DO CHILDREN USE A DIFFERENT STRATEGY IN ADAPTING TO A TENDON VIBRATION PERTURBATION DURING STANDING?

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INTRODUCTION

Children quickly develop postural control strategies over the first several years of their lives. Around 7-8 years of age children show more adult-like postural control patterns [1]. Center-of-mass (COM) is usually studied to reveal the whole body control during quiet standing as well as while confronting an external perturbation. This study investigated how children at different ages regulate their COM while adapting to a tendon vibration perturbation during standing. Position of the COM before and during the vibration as well as segmental angles was studied to investigate whether children use an adult-like control strategy.

METHODS

Three groups of healthy people participated in this study: (1) young children (YC) n=8, age 6.3 (SD 0.6) yrs; (2) older children (OC) n=9, age 10.3 (SD 0.9) yrs; (3) young adults (YA) n=10, age 20.5 (SD 1.4) yrs. Reflective markers were placed bilaterally on toe, ankle, knee, hip, shoulder, elbow, wrist, and temple, and one on C7 spine. A six-camera Vicon Peak® motion capture system was used to collect kinematic data. A small wave pulse motor was attached above the right ankle to alter proprio-ceptive information in muscle spindles. When the motor was on, a false impression of ankle plantar-flexion was produced.

Participants stood on a level surface with hands on hips. Two visual conditions were tested: eyes-open (EO) and eyes-closed (EC). Three 40-second trials were collected in each condition. The first 10 seconds of each trial was standing without vibration. Then, vibration (8 seconds) was triggered when the ground reaction force and moment in the sagittal plane were both pointing to the anterior direction. Posterior body sway was elicited during vibration due to the false impression of ankle plantarflexion. Kinematic data were processed to calculate the position of the COM and the segmental angle at the foot, shank, thigh, trunk, and head in the sagittal plane.

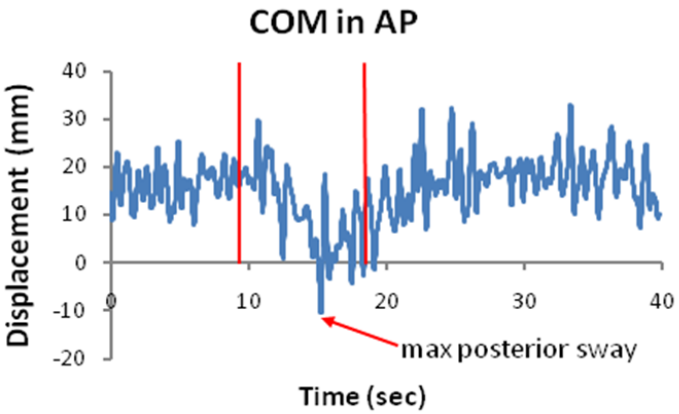

Figure 1: A representative plot of the COM vs. time in the AP direction. Two vertical red lines denote the onset and offset of vibration, respectively. Positive displacement denotes the anterior direction.

Dependent variables include: (1) NpreCOM and NmaxCOM (distance from the COM to the right ankle, normalized by foot length, before the vibration and at the maximal posterior sway during the vibration, respectively), (2) NCOMsway (difference between NpreCOM and NmaxCOM, normalized by foot length), (3) segmental angles with respect to the horizontal for the foot, shank, thigh, trunk, and head.

ANOVAs (3 Group x 2 Visual) with repeated measures on visual condition were conducted on each variable. Post-hoc Tukey analyses were conducted when necessary. Statistical analysis was conducted using SAS® software with an alpha level of $p<0.05$ set for significance.

RESULTS AND DISCUSSION

Before the vibration, all three groups demonstrated similar COM positions in front of the right ankle (NpreCOM in Table 1). There was a visual effect such that the COM was further in front of the right ankle in the EC condition. During the vibration, no difference was found between three groups in the COM at the maximal posterior sway (NmaxCOM in Table 1). Children as young as 6 years old (i.e., YC group) demonstrate similar COM positions with respect to the right ankle before the vibration and at the maximal posterior sway during the vibration.

The magnitude of maximal posterior sway was significantly greater in the YC group compared to the YA group, and all three groups increased the magnitude of posterior sway from EO to EC condition (NCOMsway in Table 1). Even though both YC and OC groups demonstrated similar COM positions with respect to the right ankle when compared to adults, the YC group produced greater posterior sway than adults during vibration.

Table 2 shows the segmental angles at the maximal posterior sway during the perturbation. Significant group difference was found in the thigh, trunk, and head angles between three groups. Specifically, the YC group produced a significantly smaller thigh angle and a greater trunk angle than the YA group in both EO and EC conditions. Also, the OC group produced a significantly smaller head angle than the YA group.

Since all three groups showed similar segmental angles during quiet standing [2], our results indicate that younger children adopt different segmental orientation at the maximal posterior sway when adapting to a tendon vibration perturbation. When responding to a false impression of ankle plantar-flexion, YC group moved the thigh vertical while bending the trunk. In contrast, adults moved the trunk vertical while rotating the thigh forward.

CONCLUSIONS

Children at about 10 years of age demonstrate similar postural control strategy like adults when adapting a tendon vibration perturbation during standing. Children as young as 6 years of age show similar COM positions like adults, but they orient the thigh and trunk differently from adults while adapting to an external perturbation of tendon vibration during standing.

REFERENCES

1.Kirshenbaum N, et al., *Exp Brain Res,* **140**, 420-431, 2001.

2.Wu J, et al. *Exp Brain Res,* **196**, 329-339, 2009.

Table 1: Mean (SD) of normalized COM variables and statistical results.

	EO			EC			Statistical results
	YC	OC	YA	YC	OC	YA	
NpreCOM	0.35 (0.08)	0.34 (0.09)	0.32 (0.10)	0.37 (0.07)	0.34 (0.07)	0.34 (0.10)	V
NmaxCOM	0.27 (0.07)	0.27 (0.08)	0.28 (0.09)	0.26 (0.08)	0.25 (0.06)	0.28 (0.09)	-
NCOMsway	0.08 (0.04)	0.07 (0.03)	0.04 (0.01)	0.12 (0.07)	0.09 (0.03)	0.05 (0.03)	G,V

Note that in statistical results G, V, and G*V denotes a group effect, a visual effect, and a group by visual interaction, respectively.

Table 2: Mean (SD) of segmental angles (unit: degrees) and statistical results.

	EO			EC			Statistical results
	YC	OC	YA	YC	OC	YA	
Foot	172.7 (2.0)	171.7 (3.5)	172.7 (1.8)	172.2 (2.1)	171.4 (3.3)	172.8 (1.8)	-
Shank	87.5 (4.3)	85.0 (4.0)	84.6 (3.2)	85.5 (4.7)	85.2 (3.8)	85.0 (3.1)	G*V
Thigh	90.6 (4.3)	88.2 (4.2)	85.6 (2.5)	90.4 (4.9)	88.1 (4.4)	85.5 (3.0)	G
Trunk	82.9 (5.9)	89.1 (5.1)	92.2 (4.6)	87.1 (6.1)	90.1 (4.7)	91.6 (4.7)	G, V, G*V
Head	21.4 (6.9)	24.7 (5.8)	30.7 (6.3)	25.6 (4.6)	20.5 (12.8)	29.7 (6.5)	G