VISUALLY-INDUCED POSTURAL SWAY IN CHILDREN AGED 7-12: EFFECT OF FREQUENCY AND SURFACE SUPPORT

PJ Sparto [1,2], MS Redfern [2], JM Furman [2], EM Mandel [2], and ML Casselbrant [2]

[1] Department of Physical Therapy, University of Pittsburgh, Pittsburgh, PA, USA
[2] Department of Otolaryngology, University of Pittsburgh, Pittsburgh, PA, USA
E-mail: psparto@pitt.edu

INTRODUCTION

The integration of visual, somatosensory, and vestibular inputs for the control of balance develops throughout childhood. Initially, children demonstrate a strong visual dependence for control of balance (Lee and Aronson, 1974, Shumway-Cook and Woolacott, 1985, Wann et al., 1998). Adult patterns of sensory integration that include more veswtubular and proprioceptive weighting occur around 10-12 years (Wann et al., 1998), but can as early as 4-6 years (Shumway-Cook and Woolacott, 1985). However, we have observed visually-induced postural responses in children aged 7-12 that remain different from adults. The purpose of this study was to examine the sensory integration process in children aged 7-12 in altered visual and somatosensory conditions.

METHODS

Nineteen subjects between the ages of 7-12 participated in the study after parental consent and subject assent was obtained. Unequal distribution of subjects did not allow a full analysis of effects due to age.

Postural sway was induced by movement of a visual scene and by altering the stability of the flooring surface. Four frequencies of visual scene movement (0.1, 0.25, 0.4 and 0.7 Hz) were chosen. The surface upon which they stood was either fixed or sway-referenced in order to reduce the availability of proprioceptive information from the ankles. Sway referencing about the ankles attempts to keep them at a constant angle, thereby reducing proprioceptive inputs.

Prior to testing, electromagnetic sensors (Polhemus, Inc.) were secured over the crown of the head and the pelvis at the level of L4. A harness was worn by the subjects to prevent an impending fall. Subjects stood without shoes on the platform which recorded center of pressure displacements (COP). Only results from the head motion recordings are reported in this abstract.

Surrounding the subjects were 3 back-projected screens that entirely subtended the horizontal viewing plane (Figure 1). The visual stimulus consisted of a set of concentric rings that occupied the central 60^{o} field of view and an array of squares that extended peripherally beyond 180^{o}. This stimulus assured maximal stimulation of both the central and peripheral retina.

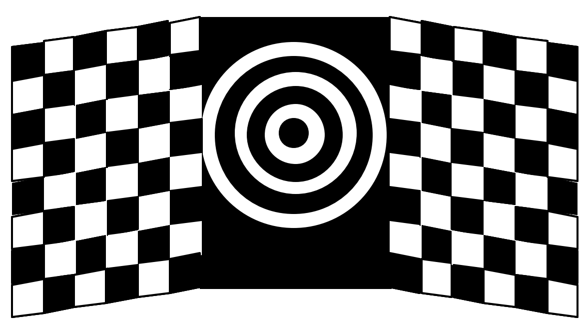

Figure 1. Unfolded view of the visual stimulus. Side walls were folded around subject to encompass full horizontal field of view.

Each trial consisted of a 30 s baseline during which there was no visual movement, followed by at least 9 cycles of visual field movement in the anterior-posterior (AP) direction (8 cm amplitude, Figure 2).

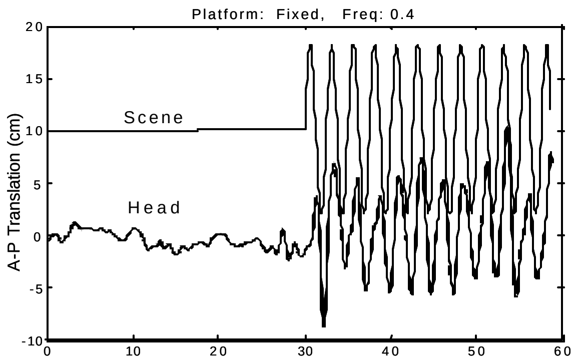

Figure 2. Anterior-posterior (A-P) translation of the head in response to 0.4 Hz stimulus with the surface fixed.

Head, pelvis and COP data were sampled at 20 Hz and stored for subsequent processing. The time series were filtered using a second-order Butterworth bandpass filter centered at the stimulus frequency ($\pm$ 0.05 Hz). The root-mean-square (RMS) of the AP translation of the head was computed during the period of scene movement and analyzed using a repeated measures ANOVA to test for the effects of movement frequency and somatosensory condition ($\alpha = .05$).

RESULTS AND DISCUSSION

Figure 2 shows a time series from a 9 year old female who had considerable visual dependence. Observe the immediate response when the visual stimulus began moving, as well as the strict phase-locking of the response. The effects of visual frequency and surface stability on the RMS head sway are shown in Figure 3. The main effects of frequency ($p = 0.006$) and surface ($p<.001$) were both significant, while the interaction was not. In comparison with patterns that have been found in adults, the following differences emerge. First, the amplitude of the sway in children aged 7-12 is approximately 1.5 - 3 times that of adults for similar conditions. Second, these children demonstrate a peak response at 0.25 Hz, whereas adults generally show a level to declining response at 0.25 Hz. Third, the children show significant postural responses at 0.4 and 0.7 Hz, which are rarely seen in adults. These findings may indicate that the vestibular control of posture, which is thought to stabilize posture at these intermediate frequencies in adults, may not be fully integrated by the ages of 7-12.

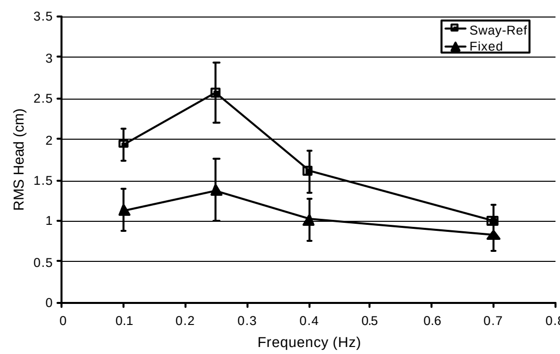

Figure 3. Mean + S.E.M. values of RMS anterior-posterior head translation due to frequency and surface conditions.

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