Weight-bearing evaluation of non-ambulant children using assistive standing devices: a pilot study

Miray Kirollos[1], Angela Kedgley[1]
[1]Department of Bioengineering, Imperial College London, London, United Kingdom
Email: miray.kirollos22@imperial.ac.uk

Summary

Standing devices are used as part of therapy regimens for non-ambulant children with neurodisability (ND) to load their lower limbs. This study investigated the efficacy of these devices in facilitating weight-bearing. Pressure insoles were used to measure vertical ground reaction forces (vGRF) of children in static and dynamic devices. The dynamic device did not reflect forces of typical gait and resulted in lower loading than static devices for most participants. Dynamic standing devices may not result in higher loading than static.

Introduction

ND represents the leading source of disability in the UK, impacting 3-4% of children [1]. Muscle stresses and atypical motion result in decreased ambulation, leading to low bone mineral density and fragility fractures. 21-26% of children with ND experience fractures, over 70% of which occur in the lower limbs [2]. Standing devices enable assisted weight-bearing, which should increase loading of the lower limb bones, promoting bone strength and decreasing fracture risk. Dynamic (gait) weight-bearing provides more loading than static in typically developing (TD) children, suggesting similar benefits for children with ND [3]. Hence, cyclical dynamic standing devices were developed. However, dynamic device weight-bearing is unquantified, and static device efficacy remains unclear. The aim was to evaluate weight-bearing associated with standing device use.

Methods

Participants comprised five non-ambulant children with ND (age: 10±3.8 years, sex: three males and two females, muscle tone: two hypertone and three hypotone) and one TD child (4 years, male, normal muscle tone). vGRFs were collected using portable pressure shoe insoles (Pedar, Novel.de). Participants were positioned for five minutes in each static (prone, upright, supine; Leckey and Jenx) and dynamic (Innowalk Pro, Made for Movement) device based on their tolerance. The TD child also performed free standing and walking and one ND child walked assisted by a walking aid. vGRF was quantified as a percent of body weight (% BW).

Results and Discussion

vGRF for participants with ND was lower in all static devices compared to the TD participant (Figure 1). Due to poor head control or unfamiliarity to devices, participants with ND could only stand in one static device, but all could use the dynamic. For the TD participant the upright static device resulted in the greatest vGRF, approximately 10 times higher than the mean vGRF in the dynamic device. This could be due to less support from device surfaces and straps, and a more aligned position. The mean vGRF were 9, 8 and 1.5 times higher in the prone stander than the dynamic stander for the TD, hypertone 1 and hypotone 2 participants, respectively. A greater mean vGRF in the dynamic than the supine stander for the hypotone 1 participant might be caused by greater reliance on the support surfaces of the supine stander. The loading pattern produced by the dynamic device was not gait-like [4] and vGRFs in the device did not reflect those of walking (Figure 2).

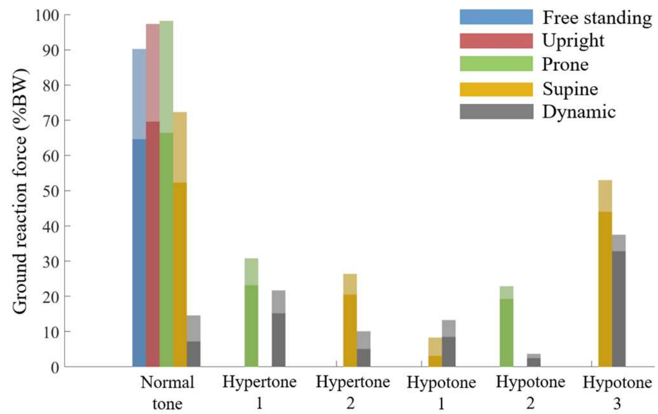

Figure 1: Mean (solid) and maximum (shaded) vGRF (%BW).

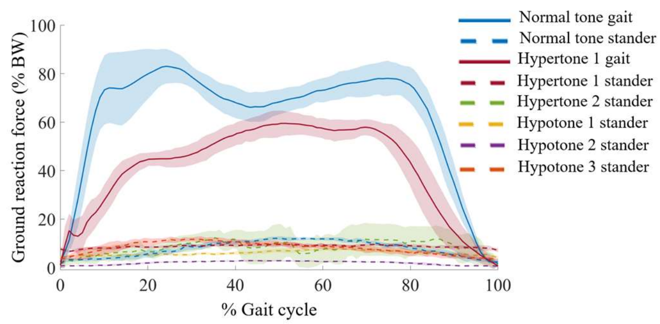

Figure 2: Mean stance curves with standard deviations;10 cycles for right foot of gait (solid) and dynamic stander (dotted).

Conclusions

While confirmation on a larger population is required, this study has shown that weight-bearing outcomes differ between standing devices, with dynamic devices not providing greater weight-bearing than static. Further research may explore design modifications to potentially improve weight-bearing.

Acknowledgments

This work was supported by Imperial College London and Orthopaedic Research UK.

References

[1] Amanda A et al. (2014). *BMJ Open*, **4**: e004611.
[2] Henderson RC et al. (2002). *Pediatrics*, **110**: e5.
[3] Zacharin M (2004). *Curr Opin Pediatr*., **16**: 545-551.
[4] Pekanovic A et al. (2022). *J Rehabil Med*., **54**: jrm00284.