Influence of Different Entries on the Mean Center of Pressure Displacement

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***Abstract*- The aim of this study is to define the effects of influence of the gender, age, height, weight, direction, visual and proprioceptive entries on the mean center of pressure (COP) positions. For that we examined 25 healthy subjects aged between 19-42 years during the quiet stance under static conditions: keeping outspread foot and opened eyes (FO_EO), tighten foot and opened eyes (FT_EO), outspread foot and closed eyes (FO_EC), tightened foot and closed eyes (FT_EC).**

Experimental results show that since the majority of subjects are right-handled the mean COP position (MCOPP) is on the right sight. They also show that the increase of height moves the COP on the right and forward. The decrease of age and weight moves the COP on the right and forward. It is also displayed that males COP is situated more in the right sight than females COP.

Results also show that with absence of visual information, people lean more on forward and the increase of distance between feet lean the COP on backward and to the right.

Keywords- Center of Pressure Displacement; Age; Gender; Weight; Height; Vision; Proprioception; Direction

I. INTRODUCTION

Falling is a consequence of failure in the postural control system due to aging or pathology [1, 2]. So for many elderly subjects, the aging is accompanied with an impairment of the ability to maintain equilibrium especially after the age of 60 years [3, 4, 5]. The ability to maintain equilibrium seems to be optimal at the age of 50 years [6].

There is much other information that can have effects on the human postural process like sensory systems (somatosensory, visual and vestibular) [7]. The degradation of these systems can cause impairment in the ability to maintain equilibrium in stance [8, 9, 10]. Proprioceptive entry also has effects on the postural stability aspect [11, 12].

The postural control is related to the motion of COP. The mean displacement of the COP is expressed in a platform with subjects in upright stance [13]. Analysing the MCOPP allows to display that there is an asymmetry in human stance; the MCOPP is influenced by the laterality of subjects [14]. Several studies associated the analysis of MCOPP with posturographic parameters to study the effect of aging on the stability [3, 15, 16], to confirm that gender has effects on the stability [17] especially with elderly [18, 19], to show the effect of weight on the postural stability [20], to display the effect of anthropometry and foot placement on stabilometric parameters [21] and to allow assessing individual's postural control during unperturbed stance [22, 23].

The aim of this study is to analyse the effect of vision, proprioception, age, direction, height, weight and gender on postural behaviour, by calculating COP mean displacement. In Section Two, we display the method and materials. In section three, we present the results and discussion.

II. METHODS, MATERIALS AND MEASURES

Postural data are assessed using an electromagnetic platform. The device content is an electromagnetic sensor that must be placed on the mass center of subject and indicate the three-dimensional position and orientation of COP. The coordination between the transmission and the reception part is ensured by the acquisition board linked to the PC [24].

The postural data formed the COP displacement. The representation of this COP in mediolateral and anterioposterior directions is the stabilogram respectively in ML and AP [12] (Fig. 1).

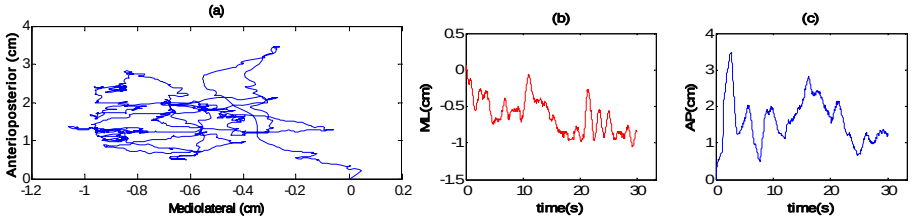


Fig. 1 Displacement of the center of pressure in (a) the horizontal plane (b) mediolatéral (ML) direction and (c) Anteroposterior (AP) displacement

The analysis of balance control was assessed by one parameter extracted from the stabilogram: The mean displacement of COP is calculated for AP and ML directions (M_{AP}, M_{ML}), where:

$$M_{AP} = (\frac{1}{n}) \sum_{n=1}^{N} CoP_{AP}(n)$$

$$M_{ML} = (\frac{1}{n}) \sum_{n=1}^{N} CoP_{ML}(n)$$

A positive value in the anteroposterior direction (M_{AP}) corresponds to a forward displacement of the COP, while a positive mediolateral (M_{ML}) displacement is a movement of the COP on the right side from its central body position.

Experiences are achieved for twenty five healthy volunteers (8 females and 17 males) placed onto the platform, standing upright with arms by their sides.

Information about each subject is provided, namely: name, age, height, weight. The subject's ages vary between 19 years and 42 years; weights are between 52 and 105 kg and heights vary between 160cm and 192cm.

Four types of measures are evaluated for every subject.

- The first measure is tested by keeping foot outspread and opened eyes fixing a point placed on the wall in front of the subject (FO_EO),
- The second measure is evaluated with tighten foot and opened eyes (FT_EO),
- The third measure is with outspread foot and closed eyes (FO_EC),
- The last is measured with tightened foot and closed eyes (FT_EC).

Each group of these four types of measures presents a set and for each subject we extract multiple sets. The gathering of these sets for all subjects constitutes a database. Every recording process is measured during 30 sec and each recorded signal is sampled at 60Hz.

III. RESULTS AND DISCUSSION

A. Visual Entry Effects

Visual entries have an important effect on the human postural behavior. In fact, for the AP direction and for situations with closed eyes and especially with tighten feet (FT_EC) values of mean COP displacement are positives (Fig. 2, Fig. 3(b), Fig. 4(b), Fig. 5(b), Fig. 6(b)).

This displays that with condition of removed vision human corpus, independently of the age or gender, lean on the forwards. This is in agreement with previous studies showing that for unstable conditions (closed eyes), the leaning on the forwards allows human corpus to better maintain the equilibrium [25, 26].

B. Proprioceptive and Directional Effects

Related to ML direction (Fig. 2, Fig. 3(a), Fig. 4(a), Fig. 5(a), Fig. 6(a)); it is noticed that values are positive (except for few cases), which indicates that the COP is generally situated on the right sight of subjects. This result is related to their laterality because the majority of subjects are right-handed (only two subjects are left-handed). This is in agreement with the finding of previous studies displaying that the subjects lean on their right foot because of their literality so in orthostatic position, their mean COP position is in the right sight [26, 27].

This displays that there is an asymmetry of orthostatic posture [14]. It is also noticed in ML direction, that for the both visual conditions (closed eyes and opened eyes), values with outspread feet are greater than values with tighten feet: FO_EC greater than FT_EC and FO_EO greater than FT_EO. In agreement with previous studies, this indicates that the increase in clearance between feet moves the mean COP on the right [14].

Related to AP direction with outspread feet (FO) (Fig. 2, Fig. 3(b), Fig. 4(b), Fig. 5(b), Fig. 6(b)); it is noticed that the values are positive. This indicates that the COP is generally situated on the forward of subjects [25, 26].

Although with outspread feet values are highly lower: several values are negative especially with FO_EO. According to previous studies this indicates that when the distance between feet increases the MCOPP moves on the backward [14].

C. Age Effects

The healthy subjects are divided into two groups according to their ages: control subject's mean age is 22.5 ± 2.5y and

adult subject's mean age is 34.5±7. 5y.

It is noticed that mean COP position absolute values for control subjects are greater than for adult for both AP (Fig. 3(b)) and ML (Fig. 3(a)) directions (except for one the case of AP in FO_EC). The results in AP direction, similar to previous studies, indicate that the more subject is aged the more the COP moves on the backward [28]. Related to ML direction, it is deduced that the increase in age moves the COP in the right.

D. Gender Effects

The healthy subjects are now divided into two groups according to their gender. Female subject's (mean age is 24.5 ± 5.5y and males subject's mean age is 31± 11y.

It is remarkably noticed that the MCOPP of males are more situated on the right sight than females since male's absolute values are much greater than female's values in ML direction (Fig. 4(a)). So, it is confirmed that males COP is more in the right than females and this is in agreement with previous studies [19]. For AP direction (Fig. 4(b)), there are no significant results, although previous studies find that the COP of males is more on the forwards than females [17].

E. Weight Effects

The subjects are now divided into groups according to their weight: Fat group (13 subjects with weight varying between 72 and 105 kg) and thin group (12 subjects with weight varying between 52 and 66 kg). Previous study finds that the increase in weight moves the COP on the forward [29]. Other research finds that the COP mean location was not influenced by weight [30]. In this study, absolute values of fat are greater than thin in ML direction (Fig. 5(a)) and in AP direction (except for one case) (Fig. 5(b)). So, it is deduced that the decrease of weight moves the COP more on the forward and on the right.

F. Height Effects

The healthy subjects are now divided into two groups according to their height: Tall group (14 subjects with height varying between 174 and 192 cm) and small group (11 subjects with height varying between 160 and 172cm).

Experimental results show that absolute values of tall are greater than small for ML (Fig. 6(a)) and AP direction (especially with FO)(Fig. 6(b)). This indicates that the increase of height moves the COP more on the right and more on the forward with outspread feet.

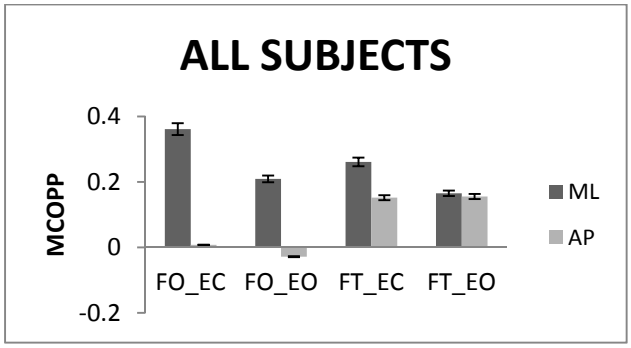
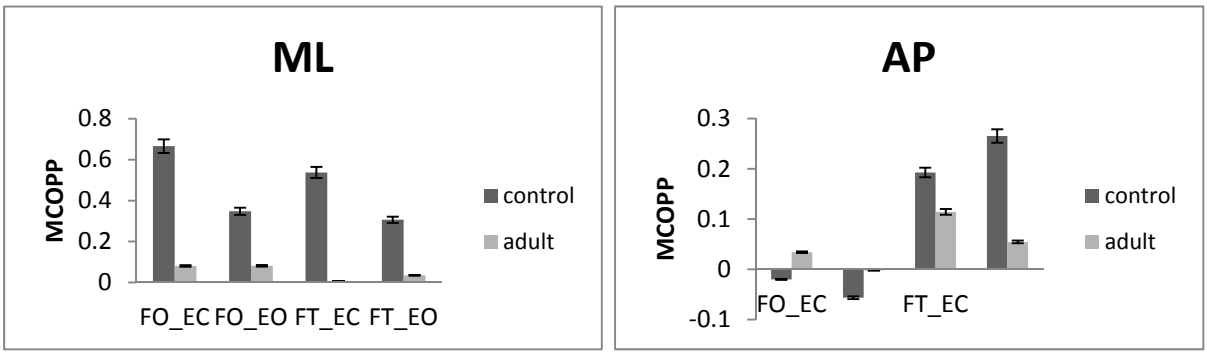
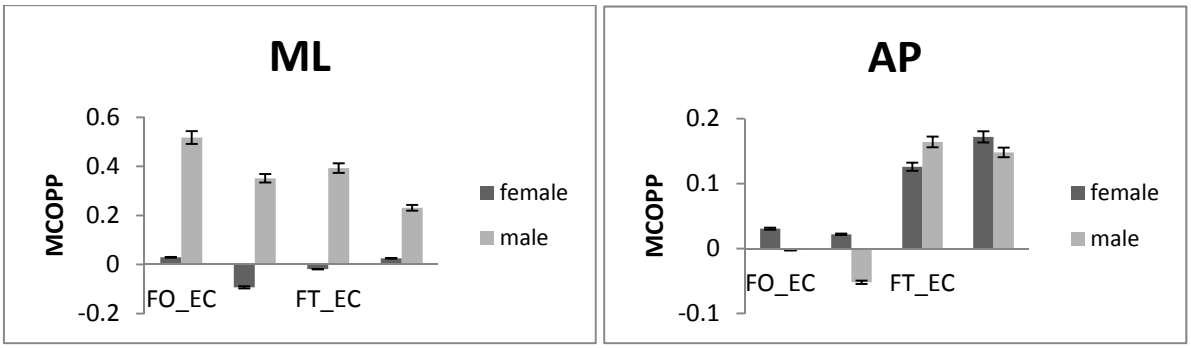


Fig. 2 Mean displacement of the center of pressure for all subjects in the mediolatéral (ML) direction and Anteroposterior (AP) direction. Data are mean and 95% confidence intervals



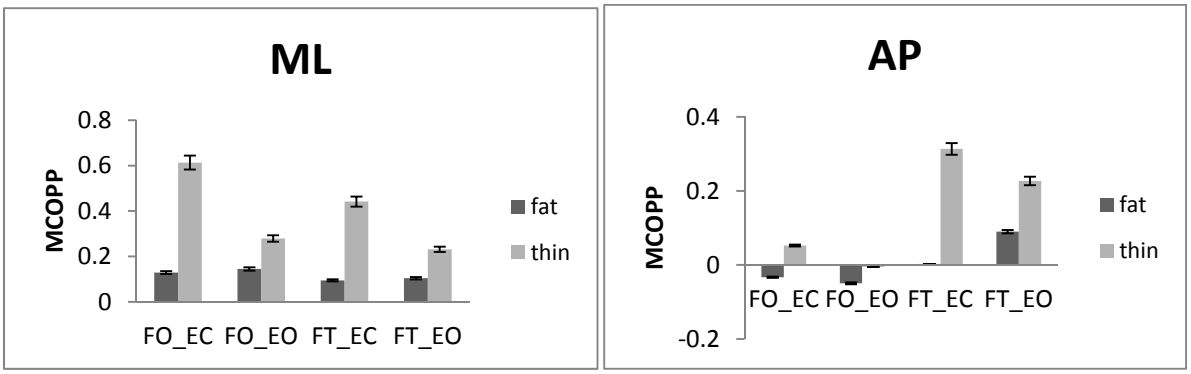
(a) (b)

Fig. 3 Mean displacement of the center of pressure for control and adult in the (a) mediolatéral (ML) direction and (b) Anteroposterior (AP) direction. Data are mean and 95% confidence intervals



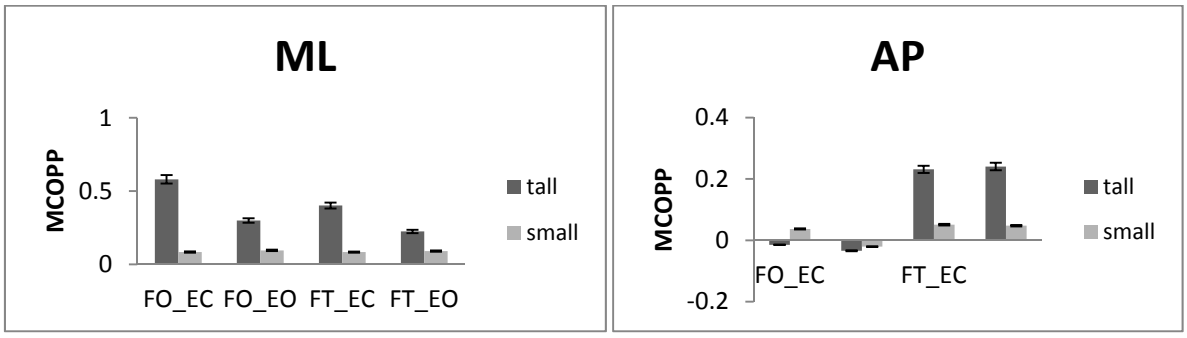
(a) (b)

Fig. 4 Mean displacement of the center of pressure for female and male in the (a) mediolatéral (ML) direction and (b) Anteroposterior (AP) direction. Data are mean and 95% confidence intervals



(a) (b)

Fig. 5 Mean displacement of the center of pressure for fat and thin in the (a) mediolatéral (ML) direction and (b) Anteroposterior (AP) direction. Data are mean and 95% confidence intervals



(a) (b)

Fig. 6 Mean displacement of the center of pressure for tall and small in the (a) mediolatéral (ML) direction and (b) Anteroposterior (AP) direction. Data are mean and 95% confidence intervals

IV. CONCLUSIONS

In this study, we analysed the effects of several entries on the human center of pressure behavior by analyzing the MCOPP. The MCOPP is calculated for subjects standing upright on an electromagnetic platform for AP and ML directions for all situations (FO_EC, FO_EO, FT_EC and FT_EO). The study of this parameter enables to characterize the influence of age, gender, anthropometric parameters, direction, visual and proprioceptive entries on the behaviour of MCOPP in both ML and AP directions.

Following studies will focus on the effect of these entries on the human stability control using several posturographic parameters.

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