A tensegrity-based soft exoskeleton improves the postural stability of children with cerebral palsy

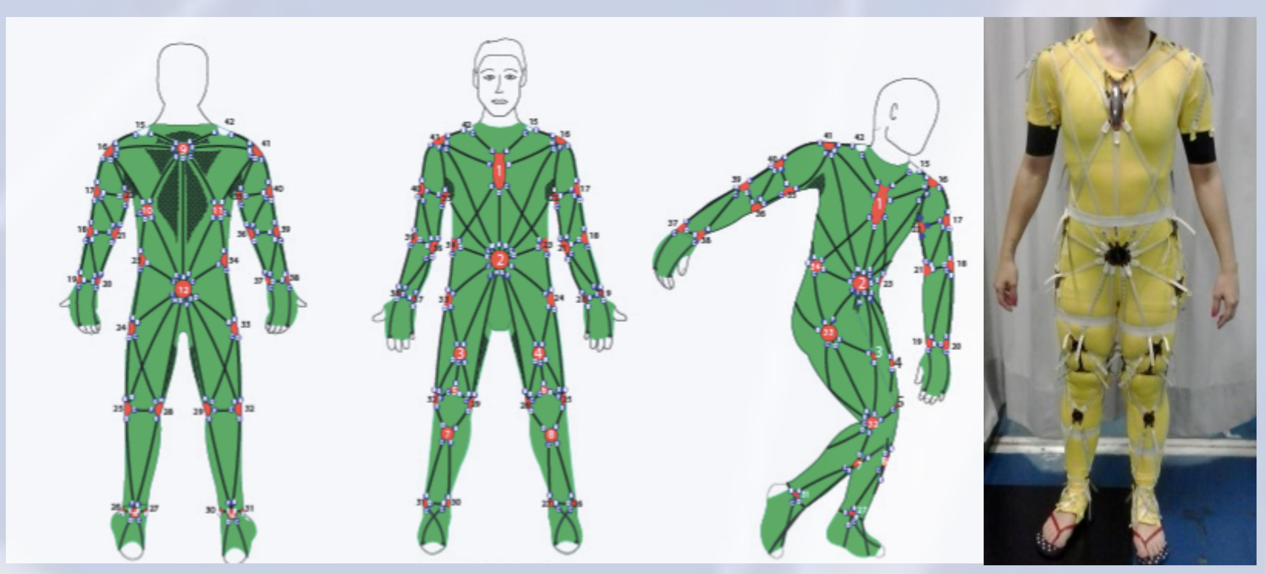
Sergio T Fonseca*, Marisa C Mancini*, Emmanuelle B Rodriguez, Juliana M Ocarino*, Paula M M Arantes, Thales R Souza*

* Graduate Program in Rehabilitation Sciences, Universidade Federal de Minas Gerais, Brazil

Introduction

Interventions in rehabilitation have been designed with the goal of minimizing impairments that alter the posture and movement of children with cerebral palsy (CP). A flexible exoskeleton, inspired on the fascial organization of the human body (Figure 1), was developed with the objective to provide extra support to the musculoskeletal system. The exoskeleton is based on the concept of tensegrity [1] and follows the architecture of the muscles and fascial connections. We evaluated the effects of the tensegrity-based exoskeleton (TBE) on the postural stability of children with normal development (ND) and with CP.

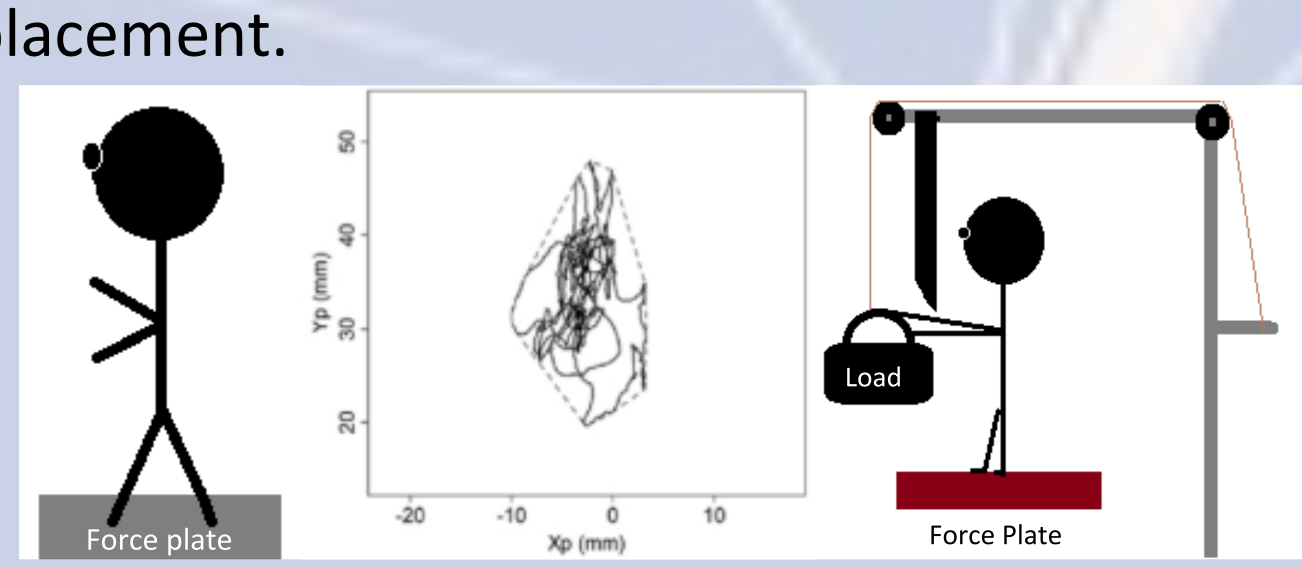
Figure 1



Methods

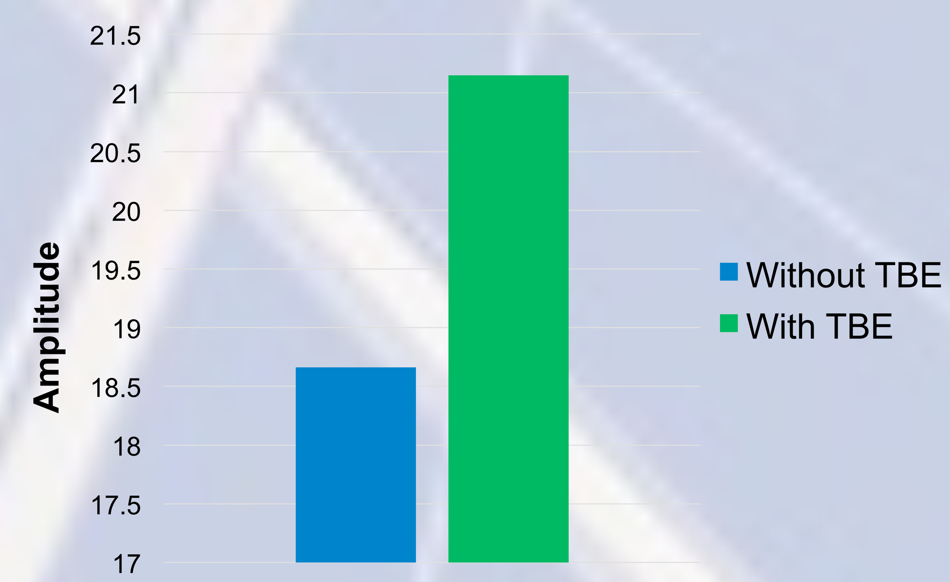
Ten children with ND and 10 children with unilateral CP, ages 7-12 years, matched by sex and age were tested with the TBE and with a placebo body suit, on the following experimental situations: (1) static maintenance of posture and (2) maintenance of posture in response to perturbation (Figure 2). Postural stability was evaluated by means of the oscillations of the center of pressure (CoP). Postural perturbation was produced by the release of a load (5% of the body mass) that was supported by children's upper limbs. Mixed ANOVAs for the antero-posterior axis (y), under the static and post-perturbation situations, tested group (CP, ND), suit (TBE, placebo) and interaction effects on: amplitude, velocity, total displacement and root mean square (RMS) of the CoP displacement.

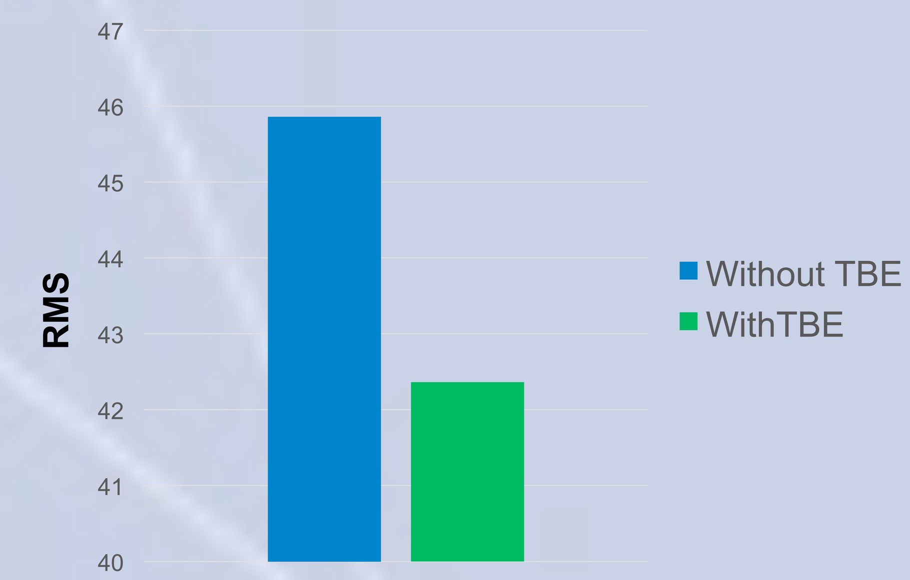
Figure 2



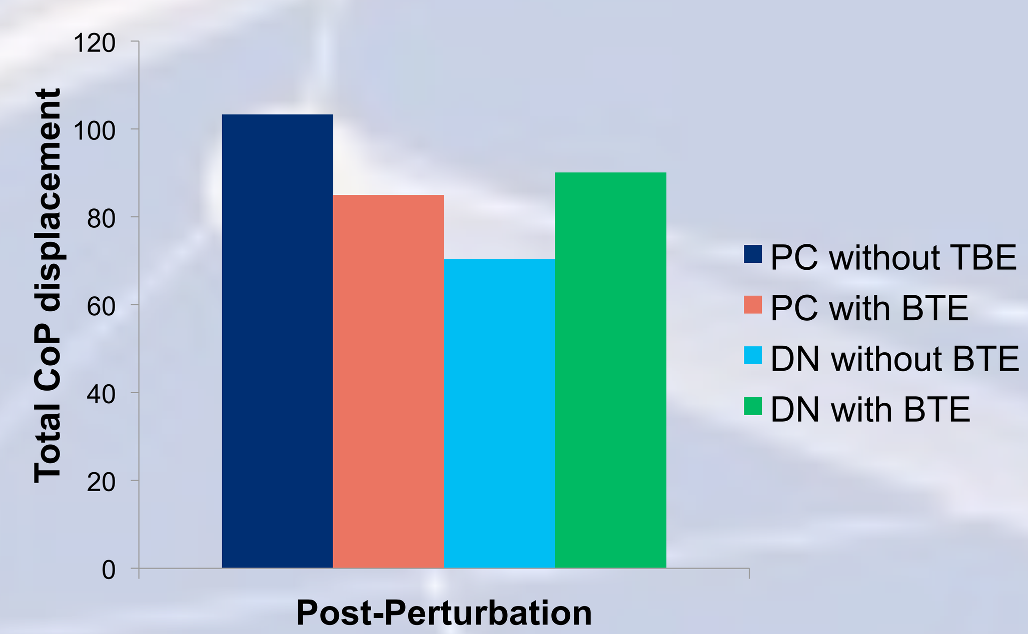
Results

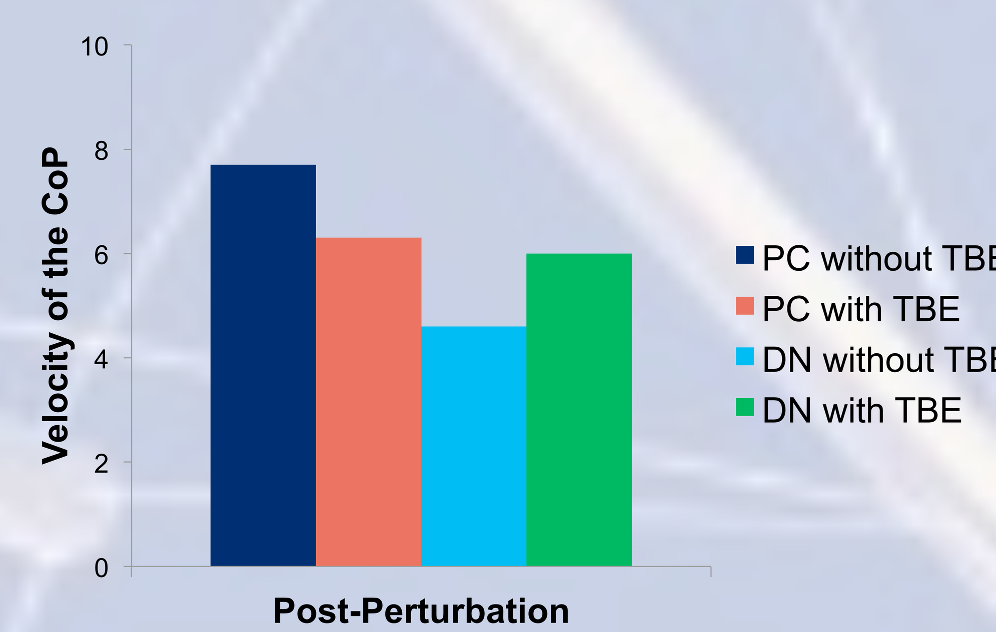
For the static situation, results revealed only suit effects. The use of the TBE increased the amplitude of oscillation (*p=0,018; η^2=0,272; power=0,689*), but marginally reduced CoP displacement RMS (*p=0,055; η^2=0,189; power=0,492*). No other effect was found.





Post-perturbation results revealed suit-related effects only for the velocity of the CoP displacement (*p=0,044)* and for total CoP displacement (*p=0,025)*. No other effect involving the use of the exoskeleton was observed in the other dependent variables. Contrasts showed that the exoskeleton affected distinctly the two groups. While children with CP decreased their COP velocity and displacement after perturbation, children with ND increased on these variables. The behavior of the groups was not different, when using the TBE.





Conclusion

The TBE allowed increased amplitude of oscillation, but with reduced oscillation around its mean. After perturbation, children with CP converged their behavior to that of children with ND. These results suggest that the improved postural stability was not due to mechanical restrictions provided by the exoskeleton. As the human fascia, the TBE was capable to provide proper support without restricting the children's movement capability.

Reference

1 - Turvey MT, Fonseca ST. The Medium of Haptic Perception: A Tensegrity Hypothesis. *Journal of Motor Behavior*, 46:3, 143-187, 2014.

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