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BODY BALANCE AND HYPERMOBILITY

Static and dynamic body balance following provocation of the visual and vestibular systems in females with and without joint hypermobility syndrome

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Summary *Objectives:* Joint hypermobility syndrome (JHS) is a heritable disorder of the connective tissue characterized by excessive joint movement, musculoskeletal pain and neurophysiological deficits (i.e. decreased proprioceptive acuity, altered neuromuscular reflexes). Such deficits may affect body balance thus increasing the risk of injury. The present study aimed at examining static and dynamic body balance following challenge of the visual and vestibular systems in individuals with JHS.
Methods: The sample consisted of 21 females with JHS and 20 controls without signs of JHS. Static body balance was assessed by the degree of anteroposterior and mediolateral deviation of the center of pressure, during 20-sec single-leg stances with eyes opened (EO), eyes closed (EC) and eyes opened with head extension (EO-HE) using a foot pressure platform. Dynamic

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body balance was assessed by the number of landing and balance errors committed during a multiple single-leg-hop-stabilization test.
Results: Nonparametric analysis showed that the JHS-group demonstrated significantly greater (a) mediolateral deviation during single-leg-stance with EO ($p < 0.01$), (b) mediolateral and anteroposterior deviation during single-leg-stance with EO-HE ($p < 0.05$), and (c) number of landing errors ($p < 0.05$) compared to the control group.
Conclusions: Poor static balance following challenge of the vestibular system may be justified by vestibular deficiency and/or insufficient proprioceptive capabilities of the neck. Impairments of dynamic balance in individuals with JHS may be attributed to proprioceptive deficits, which can alter feedforward and feedback mechanisms.

Introduction

Joint hypermobility syndrome (JHS) is an insufficiently understood and often poorly managed multi-system hereditary disorder of the connective tissue (Simmonds and Keer, 2007) that prevails among young, non-Caucasian females (Grahame and Hakim, 2004; Forleo et al., 1993). It is characterized by excessive joint laxity combined with widespread musculoskeletal pain and/or other extra-articular features of connective tissue laxity (revised Brighton criteria) (Grahame et al., 2000), in the absence of signs of infectious, inflammatory and autoimmune disorders (Everman and Robin, 1998). The revised Brighton criteria is a validated (Grahame et al., 2000) and reproducible set of criteria ($k > 0.73$, Juul-Kristensen et al., 2007) that have been commonly used in the diagnosis of JHS. Based on these criteria, an individual is diagnosed with JHS in the presence of (i) a Beighton score of $\geq$4/9 — a nine-point score that is being gained if someone can passively dorsiflex the little fingers beyond 90° (2 points), passively oppose the thumbs to the flexor aspect of the forearms (2 points), hyperextend the elbows beyond 10° (2 points), hyperextend the knees beyond 10° (2 points), forward flex the trunk with knees straight and the palms of the hands rest easily on the floor (1 point) — and (ii) arthralgia for $\geq$3 months in $\geq$4 joints (major criteria). Alternatively, an individual with JHS may fulfill one of the aforementioned major criteria and at least two minor criteria or none of the major and at least four minor criteria. The minor criteria include (i) a Beighton score of 1—3/9 (or 0—3/9 if aged >50 yrs), (ii) arthralgia for $\geq$3 months in 1—3 joints, back pain for $\geq$3 months, spondylosis or spondylolysis/spondylolisthesis, (iii) acute or recurrent dislocation/subluxation in $\geq$1 joint, (iv) $\geq$3 soft tissue lesions (i.e. epicondylitis, bursitis), (v) Marfanoid habitus (ectomorphic somatotype), (vi) skin abnormalities (i.e. thin and hyperextensible skin, abnormal skin striae), (vii) eye pathology (i.e. drooping eyelids, myopia) and (viii) varicose veins or hernia or uterine/rectal prolapse.

Individuals with JHS have also demonstrated poor proprioceptive capabilities with regard to the knee joint (Baskent et al., 2008; Ferrell et al., 2004; Hall et al., 1995) and the proximal interphalangeal joints (Mallik et al., 1994). Other authors revealed that the reflex activation of certain muscles (e.g. quadriceps) that is usually elicited following stimulation of peripheral nerves (e.g. common peroneal nerve) was either insufficient or absent in this group of individuals suggesting decreased neuromuscular co-ordination (Ferrell et al., 2007).

Another somatosensory-depended function of the human body that has been assessed in individuals with JHS was body balance. Body balance is referred to as the ability to maintain the body's center of gravity over its base of support with minimal sway or maximal steadiness (Horak, 1987; Shumway-Cook et al., 1988). Although it is considered vital for optimal performance of the human body and injury prevention, particularly of the lower limbs (Hrysomallis, 2007), in the JHS population has been investigated only under static conditions (bipedal and unipedal upright stance) with eyes open (Ferrell et al., 2004; Mebes et al., 2008). However, body balance may be examined either under static or dynamic conditions. When static body balance is performed with eyes closed, clinicians may extract additional information of how it is controlled under the interactive information of the somatosensory and the visual systems via the CNS (Gatev et al., 1999). Backward tilting of the head (neck extension) during upright stance may also provide information of the ability of the somatosensory system to compensate for the increasing demands in maintaining body balance due to proprioceptive and vestibular provocation (Brandt et al., 1981). The neck flexors, which are muscles with a high density of muscle spindles (e.g. longus colli), are stretched in this position and may possibly affect postural control by compromising modulation of musculotendinous and capsuloligamentous reflexes (Boyd-Clark et al., 2002). Furthermore postural control, in this position, may be compromised by dysfunction of the vestibular system and especially the otoliths which contain several fluid-filled membranous sensory end-organs. The macula, which is the sensory area of otoliths, support hair cells that act as mechanoreceptors. When the head is tilting backwards, the mass of statoconium membrane prevents these hair cells from returning to their resting position, thus generating tonic signals that represent head position in relation to gravity (Keshner and Cohen, 1989).

Dynamic body balance testing [i.e. the multiple single-leg-hop stabilization test (Riemann et al., 1999)], on the other hand, may provide information with regard to the effectiveness of the feedforward and feedback mechanisms in correcting postural deviations that are necessary in achieving a successful performance during daily and sporting activities. Such testing may also be more appropriate in revealing balance deficiencies particularly in a young population with increased physical activity.

The aim of the present study was to investigate by means of postural sway, the contribution of proprioceptive