XXIV CONGRESS OF THE INTERNATIONAL SOCIETY OF BIOMECHANICS

XV BRAZILIAN CONGRESS OF BIOMECHANICS

The importance of sensory information for the postural control: is the inverted pendulum important for the static balance control

Angélica Castilho Alonso[1;] Luis Mochizuki[1], Natália Mariana S Luna[1], Fábio Barbieri[2]; Julia Maria D'Andréia Greve[1]

[1]Researcher on the Movement Study Laboratory (LEM), Institute of Orthopedics and Traumatology (IOT), Hospital das Clinicas (HC), FMUSP, São Paulo, SP; [2]Radiologist. Director of Radiology, IOT-HC-FMUSP; angelicacastilho@msn.com

SUMMARY

The aim of the present study was to evaluate the influence of anthropometric characteristics and gender on postural balance among adults. One hundred individuals (50 men, 50 women; 20-40 years old). *Body composition* (measurements bone densitometry) percentage of fat tissue, fat, lean mass, bone mineral content and bone mineral density; *Anthropometry:* body mass, height, trunk-head length, lower limb length, upper limb length. The postural sway was measured during the quiet standing posture the eyes opened and closed. The correlation analysis showed low correlations between postural balance and anthropometric variables. The multiple linear regression analyzes showed that the height explained 12% of the medio-lateral displacement and 11% of the displacement area. The length of the trunk head explained 6% of displacement in the antero-posterior direction. With eyes closed, his support base and height explained 18% of medial displacement of lateral height explained and 5% of the scroll area. The postural control depends on body composition and dimension. This relation is mediated by the sensory information. The height was the anthropometric variable that most influenced the postural sway.

INTRODUCTION

During the quiet upright position, both mechanical and sensory conditions affect the postural sway. The sensory information about posture and kinesthesia feeds the postural control to build a postural frame of reference. For the sagital plane, the quiet upright posture can be modeled as an inverted pendulum which sways around the ankle joint. This condition reveals the ankle strategy. On the other hand, for the frontal plane, that orthostatic posture is modeled as a double inverted pendulum with the ankle and hip joints, revealing two postural strategies: the ankle and hip strategies. The postural control uses the combination of both strategies to keep the postural sway inside the basis of support. Considering such biomechanical modeling of the quiet standing posture, the afferent sensory information and the anthropometric variables are important factors for the postural control [1].

What does happen when there is less sensory information available for the postural control? Is the inverted pendulum model capable to explain how the postural control regulates the body sway to reduce a falling risk? The aim of this study was to evaluate the relation between the sensory and anthropometric variables in the quiet standing postural control. The hypothesis of this study is that sensory information constrain enhances the importance of the inverted pendulum variables for the postural control.

METHODS

Fifty young men and fifty young women were the participants. The anthropometric and body composition variables were measured. The participants' height, weight, BMI, trunk-encephalic length and the waist-hip ratio were obtained. The bone densitometry, using dual energy X-ray absorptiometry (DEXA), gave the body composition: the percentage of body fat, bone mineral content and body lean mass.

A portable force platform (AccuSway Plus, AMTI®, MA, USA) was applied to measure the ground reaction forces and moments of force during the quiet standing posture task.

RESULTS AND DISCUSSION

For the opened eyes condition, the height, waist-hip ration, trunk-cephalic length and bone mineral composition were correlated to AP and ML COP RMS and COP area. For the closed eyes condition, the height was correlated to AP and ML COP RMS and COP area.

The multiple linear regression model analysis with the postural sway and the anthropometric and body composition variables for the visual conditions are described in Table 1. For the opened eyes condition, the height explained 12% of the ML COP RMS, 10% of the Sway velocity and 11% of the COP area; and the trunk-cephalic length explained 6% of the AP COP RMS. For the closed eyes condition, the height explained 18% of the ML COP RMS; and the Trunk-cephalic length explained 10% of the Sway velocity and 5% of the COP area.

When there is no restriction for the sensory information to the postural control, the anthropometric and body composition variables affect the postural sway. [2]

Under normal conditions of sensory information availability for the postural control, the health indexes are related to the postural control. The waist-hip ratio was positively related to the ML postural sway. It is possible that the fat mass concentration in the chest and abdomen (android shape) increases the load on the hips, explaining the larger ML COP. [3] Therefore, we showed that the lean mass was positively correlated to the postural control. Those results suggest that lower lean body mass and higher waist-hip ration can be risk factors for the postural control.

The absence of visual information changes the importance of body composition and dimensions. The regression analysis showed that, under the closed eyes condition, only the anthropometric variables explained the postural sway. When the visual information is suppressed, a greater importance is required from the somatosensory and vestibular systems for the postural control. The afferent information is important to set the muscle activity and tonus in an adequate level. And we just showed that the body lean mass is related to postural sway.

The motion of a pendulum depends on its length, mass and stiffness. For the postural control, it means that the ankle strategy depends on the body mass, height and ankle stiffness. The taller is the participant, the worse the balance will be [4]. The participants' height is positively correlated to the balance sway. For the hip strategy, under the inverted pendulum model, the postural control depends on the body mass, the head and trunk length and the hip and lower back joints stiffness [1].

The trunk-cephalic length, or the head and trunk length, was positively correlated to the postural sway. For the regression analysis, the importance of the trunk-cephalic length for the postural sway decreased when the participants closed their eyes. Both results suggest that, under the visual information restriction, the physical parameters of the inverted pendulum become more important for the postural control [4].

Our results suggest that during the quiet standing posture, the ankle and the hip strategies are challenged when the sensory information is reduced. Besides the experimental condition, the visual information can be reduced during aging or if the person has any eyes problem. For the prevention of fallings, it seems that to improve both strategies might be important when the visual information is impaired.

CONCLUSION

The postural control depends on body composition and dimension. This relation is mediated by the sensory information. The height was the anthropometric variable that most influenced the postural sway. Under the absence of visual information, the ankle and hip strategies are more challenged during the quiet standing posture.

REFERENCES

1.Allardy P, Naulty ML, S. Hinsey S, LeBlanc R, Labelle H Relationship between morphologic somatotypes and standing posture equilibrium. Ann. Hum. Biol 6, 624-633,2001.

2.Greve J, Alonso AC, BordiniACPG, Camanho, GL. (2007) Correlation between body mass index and postural balance. Clinics 62,717-20.

3.Goulding A, Jones IE, Taylor RW, Piggot JM, Taylor D. (2003) Dynamic and static tests of balance and postural sway in boys: effects of previous wrist bone fractures and high adiposity. Gait Posture 17,136-/141.

4. ALONSO, AC ; Luna NMS ; MOCHIZUKI, L. ; Barbieri F ; SANTOS, S. ; GREVE, J. M. D. The influence of anthropometric factors on postural balance: the relationship between body composition and posturographic measurements in young adults. Clinics, 67(12):1433-1441,2012

Table 4. Linear regression analysis on postural balance and the anthropometric variables for the whole group and separated according to gender, with eyes open and eyes closed

Group condition	Variables	Height β *(p)*	Trunk-cephalic length β *(p)*	Lean mass β *(p)*	Waist-hip ratio β *(p)*	r^2 adjust
Whole group						
Eyes open						
	Mediolateral displacement	+0.006(<0.001)	-	-	-	0.12
	Anteroposterior displacement		+0.008 (0.006)	-	-	0.06
	Sway velocity	+0.003 (0.001)	-			0.10
	Displacement area	+0.009(<0.001)	-	-	-	0.11
Eyes closed						
	Mediolateral displacement	+0.007(<0.001)	-	-	-	0.18
	Anteroposterior displacement	-	-	-	-	
	Sway velocity	-	+0.004(<0.001)	-	-	0.10
	Displacement area	-	+0.007(0.01)	-	-	0.05

Legend: β – beta value r^2 – r adjusted; * *p ≤ 0.05*