RUNNING IN CHILDREN WITH HEMIPLEGIA USING A NEW POSTERIOR LEAF ANKLE FOOT ORTHOSIS

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Introduction

Cerebral palsy involves muscle weakness and spasticity that cause alteration in gait and running cycle [1]. These difficulties are usually overcome by using orthoses, in particular ankle-foot orthoses (AFOs). However, the existing AFOs are unsuitable for sport or running practice both from a design point of view and for prescription of use. Therefore, the aim of this study was to compare the kinematics, kinetics, and spatiotemporal parameters during running with a new AFO specifically designed for sport activities versus barefoot condition.

Methods

Eighteen children with a diagnosis of hemiplegia (GMFCS I-II) were recruited at IRCCS Eugenio Medea and experiments were conducted with the approval of its Ethical Committee. Each participant was provided with a custom made AFO (an evolution of the Carbon Modular Orthosis [2]), specifically designed by ITOP Officine Ortopediche SpA to support motor activities.

Running was evaluated in three conditions, at self-selected speed: (i) barefoot; (ii) upon delivery of the AFO (t0); (iii) after an adaptation period of approximately one month (t1).

Data acquisition was performed through eight-camera optoelectronic system (BTS Smart DX 700) and four coupled force platforms (BTS P-6000) using Davis protocol.

For each participant only one valid trial for each lower limb for each condition was chosen. Kinematic and kinetic data were processed using an ad hoc script in Matlab®; SPM was used to detected statistical differences among the conditions. A non-parametric bivariate ANOVA (α = 0.05) was implemented (an independent factor, affected vs non-affected limb, plus a repeated-measures factor, barefoot vs with orthosis) followed by Mann-Whitney post hoc tests. The spatio-temporal parameters were instead analysed thanks to Minitab software, through which a 3x2 ANOVA (α = 0.05) with Tukey's post hoc test was carried out.

Results

Figure 1 shows the affected ankle dorsi-plantarflexion in the running cycle in the three tested conditions (barefoot in black, with the new AFO at t0 in green and at t1 in blue).

Table 1 shows the effects of the new AFO on running spatio-temporal parameters: stride length, stride duration, speed, step length and cadence.

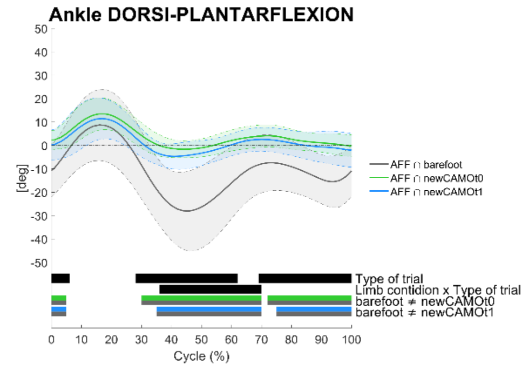

Figure 1: The affected side ankle dorsi-plantarflexion with the respective SPM analysis.

	barefoot	newAFO t0	newAFO t1
Stride length (m)	1.61 (0.28)	1.67 (0.26)	1.81 (0.30)
Stride duration (s)	0.55 (0.06)[1]	0.60 (0.05)[1]	0.59 (0.06)
Speed (m/s)	3.0 (0.53)	2.8 (0.44)	3.2 (0.53)
Step length (m)	0.78 (0.12)	0.81 (0.14)	0.87 (0.13)
Cadence (steps/min)	226 (22)[1,2]	203 (20)[1]	209 (19)[2]

Table 1: Mean and (standard deviation) of listed spatio-temporal parameters for the affected side. [1]p < 0.05 between barefoot and newAFO t0. [2]p < 0.05 between barefoot and newAFO t1.

Discussion

During barefoot trials the recruited participants shown the equinus foot deviation, a prolonged plantarflexion during the entire cycle (Figure 1) and a power generation capacity at push-off 60% lower than physiological. The new AFO proved to be effective in correcting the foot position at initial contact (0-5%, $p < 0.001$) and to significantly reduce ankle plantarflexion throughout the running cycle (30-100%, $p < 0.001$); however was not able to decrease the deficit at push-off, but rather left it unchanged. The new AFO lead to an increase in stride length and duration, running speed, step length and to a decrease in cadence (Table 1). The elapse of an adaptation period did not seem to have significant effects on kinematics and kinetics; on the other hand, it contributed to increasing stride length, running speed and step length.

References

1. Rethwilm et al., Gait Posture, 84:329–334,2021
2. Tavernese et al., NeuroRehabilitation, 40(3):447–457,2017