollacott, M.H. (1985). *J. of Motor Behavior*, **17**, 131-47.  
 Sparto P.J. et al (2006). *Exp Brain Res*, **168**, 505-16.

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**Table 1: Summary of Postural Control Measures** (mean  $\pm 1$  SD). Differences ( $p < 0.05$ ) between AD and YC and AD and OC are indicated with \* and †, respectively.

Group	$Er$	$UnST$	$PL_1$	$PL_2$	$V_1$	$V_2$	$RC$	$T_T$
YC	1.20 $\pm$ 0.15*	0.84 $\pm$ 0.16*	29.02 $\pm$ 9.64*	82.13 $\pm$ 25.29*	18.92 $\pm$ 3.89*	17.00 $\pm$ 4.29*	10.00 $\pm$ 4.29*	6.35 $\pm$ 0.61*
OC	1.02 $\pm$ 0.15	0.63 $\pm$ 0.16	21.53 $\pm$ 5.70	40.25 $\pm$ 8.95†	13.82 $\pm$ 2.59	11.11 $\pm$ 2.09†	4.41 $\pm$ 1.14†	5.21 $\pm$ 0.44
AD	0.90 $\pm$ 0.11	0.52 $\pm$ 0.11	12.97 $\pm$ 2.01	23.54 $\pm$ 7.31	10.10 $\pm$ 2.06	7.28 $\pm$ 1.92	2.28 $\pm$ 0.89	4.52 $\pm$ 0.32