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Identification of a relationship between cervical spine function and rotational movement control

Recherche d'une relation entre fonction du rachis cervical et contrôle du mouvement de rotation

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Abstract

The cervical spine's stabilising function is generated by three interacting systems: an active system (the muscles), a passive system (capsules, intervertebral disks and ligaments) and a neutral system (the nervous system). Functional impairment induced by alteration of one or several systems can disturb movement control. Thus, a decrease in the quality of movement control could be directly linked to the cervical spine's state of impairment. The aim of the present study was to assess the relationship between cervical spine status (measured using a validated questionnaire) and the control of low-amplitude neck movements. Our starting hypothesis was that the more precise the movement, the faster it would be. We devised a test in which a sequence of rotational movements of the neck (to the left and to the right, alternately) was timed while monitoring the targeting of a laser beam (fixed to the right side of a pair of spectacles) on photodetectors placed directly in front of the subject and 30° to the left and to the right of the body line. The test was performed using a system called the ''Didren laser''. Fifty-six subjects (of varying ages and both genders, classified as ''disabled'' or ''healthy'' according to the Neck Disability Index [NDI] questionnaire score) performed the test. Our results showed that: the score differed from one individual to another but was reproducible for a given subject; the score was age- and gender-independent; the highest scores (i.e. the slowest rotations) were generally produced by individuals classified as ''disabled'' in terms of the NDI questionnaire score. Our results led us to conclude that there is a relationship between functional disorders of the cervical spine and low-amplitude rotational movement control, although we were unable to define the exact nature of this relationship.

Keywords: Cervical spine function; Movement control; Neck rotation

Résumé

La fonction de la colonne cervicale dépend de trois systèmes interdépendants : l'actif (muscles), le passif (capsules, ligaments, disques intervertébraux) et le neural (système nerveux). Une gène fonctionnelle induite par la déficience d'un ou de plusieurs de ces systèmes, pourrait avoir pour conséquence de perturber le contrôle du mouvement. Par conséquence, une diminution du contrôle du mouvement pourrait être donc directement mise en relation avec l'état déficient de la colonne cervicale. Le but de notre étude était d'objectiver la relation entre le statut fonctionnel du rachis cervical, mesurée par un questionnaire validé et le contrôle des mouvements cervicaux de faible amplitude. Pour réaliser cet objectif, nous sommes partis de l'hypothèse que plus le mouvement réalisé était précis, plus il devait être rapide. Nous avons donc imaginé le test suivant : chronométrer une succession de rotations de nuque alternativement à gauche et à droite en dirigeant le rayon d'un laser accroché sur la branche droite d'une paire de lunette vers des capteurs photosensibles écartés de 30° de part et d'autre de l'axe neutre. Le test a été instrumenté par un dispositif, baptisé *Didren laser*. Nous avons soumis le test à 56 personnes de différents âges et sexes, classées comme « déficientes » ou « saines » selon leurs réponses au questionnaire NDI. Les résultats au test ont montré que : le temps mesuré était différent entre individus mais reproductible pour chaque individu ; le temps mesuré ne dépendait pas de l'âge ni du sexe ; les temps mesurés les plus élevés (rotations les plus lentes) étaient généralement obtenus par les individus classés « déficients » au travers du questionnaire NDI. Notre étude nous mène à conclure

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qu'il existe une relation entre gène fonctionnelle de la colonne cervicale et contrôle des mouvements de rotation de faibles amplitudes sans pour autant permettre d'identifier la nature de cette relation.

Mots clés : Fonction cervicale ; Contrôle du mouvement ; Rotation cervicale

1. English version

1.1. Introduction

In biomechanical terms, the vertebral column:

- enables the performance of smooth intersegment movements;
- bears load;
- protects the spinal cord and the nerve roots.

Correct movement control of the cervical, thoracic and lumbar spinal is essential for performing these functions [2,13].

According to Panjabi, the various structures ensuring vertebral function can be classified into three interdependent systems: the passive, active and nervous systems [13,14,16].

The passive system (composed notably of joint capsules and facets and intervertebral disks and ligaments) ensures the intrinsic stability of the vertebral column [13]. However, it does not contribute significantly to vertebral column stability when movement remains with an amplitude range that is close to the static position. It is only in the zone between the onset of the vertebral segment's rigidity and the latter's peak rigidity that the passive elements develop a reactive force which opposes the movement performed [13], i.e., in the mid-range and at the end of the movement. These components are passive in the sense that they do not produce any movement (given the lack of contractile elements) but they do have a proprioceptive role [13].

The active system corresponds to the spinal muscles and produces dynamic stability [13,14].

The nervous system includes the peripheral nerves and the central nervous system. This system receives information from various sensors, determines the requirements for maintaining vertebral stability and coordinates the muscle system's responses [13–15].

These three systems are closely intermeshed and, under normal conditions, work together in harmony [13,16]. They provide the mechanical stability required for appropriate movement and monitor the quality of the latter. Dysfunction in one of these systems (following trauma or via a degenerative process) can have an influence on the other systems and endanger the overall stabilization system by perturbing neck movement control [13,14,16–19].

If the passive system is altered, the role of the muscles becomes primordial in controlling the low-amplitude movements generally used in functional tasks [3]. In neutral positions and low-amplitude rotations, passive resistance to movement is low; the destabilizing force of gravity is countered by the anterior and posterior neck muscles [7].

According to Falla et al., the deep flexor muscles are primarily responsible for controlling cervical lordosis, maintaining the posture of the cervical spine and thus, stabilizing the vertebral column [6,7]. In the case of neck pain, the deep muscles are weakened and present a subnormal level of electrical activity, whereas the electrical activity of the superficial muscles increases [3,5,8]. The decrease in muscle activity could lead to a reduction in the cortical representation of the stabilizing muscles and thus, hinder automatic contraction during head movement [20].

Lastly, impairment of the passive system can perturb the nervous system and provoke a decrease in the control exerted by the active system. Consequently, the active system (poorly informed by the nervous system) will have trouble producing adequate muscle force for controlling the movement [11,13]. The extent of these various interactions shows that the impairment of passive elements (joint capsules and facets and intervertebral disks and ligaments), active elements (spinal muscles) and neural elements (the peripheral and central nervous system) could have an impact on movement control. Thus, impairment of the cervical vertebral column should translate into the imprecise execution of low-amplitude neck movements.

In the present study, we sought to identify a relationship between the neck's functional status (as measured by a validated questionnaire) and the control of low-amplitude neck movements. Our starting hypothesis was that poor movement control would translate into longer times when performing a series of precise neck movements. Consequently, a decrease in the rapidity of movement execution would be directly related to an impaired cervical spine status. To address this question, a measuring system called the ''Didren laser'' was developed in order to quantify the time needed to execute a series of low-amplitude neck rotations.

1.2. Methods

1.2.1. Study subjects

The test was performed on 56 subjects of both genders. All had received information on the study's objectives and procedures and had given their consent to participation. In order to include a population that was as broad as possible in terms of age and functional impairment, subjects were recruited either via an advert displayed at the *Haute École Libre* paramedical training school in Brussels (Belgium) or from among the patients attending a private physiotherapy practice in the city.

Subjects presenting dizziness, vestibular dysfunction, blindness or deafness were excluded from the study.

Before starting the test, each participant had to fill out the French version [21] of the validated Neck Disability Index