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Motor function levels and pelvic parameters in walking or ambulating children with cerebral palsy

Niveaux fonctionnels et évaluation des paramètres pelviens chez l'enfant PC marchant ou déambulant

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Abstract

Background. – In children with cerebral palsy, spinal equilibrium and pelvic strategies may vary according to the functional status.
Objectives. – To study the relationship between motor function and pelvic and spinal parameters in a population of children and adolescents with cerebral palsy (rated from level I to level IV on Gross Motor Function Classification System [GMFCS]). A sagittal X-ray of the spine in the standing position was analyzed with Optispine® software.
Results. – The study population comprised 114 children and adolescents (mean [range] age: 12.35 [4–17]). For the study population as a whole, there were significant overall correlations between the GMFCS level on one hand and pelvic incidence and pelvic tilt (PT) on the other ($P = 0.013$ and 0.021, respectively).
Discussion. – Pelvic parameters vary according to the GMFCS level but do not appear to affect spinal curvature. The sacrum is positioned in front of the head of the femur (i.e. negative PT) in GMFCS level I and progressively moves backwards (i.e. positive PT) in GMFCS levels II, III and IV.
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Keywords: Cerebral palsy; Spinal equilibrium; GMFCS; Pelvic incidence; Pelvic tilt

Résumé

Introduction. – Cette étude s'intéresse à l'équilibre rachidien et aux stratégies développées au niveau pelvien en fonction du statut fonctionnel de l'enfant paralysé cérébral.
Background. – L'évaluation clinique du patient paralysé cérébral (PC) marchant ou déambulant est basée sur l'examen neuro-moteur et l'utilisation d'échelle fonctionnelle comme la Gross Motor Function Classification System (GMFCS) ; l'évaluation paraclinique comporte des radiographies du rachis et du bassin effectuées debout et mesurées en impliquant la forme du bassin établie par l'incidence pelvienne (IP). Comme pour la population asymptomatique, les courbures rachidiennes de profil, en particulier, lordose lombaire et cyphose thoracique, sont directement sous la dépendance du paramètre IP.
Objectifs. – L'objectif principal de cette étude est de montrer si la forme du bassin évaluée par l'incidence pelvienne varie en fonction du statut fonctionnel établi par la GMFCS ; l'objectif secondaire est de mettre en évidence une relation entre la fonction motrice et les paramètres pelviens et rachidiens chez une population PC marchante de niveau I à IV sur la Gross Motor Function Classification System (GMFCS). Étude réalisée à partir d'une radiographie du rachis de profil réalisée en position debout et analysée par le logiciel Optispine®.

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Résultats. – Nos résultats portent sur 114 patients dont la moyenne d'âge est de 12,35 (4–17). Il existe une corrélation significative entre la GMFCS et l'incidence pelvienne (IP) ($p = 0{,}013$) et entre la GMFCS et la version pelvienne (VP) ($p = 0{,}021$) pour l'ensemble de la population PC étudiée.

Discussion. – Ce travail montre une adaptation des paramètres pelviens en fonction de la GMFCS sans que l'on puisse démontrer de réelles répercussions sur l'amplitude des courbures rachidiennes sus-jacentes. La version pelvienne s'ajusterait en fonction de la GMFCS, évoluant d'une position du sacrum en avant des têtes fémorales (côté négativement) pour la GMFCS de niveau I vers un sacrum qui va progressivement passer en arrière des têtes fémorales (côté positivement) pour les GMFCS de niveau II, III, IV.

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Mots clés : Paralysie cérébrale ; Équilibre rachidien ; GMFCS ; Incidence pelvienne ; Version pelvienne

1. English version

1.1. Introduction

Cerebral palsy (CP) is a disorder of movement, muscle tone or posture that is caused by non-progressive insult to the immature or developing brain [1]. These disorders are considered to be permanent but their clinical expression may change over time (particularly during growth phases).

In France, the prevalence of CP (2 per 1000) has been relatively stable since the 1990s. There were 1600 new cases in France in 2009 [2,3].

Researchers have developed a number of gait-based motor function classifications for (mainly diplegic) patients with CP. In 1987, Winters et al. [4] described four gait patterns in spastic hemiplegia (drop foot, true equinus, jump gait and jump gait with rotational disorders). In 1993, Sutherland and Davids described four types of gait abnormality in spastic diplegia as a function of the knee's position in the sagittal plan (jump knee, crouch knee, recurvatum knee, and stiff knee) [5]. Rodda and Graham [6,7] developed a management algorithm for each gait pattern in spastic hemiplegia and diplegia. Their kinematic analysis encompassed the ankle, knee, hip and pelvis and showed that movements of the pelvis in the sagittal plane varied according to the type of gait performed by the patient with CP. The pelvis was tilted forward in true equinus and then moved progressively to a neutral position or even a rearward tilt in crouch knee gait.

Clinical and radiological evaluation of the spine in children with CP is part of the overall assessment of neuromuscular and balance abilities during the growth period. Analysis of a sagittal plane X-ray of the spine in the standing position is based on now internationally renowned research (on healthy individuals) by Legaye and Duval-Beaupere [8], who studied the relationship between the shape of the pelvic bones (as measured by the pelvic incidence [PI]) and the amplitude of lumbar lordosis and overall spinal curvature [9]. Pelvic incidence is a geometric pelvic shape parameter that is measured on a sagittal X-ray of the spine-pelvis-femur complex. The final PI value is not established until the end of the growth period in childhood [10] and is specific for each individual. This shape parameter corresponds to the algebraic sum of two position parameters: the sacral slope (SS) and pelvic tilt (PT). Subsequently, many researchers [11–14] have studied PI in their analyses of the sagittal plane (particularly in patients suffering from lower back pain). We consider that in CP, it is important to supplement clinical assessments [1] and paraclinical evaluations [15] (e.g. quantitative gait analysis [QGA]) with regular, codified examinations of the spine as the child grows. This follow-up must be based on the latest knowledge about spinal equilibrium from sagittal plane X-rays in healthy subjects [16], with a view to understanding the vertebral column's behaviour in growing patients with CP and the disease's possible impact on the spine. In the future, the Spinal Alignment and Range of Motion Measure will provide reproducible, validated clinical data [17] on spinal equilibrium (in the sitting position) in children with CP [18]. In a previous study [19], we showed that a population of patients with CP did not differ significantly from a healthy population in terms of the PI (as measured on a sagittal X-ray in the standing position). We therefore concluded that lumbar lordosis in an adolescent with CP was not correlated with the PI [10,20] but resulted from the disease (e.g. due to tendon/muscle retractions of the psoas or spinal muscles or to weakness of the buttock muscles). We considered that spinal assessment and early treatment in children with CP could limit balance disorders that would otherwise perturb gait abilities.

The objective of the present study was to exploit the latest knowledge on sagittal equilibrium in healthy individuals [16] and study the putative relationships between the Gross Motor Function Classification System (GMFCS) level and a number of pelvic and spinal parameters measured radiologically in a population of patients with CP [21,22]. We notably sought to establish whether the GMFCS level had an impact on the various spinal and pelvic parameters.

The present study was designed to distinguish between natural variations in spinal equilibrium in patients with CP (as measured by the PI) and the impact of the disease itself on this equilibrium.

1.2. Patients and methods

On the basis of medical records, we selected patients with CP having consulted in the same paediatric physical and rehabilitation medicine department between 2002 and 2012.

We performed a retrospective, single-centre study of clinical and X-ray data obtained in children with CP. This cross-sectional study was performed at different stages of the patients' clinical and paraclinical follow-up. The evaluations

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