Applied Soft Computing 69 (2018) 625–633

Contents lists available at ScienceDirect

Applied Soft Computing

journal homepage: www.elsevier.com/locate/asoc

Body sway and global equilibrium condition of the elderly in quiet standing posture by using competitive neural networks

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ARTICLE INFO

Article history:
Received 8 September 2016
Received in revised form 12 April 2018
Accepted 2 May 2018
Available online 8 May 2018

Keywords:
Balance control
Body sway
Competitive neural network
Elderly
Equilibrium condition
Global point of equilibrium
Postural steadiness

ABSTRACT

Objective: The balance deficit (equilibrium condition) is one of the leading sources of falls of the elderly. Finding out the quiet standing point of equilibrium of body sway in older adults by using the competitive neural network for accessing body steadiness is presented in this study.
Methods: The sample population consists of elderly aging from 60 to 80 years old quiet standing on a force measuring platform. To assess body steadiness, the values of the center of pressure (COP) are obtained by stabilometry. The center of pressure position and displacement are acquired over a time interval, COP(t), composing a body sway area. The competitive neural network use the COP(t) data as input signal for determining the Global Center of Pressure (G-COP) concerning the quiet standing point of equilibrium.
Results: The competitive neural network based statokinesigram analysis is able to achieve the G-COP regardless the sort of dynamical body sway. Results demonstrate that the competitive neural network determines the point of equilibrium for patients with uniform, conservative, homogeneous body balance as well as for those patients presenting non-uniform, non-conservative, heterogeneous body sway in quiet standing posture. The proposed approach can be used to compute the G-COP both in off-line (when the entire COP data set is available) as well as in real-time (meanwhile COP data are being acquired); not requiring the entire COP data set be available.
Conclusion: The competitive neural network comes to be a feasible alternative to compute the global center of pressure and, thus, to contribute to the postural steadiness and equilibrium condition analysis of the elderly. Such an approach is also able to be extended to any other aging group as well as in the presence of distinct pathologies that alter body control. Further, the proposed competitive neural network based statokinesigram analysis can be employed to work together with current techniques employed for steadiness analysis.

1. Introduction

The body steadiness concerns the equilibrium condition of individuals and is one of the major factors for achieving human movements. Accountable for maintaining an upright posture, the body control system enables accomplishing a posture with low balance, attaining the limits of stability and steadiness [1–3]. Such a system empowers the body to achieve the movements when performing daily activities or to react to external disturbances.

Evaluating if the body control system achieves steadiness can, for instance, be accomplished by employing the *center of gravity* (COG) of individuals. Located in a position where the weight of a body is distributed equally in all directions, the COG is the main measure for pointing out the overall body position, balance, stability, and steadiness.

Body's aging, in turn, affects the physical conditions and the COG position of individuals leading the elderly to a balance deficit, thus, with a tendency to fall. Changes in energy metabolism, increase of body fat, decrease of muscle fibers and muscle mass, reduction in stature and bone density, as well as vertebral curvatures, all of them interfere at the stability and steadiness conditions. Important in all age groups, determining the actual equilibrium condition of the elderly is of special interest.

The evaluation of the degree of stability and steadiness depends on diverse factors and can employ distinct measures of body stance. The center of gravity and its vertical projection over the *support*

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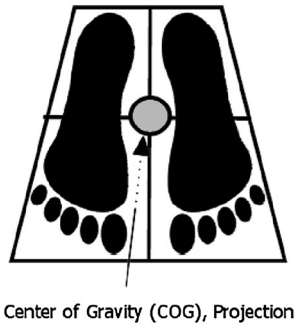
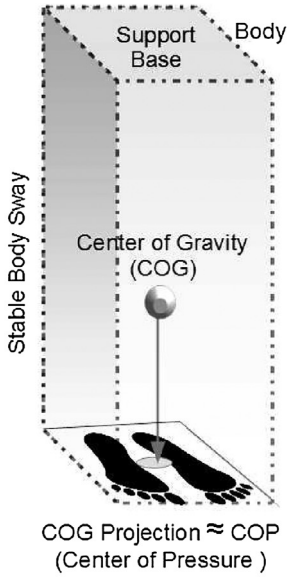
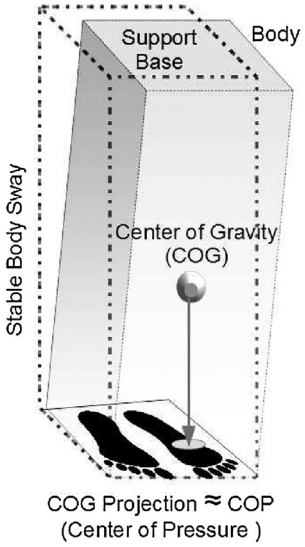
https://doi.org/10.1016/j.asoc.2018.05.004
1568-4946/



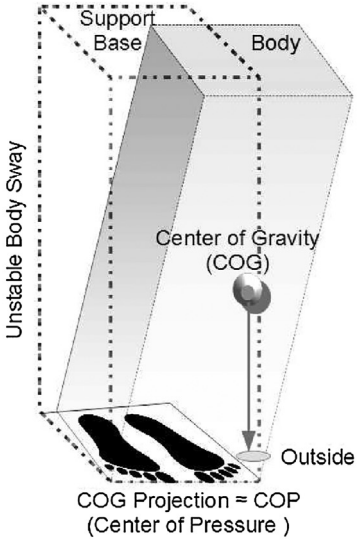
(a) Support Base.



(b) Stable Body Sway.



(c) Stable Body Sway



(d) Unstable Body Sway

Fig. 1. Body equilibrium conditions: stable (b and c) and unstable (d).

base assume, in general, a leading role in the body sway analysis, especially when in quiet standing posture (Fig. 1). The support base concerns the upper boundary, given by the line of the fingers; the side boundaries, by the sideline of the feet; and the lower bound, by the line of heels (Fig. 1(a)). Keeping the perpendicular projection of the COG over their support base is a suitable approach used to evaluate if the body control system works properly, thus achieving stability and steadiness (Fig. 1(b) and (c)). Contrary behavior, when individuals present difficulty in keeping the COG projection within the support base, concerns unstable equilibrium condition, leading to a fall (Fig. 1(d)) [4,5].

Nevertheless, determining the COG or its derived vertical projection is not a simple task [6]. An alternative to measure the body position and displacement is the *center of pressure* (COP). Concerning the body control system, it is a neuromuscular response to the displacement and position of the COG to keep it inside the support base. The center of gravity and the center of pressure can be assigned closely related, COG ≈ COP, when dealing with steadiness