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Sensory contributions to standing balance in unilateral vestibulopathy

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Introduction

Stability maintenance during bipedal stance requires complex central integration of multiple sensory and neuromuscular systems in order to keep the centre of mass within the limits of the base of support. Unilateral peripheral vestibular disorder (UPVD) leads to a diminished postural stability during stance [1] as would be expected when one sensory system is dysfunctional. The aim of this study was to examine and compare the contribution of the visual and proprioceptive sensory systems to static postural control in UPVD patients and matched healthy subjects during standing. We hypothesised that sensory disturbance would augment the postural sway in patients with UPVD more than in the healthy participants.

Methods

17 adults with UPVD and 17 healthy subjects matched for age, sex, height and body weight participated in this study (Table 1). A custom made force plate was used to track the centre of pressure (COP) trajectories under the feet during six different standing balance tasks: forwards and backwards leaning to determine the subjects' individual limits of stability, and quiet standing over 30s with eyes open (EO), eyes closed (EC), eyes open with vibration of the Achilles tendon (EOV) and eyes closed under vibration of the Achilles tendon (ECV). The tasks were carried out three times. The leaning trials with the most anterior and posterior COP position and the mean values of the standing tasks were analysed. Stability was assessed by means of 5 parameters: the total excursion distance of the COP (COP_{Path}), the distances between the most anterior and posterior points of the COP_{Path} and the anterior and posterior anatomical boundaries of the base of support (COP_{Amin} and COP_{Pmin}) and the corrected COP_{Amin} and COP_{Pmin} taking the limits of stability into account using the COP data from the leaning task. A two-way repeated measures ANOVA with subject group and task condition as factors was used with an alpha of 0.05. Results are presented as mean±SD.

Table 1: *Participant Characteristics*

	Age (yrs)	Height (cm)	Body Mass (kg)	Sex
UPVD Patients (n=17)	49±9	171.4±7.3	73.8±14.1	10 female, 7 male
Healthy Participants (n=17)	51±8	172.5±8.2	75.1±15.2	10 female, 7 male

Results

UPVD patients had a tendency for smaller limits of stability during leaning in both anterior (P=0.07) and posterior (P=0.09) directions. Significant subject group and task condition effects were found (P<0.05) for COP_{Path}. UPVD patients had lower (P<0.05) COP_{Pmin} compared to controls for all conditions, which was more pronounced when the corrected COP_{Pmin} was considered. There were no significant effects for the COP_{Amin} or the corrected COP_{Amin}. Visual disturbance lead to a distinct backward sway in both groups which became more pronounced in combination with Achilles tendon vibration.

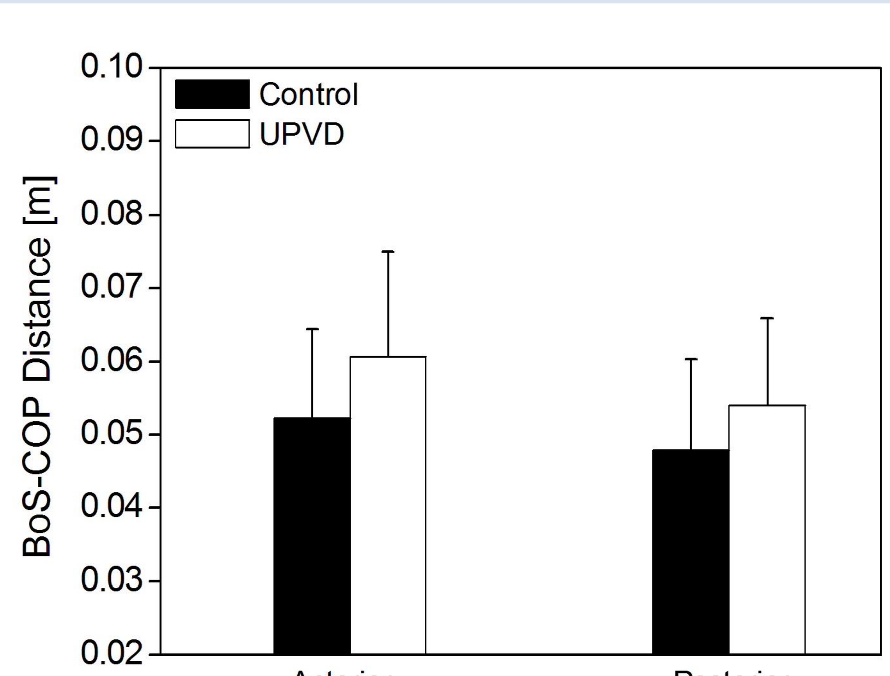

Figure 1: *Distances between the most anterior and posterior points of the COP during forward and backward leans and the anterior and posterior borders of the base of support respectively (the lines connecting left and right metatarsal five and the left and right heel respectively).*

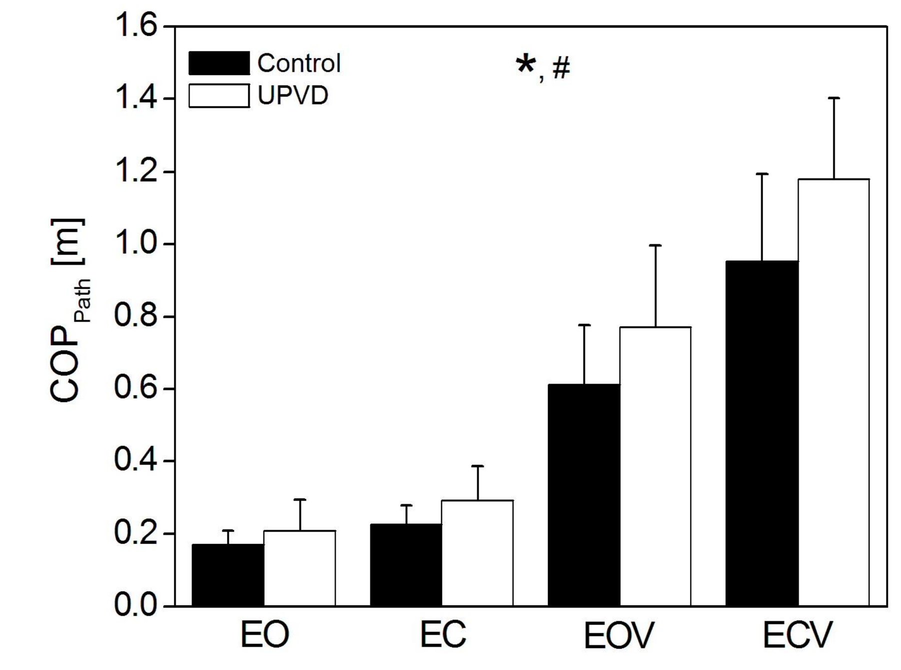

Figure 2: *COP_{Path} for UPVD patients and healthy controls during quiet standing under eyes open (EO), eyes closed (EC), eyes open with Achilles tendon vibration (EOV) and eyes closed with Achilles tendon vibration (ECV). *: significant subject group effect (P<0.05). #: significant task condition effect (P<0.05).*

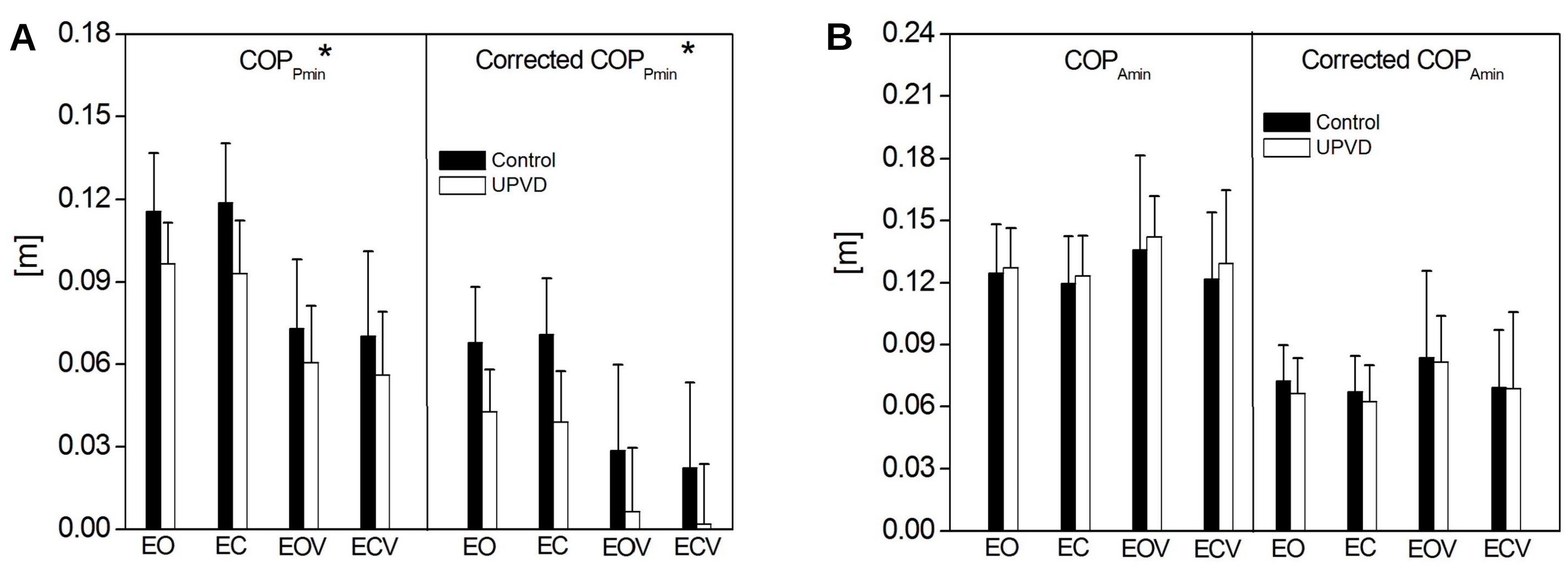

Figure 3: *A: COP_{Pmin} and corrected COP_{Pmin} and B: COP_{Amin} and corrected COP_{Amin} for UPVD patients and controls during standing under eyes open (EO), eyes closed (EC), eyes open with Achilles tendon vibration (EOV) and eyes closed with Achilles vibration (ECV). *: significant subject group effect (P<0.05).*

The ratios for the COP_{Path} showed a significant task condition effect with no differences between subject groups. The highest and lowest ratios were found in the COP_{Path} for the ECV and the EC conditions respectively, independent of the analysed subject group (Fig. 4A). Concerning the ratios for the corrected COP_{Pmin}, there was a significant subject group and task condition effect. The post hoc analysis revealed lower ratio values for the UPVD group compared to controls in a dose dependent manner, with the highest and lowest differences in the ECV and EC, respectively (Fig. 4B).

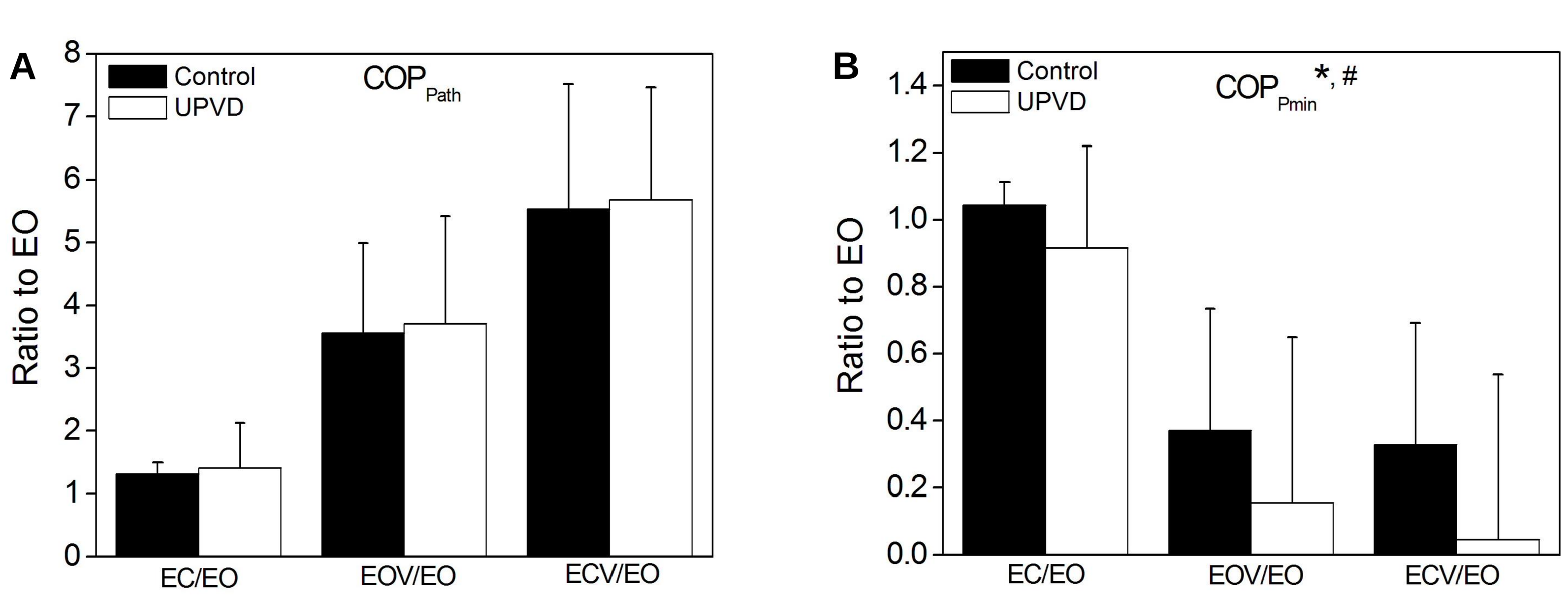

Figure 5: *A: COP_{Path} and B: COP_{Pmin} ratios compared to eyes open (EO) for eyes closed (EC), eyes open with Achilles tendon vibration (EOV) and eyes closed with Achilles tendon vibration (ECV) task conditions for UPVD patients and healthy controls. *: significant task condition effect (P<0.05). #: significant subject group effect (P<0.05).*

Conclusion

A higher reliance on proprioceptive information was apparent in all subjects. UPVD patients, in particular, showed decreases in postural stability with visual and proprioceptive sensory disturbance. The individual limits of stability should be considered when conducting posturography in vestibulopathy and other groups, as differences between subject groups may lead to erroneous comparisons.

References

[1] Aoki et al. 2014. *Gait Posture* **40**, 435-440.

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