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## Original article

# Effects of plantar foot sensitivity manipulation on postural control of young adult and elderly

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### ABSTRACT

**Introduction:** Subjects with sensorial losses present balance deficits. Although such condition is often observed among elderly, there is discussion concerning the dependence on sensorial information for body sway control in the elderly without sensorial losses.

**Purpose:** We investigated the effects of foot sensitivity manipulation on postural control during upright standing in young adults and independent elderly ( $n = 19/\text{group}$ ).

**Methods:** Plantar sensitivity was evaluated by esthesiometry, and speed of center of pressure shift data during upright posture were evaluated for each foot using a baropodometer while the subjects were standing with eyes open or closed. The young adult group was evaluated for center of pressure in normal conditions and after plantar sensitivity disturbance, by immersing their feet in water and ice.

**Results:** Young adults did not show alterations in their center of pressure after sensorial perturbation and presented, even under sensorial perturbation, better postural control than elderly subjects. The elderly showed lower foot sensitivity and greater center of pressure oscillation than young adults.

**Conclusion:** Elderly subjects seem to rely more on foot sensitivity for control of body sway than young adults. In the elderly, a clinical intervention to improve foot sensitivity may help in upright posture maintenance.

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## Efeitos da manipulação da sensibilidade plantar sobre o controle da postura ereta em adultos jovens e idosos

### RESUMO

**Introdução:** Pessoas com perdas sensoriais apresentam déficits de equilíbrio. Embora esse quadro seja comum em idosos, ainda se discute o quanto idosos sem doenças que afetam as vias sensoriais dependem dessa informação para controlar oscilações corporais durante o controle da postura.

**Objetivo:** Investigar os efeitos da perturbação da sensibilidade plantar sobre o controle da postura ereta em adultos jovens e idosos independentes ( $n = 19/\text{grupo}$ ).

#### Palavras-chave:

Controle postural

Equilíbrio

Centro de pressão

Estabilidade

Envelhecimento

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**Métodos:** A sensibilidade plantar foi avaliada com estesiômetro e dados de velocidade e deslocamento do centro de pressão durante a postura de pé foram avaliados para cada pé com um baropodômetro, em condições de olhos abertos e fechados. O grupo de adultos jovens foi avaliado quanto ao centro de pressão nas condições normal e pós-perturbação da sensibilidade plantar, pela imersão dos pés em água e gelo.

**Resultados:** Adultos não apresentaram alterações no centro de pressão em resposta à perturbação sensorial e tiveram, mesmo na condição de perturbação sensorial, melhor controle postural do que idosos. Idosos apresentaram menor sensibilidade plantar e maior oscilação do centro de pressão do que os adultos jovens.

**Conclusão:** Idosos pareceram depender mais da sensibilidade plantar para manter o controle postural do que adultos jovens. Em idosos, intervenções clínicas que melhorem a sensibilidade plantar podem auxiliar na tarefa de manter a postura de pé.

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## Introduction

The control of upright posture is a skill required daily and which depends on constant neuromuscular adjustments to keep the center of pressure (CoP) within the stability limits of the supporting base.<sup>1</sup> These adjustments suffer deterioration by the aging process.<sup>2</sup> One reason for the occurrence of these deficits may be the loss of sensory function or usability of this sensory information. When subjected to situations where proprioceptive functions of the foot and ankle are compromised, young adults have a lower length and area of CoP shift *versus* elderly subjects, suggesting an improved ability to compensate for sensory loss.<sup>3,4</sup>

Billot et al.<sup>5</sup> suggest that plantar sensitivity is not a primary function for posture control in adults, since this information can be compensated by other proprioceptive pathways, for example, vision or vestibular system. However, posture control seems to be associated with plantar sensitivity in the elderly, where other systems also have deficits in response to aging, for example, losses in vestibular system function, vision and muscle strength.<sup>3</sup> Ducic et al.<sup>6</sup> showed that the reduced plantar sensitivity relates to deficits in postural control of elderly patients with peripheral neuropathy. In addition, plantar sensitivity contributes to the control of plantar pressure during upright posture in the elderly.<sup>7</sup> This helps to explain the fact that older people sometimes show greater reliance on vision, especially for the control of CoP velocity, than young adults.<sup>8</sup> However, there is still doubt as to the degree of contribution of this kind of sensory information from the plantar region for the regulation of postural control in healthy elderly.

Experimental studies have developed protocols that reduce temporarily the adult sensory function, for example, the activity of mechanoreceptors, in order to mimic sensory decline of aging and facilitate a comparison between this intact *versus* impaired afferent resource. One strategy that has proved valid in some studies consists in the immersion of the lower limbs in water and ice, in order to reduce plantar sensitivity, two-point touch discrimination ability, and sensitivity to vibration.<sup>9</sup>

In this study, our aim was to assess changes in the position of CoP under each foot, which is considered as an indicator of postural control in the elderly and in young adults in normal sensory condition and in response to a sensitivity disturbance.

Considering that aging can promote heterogeneous losses in different sensorimotor (cognitive and sensory/perceptual processing) components,<sup>10</sup> our hypothesis was that reduced plantar sensitivity would exert different impact for the elderly compared to young adults, because young adults would have the capacity to regulate CoP satisfactorily, even under conditions of disturbance in the sensory characteristics of their feet, indicating that this type of information is more important for the elderly than for young adults.

## Materials and methods

### Participants

Thirty-eight participants invited from the local community were divided into two groups matched for height and body mass. The group of young adults included 19 subjects with mean (SD) age of 35 (5) years, height of 1.65 (0.08) m, and body mass of 63 (10) kg. The elderly group consisted of 19 independent elderly subjects with mean (SD) age of 79 (6) years, height of 1.55 (0.05) m, and body mass of 68 (9) kg. The group of young adults was evaluated in two conditions: one pre- and the other post-sensory disturbance, making a total of three groups in the final analysis: adults without sensory disturbance, post-sensory disturbance adults, and elderly subjects. All participants signed an informed consent in accordance with the Declaration of Helsinki and this study was approved by the Human Research Ethics Committee of the local institution (opinion 082 011). All participants ought to be in a physical condition to walk and to stand on their own feet with no orthosis or prosthesis; moreover, they should be available to visit the laboratory to be part of the evaluations. Exclusion criteria included the presence of cerebellar disease, plantar skin lesions, lower limb traumatic injury history, neuropathy or inability to perform the proposed tasks.

### Assessment of plantar sensitivity

Before engaging in the assessment of plantar sensitivity, participants had 10 min of rest, sitting in a chair. The plantar sensitivity was evaluated according to a clinical protocol using a Semmes-Weinstein pressure esthesiometer

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