Neurophysiologie Clinique/Clinical Neurophysiology (2017) 47, 305—314

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ORIGINAL ARTICLE/ARTICLE ORIGINAL

Interaction between postural asymmetry and visual feedback effects in undisturbed upright stance control in healthy adults

Interaction entre les effets d'asymétrie posturale et de rétroaction visuelle dans le contrôle de la station debout chez des individus en bonne santé

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Received 15 November 2016; accepted 18 January 2017
Available online 15 March 2017

KEYWORDS
Augmented visual feedback;
Body-weight distribution;
Posturography;
Upright stance

Summary
Objectives. — The technique of additional visual feedback has been shown to significantly decrease the center of pressure (CP) displacements of a standing subject. Body-weight asymmetry is known to increase postural instability due to difficulties in coordinating the reaction forces exerted under each foot and is often a cardinal feature of various neurological and traumatic diseases. To examine the possible interactions between additional visual feedback and body-weight asymmetry effects, healthy adults were recruited in a protocol with and without additional visual feedback, with different levels of body-weight asymmetry.
Methods. — CP displacements under each foot were recorded and used to compute the resultant CP displacements (CP_{Res}) and to estimate vertically projected center of gravity (CG_v) and CP_{Res}-CG_v displacements. Overall, six conditions were randomly proposed combining two factors: asymmetry with three BW percentage distributions (50/50, 35/65 and 20/80; left/right leg) and feedback (with or without additional VFB).
Results. — The additional visual feedback technique principally reduces CG_v displacements, whereas asymmetry increases CP_{Res}-CG_v displacements along the mediolateral axis. Some effects on plantar CP displacements were also observed, but only under the unloaded foot. Interestingly, no interaction between additional visual feedback and body-weight asymmetry was reported.

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http://dx.doi.org/10.1016/j.neucli.2017.01.010

Discussion. — These results suggest that the various postural effects that ensue from manipulating additional visual feedback parameters, shown previously in healthy subjects in various studies, could also apply independently of the level of asymmetry.
Conclusion. — Visual feedback effects could be observed in patients presenting weight-bearing asymmetries.

MOTS CLÉS
Posturographie ;
Répartition du poids de corps ;
Rétroaction visuelle augmentée ;
Station debout

Résumé
Objectifs. — Il a été précédemment montré que la rétroaction additionnelle visuelle permettait de réduire les déplacements du centre des pressions (CP) d'un individu debout. Une asymétrie de répartition du poids est connue pour faciliter l'instabilité posturale, de par des difficultés de coordination des forces de réaction exercées sous chaque pied. Cette asymétrie constitue une caractéristique importante de diverses pathologies neurologiques ou traumatologiques. Afin d'examiner les possibles interactions entre les effets de cette rétroaction et de l'asymétrie, un protocole incluant des sujets adultes sains a été mis en place comprenant des conditions avec ou non-présence de rétroaction et différents niveaux d'asymétries de répartition.
Méthodes. — Les déplacements du CP sous chacun des pieds sont utilisés pour calculer le centre des pressions résultant (CP_{Res}) et par estimation la projection verticale du centre de gravité (CG_v) et la différence CP_{Res}-CG_v. Six conditions ont été proposées aléatoirement combinant plusieurs niveaux d'asymétries (50/50, 35/65 et 20/80) et la présence ou non de rétroaction.
Résultats. — La rétroaction additionnelle réduit principalement les mouvements du CG_v alors que l'asymétrie accroît ceux de CP_{Res}-CG_v selon l'axe médio-latéral. Des effets sur les déplacements plantaires du pied allégé sont aussi observés. Aucune interaction entre la rétroaction et l'asymétrie n'est trouvée.
Discussion. — Ces résultats suggèrent que les effets précédemment observés en manipulant diverses variables de la rétroaction chez des sujets sains puissent être retrouvés, ceci indépendamment du niveau d'asymétrie.
Conclusion. — Les effets de rétroaction peuvent être observés chez des patients montrant une asymétrie de répartition de poids.

Introduction

Stance control may be viewed as a dynamic task consisting of controlling the vertically projected center of gravity (CG_v) movements, through which stability can be assessed, via the resultant CP_{Res} displacement, the controlling variable [31]. Even though receptors from the plantar soles already play that role along with other from joints and muscles from the whole body, an enhanced sensory contribution, and therefore improved control, can be obtained by using a technological device such as a force platform (Fig. 1). Use of so-called additional visual feedback (VFB) of CP_{Res} displacements induces an increased stability (reduced CG_v movements), thereby making this a potential tool for rehabilitation protocols [26]. Another feature observed in these VFB protocols are the increased amplitudes of the CP_{Res}-CG_v movements, which have been shown to be proportional to the horizontal accelerations communicated to the CG [3] and which can be interpreted as expressing enhanced muscular activity in the lower limbs [24]. Healthy subjects, bearing their body weight (BW) symmetrically, are extensively used in such studies because there is no interaction with any clinical conditions. Several attempts have recently been made to study patients bearing their BW asymmetrically in these VFB protocols. For instance, in children with hemiplegic cerebral palsy [13] and in individuals with hemiparesis [7], beneficial effects of VFB were shown but only some individuals with hemiparesis appeared to gain stability from VFB [22]. In these studies, the possibility that the level of postural asymmetry itself plays a role in the effects cannot be ruled out. Indeed, some individuals with hemiparesis demonstrate substantial weight-bearing asymmetry [9]. The present study was therefore undertaken to ascertain to which extent this weight-bearing asymmetry could interfere with postural control effects induced by the VFB technique. Interestingly, it has been already shown that VFB (through a mirror) results in reduced body sway in transfemoral amputees without influencing weight-bearing asymmetry [11]. However, weight-bearing asymmetry is generally weak in amputees [21].

The two factors involved in this study, weight-bearing asymmetry and VFB, have the particularity of inducing postural control effects that may cancel each other out when observing the global CP_{Res} movements. This is due to the fact that the reported effects generally concern one of the two elementary movements (CP_{Res}-CG_v and CG_v) which, when added, constitute the CP_{Res} movements. First, since weight-bearing asymmetry in healthy subjects has been shown to increase CP_{Res}-CG_v movements along both the mediolateral (ML) and antero-posterior (AP) axes, and since amplitudes of CG_v movements remain constant and even increase along the AP axis, the CP_{Res} displacements could be