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The impact of walking devices on kinematics in patients with spastic bilateral cerebral palsy

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ABSTRACT

Increased anterior pelvic and trunk tilt is a common finding in patients with bilateral cerebral palsy especially during walking with assistive devices. As previous studies demonstrate various gait alterations when using assistive devices, the assessment of surgical interventions may be biased when the patients become independent of (or dependent on) assistive devices after therapy. Furthermore, some of these patients in fact are able to walk without devices even though in daily life they prefer to use them. Consequently, for such patients the classification into GMFCS level II or III may be ambiguous. The specific aim of this study was therefore to assess the influence of the use of forearm crutches and posterior walker during walking and to set this influence in relation to outcome effects of surgical intervention studies.

26 ambulatory patients with spastic bilateral CP (GMFCS II–III) were included who underwent 3D gait analysis. All patients used forearm crutches or posterior walkers in everyday life even though they were able to walk without assistive devices for short distances.

Independent of the type of assistive devices, the patients walk on average with more anterior trunk tilt and pelvic tilt ($7^\circ \pm 6^\circ$ and $3^\circ \pm 2^\circ$) and with a maximum ankle dorsiflexion decreased by 2° ($\pm 3^\circ$) when walking with assistive devices, enhancing the mal-positioning present without device. Oppositely, the knees on average are more extended by 6° ($\pm 4^\circ$) when using the assistive devices.

These effects have to be taken into account when assessing gait patterns or when monitoring the outcome after intervention as assistive devices may partially hide or exaggerate therapeutic effects.

1. Introduction

Increased anterior pelvic and trunk tilt is a common finding in patients with bilateral cerebral palsy especially during walking with assistive devices as can be monitored by simple video observation. When assessing the gait pattern of these patients for treatment planning it turns out that a significant number of them prefer to use assistive devices even though physically they are able to undergo instrumented 3D gait analysis without assistive devices. Hence, according to the gross motor function classification system (GMFCS) [1] these patients may be either classified into level III as being dependent on assistive devices or into level II as being able to manage without.

Independent of functional classification issues, the choice of assistive devices does have an influence on the walking pattern as described e.g. by Rodda et al. [2]. It has been shown that walking with posterior walker leads typically to a more physiologic gait pattern compared to using an anterior walker since trunk and pelvic position are more upright [3–8] with the exception of a study by Bachschmidt et al. [9] who did not find any significant differences in trunk kinematics when comparing both walkers. Further, reduced hip and knee flexion are reported when walking with a posterior walker [6,7]. With respect to effects on the time-distance-parameters walking speed, cadence and step length, findings are rather inconsistent [5–7,9].

Next to these studies concentrating on the effects of the choice of specific assistive devices, surprisingly little work went into the question in how far walking aids do alter the walking pattern at all. Yepremian et al. [10] found increased pelvic tilt and decreased knee flexion with a walker compared to without. Further cadence was decreased and step length increased.

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Independent of findings about the use of specific assistive devices, it is obvious that they in general alter the biomechanics of walking. Assistive devices introduce additional ground contacts and hence increase the base of support but also raise the control demand on trunk and arms.

When monitoring walking ability and gait patterns via instrumented 3D gait analysis, the use of assistive devices compromises the assessment especially in such cases where assistive devices are intermittently used and the classification into either GMFCS level II or III is difficult. This classification problem may also bias results of clinical intervention studies especially when patients become independent (or dependent) on assistive devices after therapy or when the choice of assistive devices alters.

The goals of this paper are therefore

1. to describe differences in kinematics during walking with and without assistive devices,
2. to further monitor differences between forearm crutches and posterior walker, and
3. to set these differences in context to findings in the literature concerning (a) the overall gait deviations in cerebral palsy and (b) to effects on gait attributed to surgical intervention in patients with cerebral palsy.

2. Materials and methods

26 ambulatory patients with spastic bilateral cerebral palsy (CP) were retrospectively selected from our gait laboratory database that could either be classified as GMFCS II or III. 17 of these patients (aged 18 ± 6 years) preferred to use forearm crutches (crutch group, CG) whereas 9 patients (aged 13 ± 3 years) preferred a posterior walker (walker-group, WG) in their everyday life, respectively. The data of 25 normally developing subjects (aged 11 ± 5 years) were chosen of our gait laboratory database for reference.

During the years 2001–2013, all 26 selected patients underwent conventional instrumented 3D gait analysis both with and without assistive devices on the same day as their GMFCS classification (GMFCS II vs. III) was ambivalent. They all used their preferred assistive device, i.e. 17 used forearm crutches (CG) and 9 patients used a posterior walker (WG). A standardised video was captured and 3D gait analysis was performed according to Kadaba et al. [11] with commercial software (Vicon, Oxford, United Kingdom) to monitor the lower limb kinematics. Additionally, markers on the shoulder girdle were used to analyse trunk motion in relation to the global reference frame as described by Wolf et al. [12]. All participants walked barefoot along a 7 m-walkway with self-selected speed.

The statistical analysis was performed across all subjects (CG and WG) to find out the differences between walking with and without assistive devices. To further identify differences due to the choice of assistive devices a group analysis was performed. Only left sides were considered for analysis. Average kinematics across a minimum of five strides of different trials was calculated and mean, minimum or maximum values and/or joint ranges of motion were analysed. Paired *t*-tests were performed regarding the kinematics of trunk, pelvis, hip, knee, and ankle as well as on time–distance-parameters to detect differences between walking with and without assistive devices, irrespective of the type of the assistive device, i.e. walking devices are grouped together. To determine differences due to the choice of assistive devices,

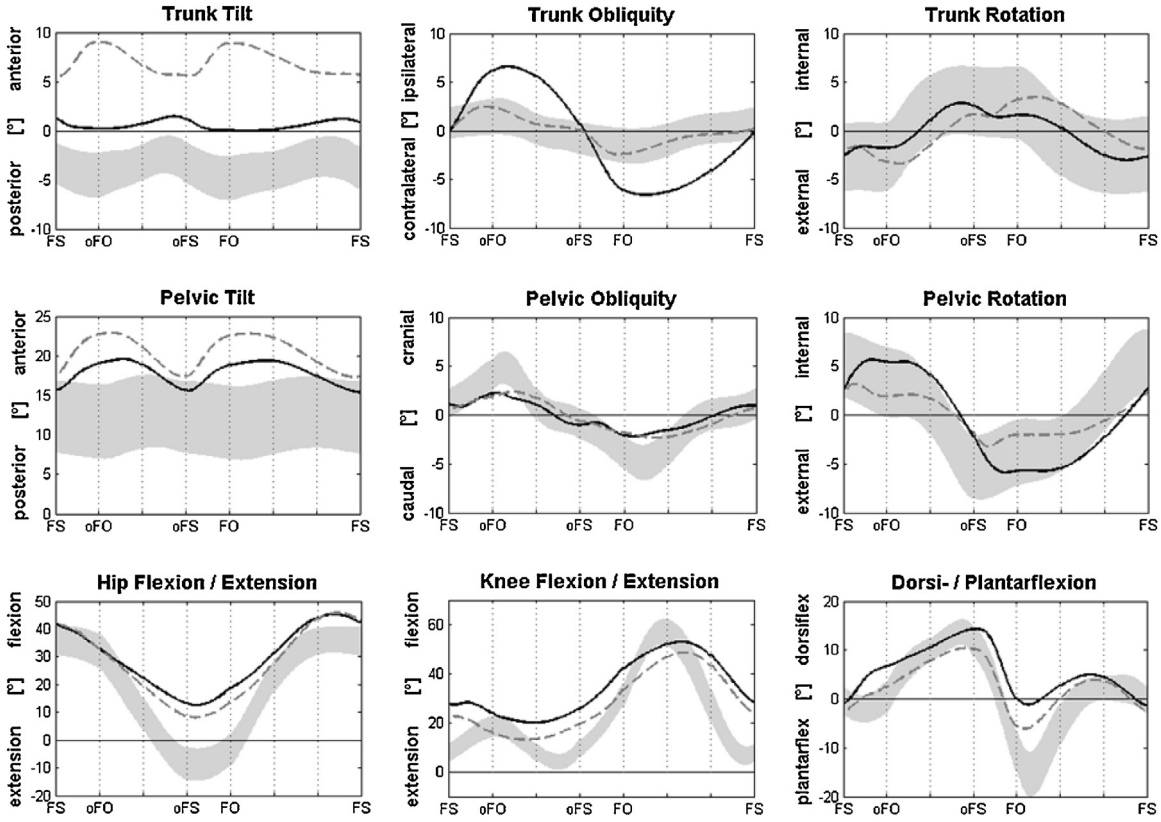

Fig. 1. Average kinematics when walking with (dashed grey line) or without (solid black line) assistive devices (crutches and posterior walker in one group). FS, foot strike; oFO, opposite foot off; oFS, opposite foot strike; FO, foot off. Grey bands: control subjects.