Effects of virtual reality and virtual heights on motor control during walking in children with and without cerebral palsy

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Summary

This study investigated how motor control changes when walking in virtual reality (VR) and at virtual heights in children with cerebral palsy (CP) and with typical development (TD). Motor control complexity was unchanged with VR, while virtual heights lead to a simplification of motor control - with different effects between CP and TD for high VR heights.

Introduction

Children with CP have limited motor control and walking ability. VR is increasingly used to support neurotherapy in CP [1]. Understanding the adaptability of motor control may help to improve therapy. We investigated changes in motor control during walking in response to VR and virtual heights in children with CP and typically developing children TD.

Methods

Twenty-two CP children (11.2±2.2 years, m/f 13/9; GMFCS I/II) and age-matched TD children (11.9±2.9 years; m/f 10/14) walked barefoot in the real world (RW) and in VR over a plank at 0, 5, 10m height (fig. 1), while electromyography (EMG) of 6 leg muscles was recorded. EMG data were filtered, rectified, smoothened, time-normalized to gait cycle (GC) and amplitude-normalized to maximum GC activation. The VR conditions were displayed through a headset (MetaQuest2) and randomized. For motor control complexity, the variance accounted for one synergy (VAF1) per gait cycle was extracted. The effect of VR and VR heights on VAF1 was tested using two linear mixed effect models including legs of groups (affected and unaffected leg CP, random leg TD), the worlds (RW, VR 0m) and heights (0, 5, 10m) ($p<.05$).

VR: VAF1 ~ legs + worlds + legs : worlds + (1|subject)
Heights: VAF1 ~ legs + heights + legs : heights + (1|subject)

Results and Discussion

In line with previous studies [2], the affected leg in CP showed reduced motor control complexity, which was unchanged with VR as in TD. This highlights the potential of a virtual environment to study children with CP in a controlled VR setting while applying different challenges. While it appears that VR height exposure resulted in simplified motor control (fig. 2), the change in motor control associated with high height exposure (10m) was different between CP and TD, although only significant for the unaffected leg. This may indicate a reduced ability to adapt to virtual heights in CP and an affection of the motor control system also on this body side, where crossing of motor tract fibers [3] may lead to disturbed or altered motor response and control ability.

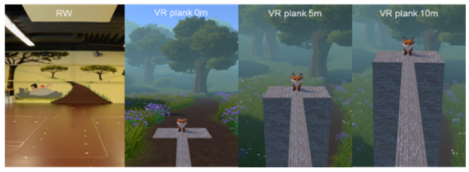
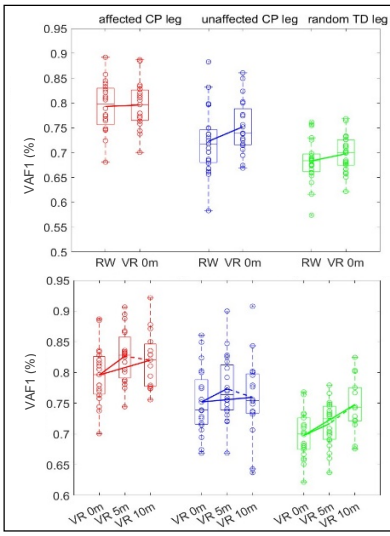


Figure 1: Walking conditions; virtual plank: 5m long x 30cm wide.



Term	VAF1 (%)
Effect of VR	
Intercept	**68.2***
affected CP	**10.9***
non-affected CP	3.9
VR 0m	1.5
affected CP : VR 0m	-1.2
non-affected CP : VR 0m	1.4
Effect of VR height	
Intercept	**69.7***
CP affected	**9.9***
CP non-affected	**5.4***
VR 5m	1.7
VR 10m	**4.8***
CP affected : VR 5m	1.3
CP non-affected : VR 5m	0.4
CP affected : VR 10m	-2.6
CP non-affected : VR 10m	**-4.3***

* significant effect p≤.05

Figure 2: VAF1 of legs in world (top) and VR height conditions (bottom) and model results (right)

Conclusions

Walking in VR has no effect on motor control complexity, providing potential for therapy. However, children with CP may have a reduced ability to adapt their motor control to VR challenges.

Acknowledgments

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References

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