PEDOBAROGRAPHIC MEASURES OF FUNCTIONAL REACH DURING SENSORY CONFLICTED STANCE

Katerina Kirilova, Plamen Gatev

Institute of Neurobiology, Bulgarian Academy of Sciences

INTRODUCTION

Stance maintenance is a complex sensory-motor task. It requires visual, vestibular and proprioceptive information to be successfully integrated and processed by the brain so that adequate muscle reactions to be achieved.

Functional reach is a fast and low-cost method for dynamic balance assessment. It was developed by Duncan et al in 1990 (1,2) to estimate the risk of falling of elderly people. It is also applied to assess the psychomotor development of children (3,4) and has many modifications up to date. However, little is known about the influence of different sensory conditions on functional reach.

AIM

To explore the influence of different sensory conditions - eyes open and sensory conflict (eyes closed and/or head extended) on a dynamic standing task (functional reach).

SUBJECTS

10 healthy adults (6 men and 4 women, aged 31.8±10.4 years) took part in the experiment. All volunteers were right-handed (verified via modified Annette's test). They went through a short training before the experiment. Subject did 2 trials in four conditions: EO – eyes open, EC – eyes closed, EO HE – eyes open, head maximally extended, EC HE – eyes closed, head maximally extended.

EXPERIMENTAL SETUP

To track the excursions of the center of pressure (COP) we used a pedobarographic platform Tekscan Evolution, provided with Research Software and Sway Analysis Module (SAM) Matscan.

Functional reach was measured in centimeters with a ruler, one meter long.

PROCEDURE

All volunteers were instructed to reach forward with both hands together as far as they could. After holding in the maximal position for three seconds, they were told to go back. No lifting of the heels or bending the knees was allowed. Each recording lasted 30s, sampling frequency – 30Hz.

PEDOBAROGRAPHIC MEASURES

The measures calculated via SAM were mean COP sway in anterior-posterior and medio-lateral directions (A-P and M-L sway) and overall COP sway path. The anterior-posterior excursions of COP versus time (Fig .1) were used to estimate the forward and backward velocity of COP (start and end of the dynamic task) by program written in MatLab. The same program calculated the initial mean level of the COP before FR start and mean return level after the dynamic task.

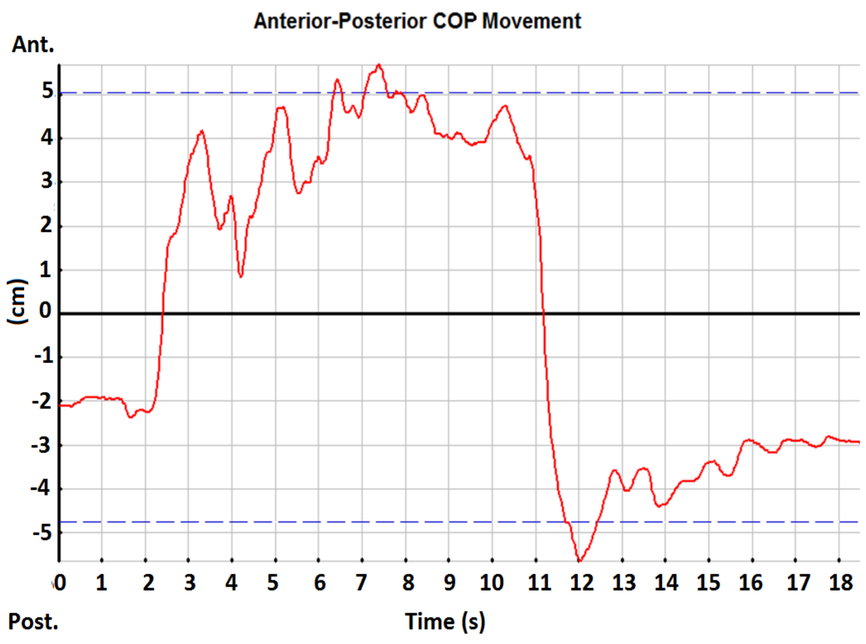

Fig. 1. Anterior-posterior movement of the center of pressure (COP) in centimeters compared to a relative zero given as a function of time during one trial of functional reach.

RESULTS AND DISSCUSSION

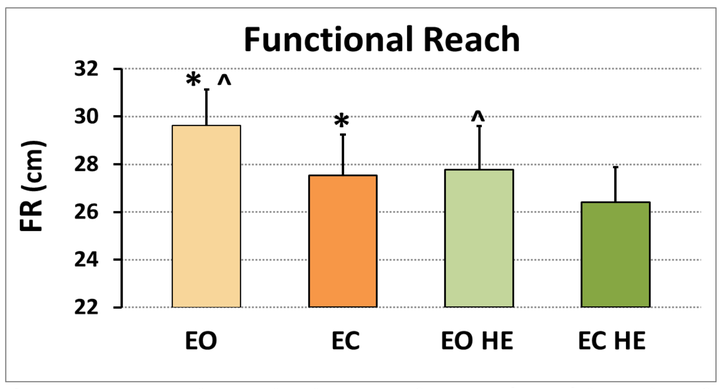

Fig. 2. Mean and standard error of mean (SEM) lengths of maximal functional reach (FR). Significant differences (p<0.05, Two Way RM Anova, post-hoc analysis - Tukey) between samples are marked by the same signs.

Considering the overall sway path of COP, both factors – vision and head position, turned out to be statistically significant, by Two Way RM Anova, and there is no interaction between them.

The results of post-hoc analysis showed that the COP sway path during functional reach increases significantly in the eyes closed (EC; ECHE) compared to the eyes open (EO; EO HE) conditions and head extension also leads to increased sway path (Fig.3).

These data suggest that absence of vision (EC) or inadequate vestibular information input (HE) impede postural task performance (see also Fig.2).

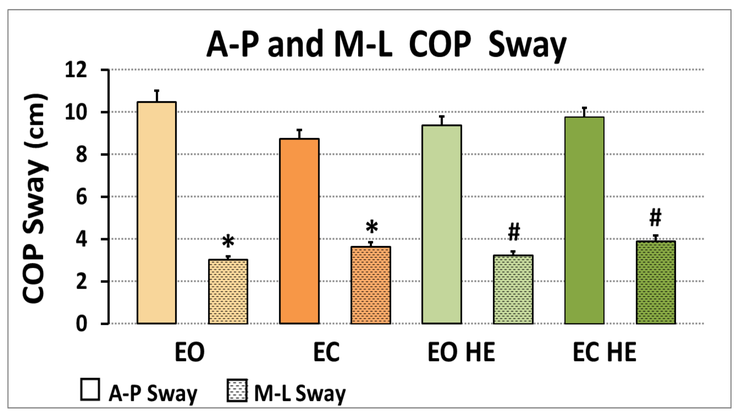

Fig. 4. Mean and standard error of mean (SEM) antero-posterior (A-P) and medio-lateral (M-L) sway of the center of pressure (COP). Significant differences (p<0.05, Two Way RM Anova, post-hoc analysis - Tukey) between samples are marked by the same signs.

After applying a paired t-test on the forward velocity of COP, significant diminution was found only for eyes closed, head extended (EC HE) condition compared to the eyes open (EO) series, supposed to be the most difficult and the easiest one (Fig.5).

Backward velocity was also significantly lower in both head extended series (EO HE, EC HE) compared to the eyes open (EO) condition (paired t-test)(Fig.5).

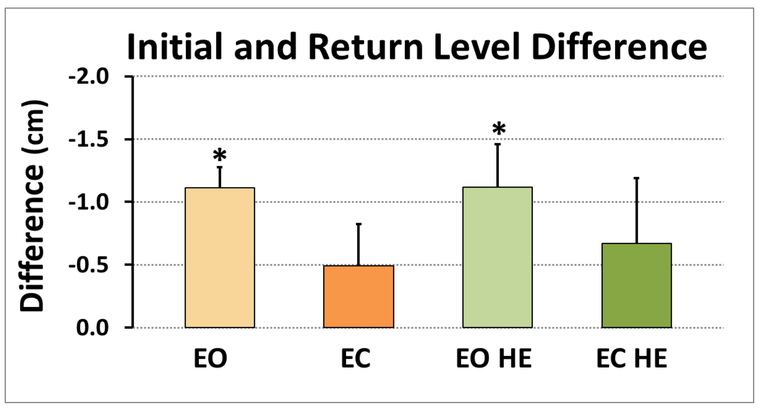

Fig.6. Mean and standard error of mean (SEM) of the difference in the mean levels of the center of pressure (COP) during functional reach. Significant differences (p<0.05, paired t-test) between each sample and 0 are marked by *.

When exploring the maximal functional reach, Two Way RM Anova revealed that factor vision is statistically significant, there is a tendency for factor head position to be significant (p<0.07) and there is no interaction between the two factors.

The results of post-hoc analysis showed that functional reach decreases significantly in the eyes closed (EC) and the eyes open, head extended conditions (EO HE) compared to the eyes open (EO) condition (Fig.2).

These data suggest that absence of vision (EC) or inadequate vestibular information input (HE) impede dynamic task performance (FR).

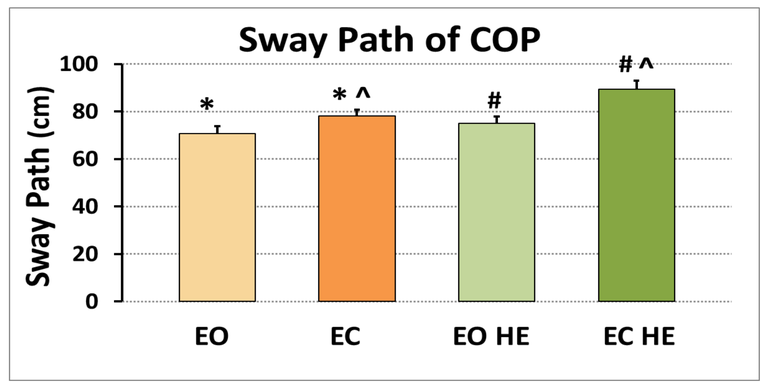

Fig. 3. Mean and standard error of mean (SEM) sway path of the center of pressure (COP). Significant differences (p<0.05, Two Way RM Anova, post-hoc analysis - Tukey) between samples are marked by the same signs.

When exploring the medio-lateral (M-L) sway of COP, Two Way RM Anova revealed that factor vision is statistically significant, while head position is not and there is no interaction between the two factors.

The results of post-hoc analysis showed that the M-L COP sway during functional reach increases significantly in the eyes closed (EC; ECHE) compared to the corresponding eyes open (EO; EO HE) conditions (Fig.4).

These data suggest that absence of vision (EC) impede postural task performance (see also Fig.2).

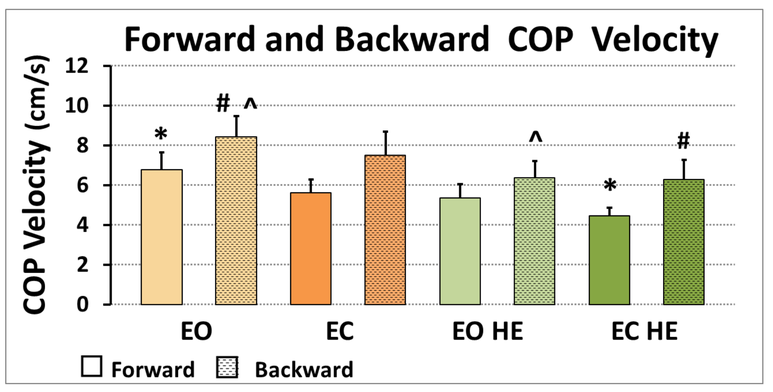

Fig. 5. Mean and standard error of mean (SEM) forward and backward velocity of the center of pressure (COP). Significant differences (p<0.05, paired t-test) between samples are marked by the same signs.

In both eyes open conditions when returning to normal position after dynamic task completion, most individuals' COP goes more backwards compared to its starting position (Fig.6). However, there is no significant difference between initial and return level during both eyes closed conditions, which suggests that an increase of weight of proprioception occurs that increases accuracy of return.

CONCLUSIONS

The results of our study suggest that pedobarographic measures can shed more light on dynamic balance and task achievement dependency on the correct multi-sensory integration. A more exact return to initial COP position with eyes closed suggests reweighting of proprioception.

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