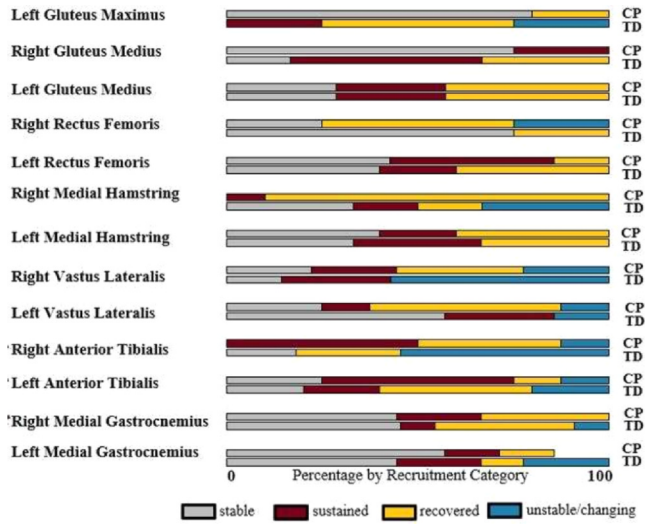
Figure 1: Post-Exercise Recruitment Category Percentages by Individual Muscles and Group



Discussion

Both groups exhibited signs of fatigability as measured by MF in individual muscles immediately after an intense progressive exercise task. Sustained fatigability was more prevalent in youth with CP The magnitude of fatigue of individual muscles in the initial post-exercise epoch appears to influence the time needed for recovery. Distal muscles tended to exhibit less recovery. Further study is needed to understand the impact on rehabilitation protocols.

References

1. Verschuren O et al. 2022 Dev Med Child Neurol doi: 10.1111/dmcn.15421
2. Brunton LK. 2021. Ann Rehabil Med 45:197-203. doi: 10.5535/arm.20250
3. Boyer ER et al. 2022 Dev Med Child Neurol 64:379-386. doi: 10.1111/dmcn.15054
4. Ettema S et al. 2022 Gait Posture 93:7-13. doi: 10.1016/j.gaitpost.2022.01.004.
5. Moll I et al. 2022 PLoS One 17(12):e0278657. doi: 10.1371/journal.pone.0278657
6. Stout J et al. 2019 Gait Posture 73:252-253.

https://doi.org/10.1016/j.gaitpost.2025.07.253

Combining immobilization and activity to influence calf muscle morphology in children with cerebral palsy: Randomized controlled trial using 3D ultrasound

Martin Švehlík *[1], Annika Kruse [2], Bernhard Guggenberger [1], Markus Tilp [2], Nina Mosser [2], Tanja Kraus [1], Hans Kainz [3], Andreas Habersack [1]

[1] *Medical University of Graz, Paediatric orthopaedics-Department of Orthopaedics and Trauma, Graz, Austria*
[2] *University of Graz, Department of Human Movement Science-Sport and Health, Graz, Austria*
[3] *University of Vienna, Department of Biomechanics- Kinesiology and Computer Science in Sport, Vienna, Austria*

Introduction

Children with cerebral palsy (CP) frequently develop muscle contractures due to neuromuscular impairments and altered musculoskeletal morphology [1,2]. Orthotic treatment using ankle-foot orthoses (AFOs) worn for extended periods is commonly used to apply sustained stretch to the spastic calf muscles [3]. While this strategy may promote muscle lengthening, prolonged immobilization can also contribute to muscle atrophy and reduced fascicle length due to disuse [4].

Research Question

Does orthotic treatment regime combining immobilization using AFO with daily phases of permitted activity lead to a superior effect on spastic calf muscle morphology and function compared to continuous AFO immobilization?

Methods

Fourteen ambulant children with CP and equinus deformity (8 unilateral, 6 bilateral; mean age 9.93 ± 3.0 years; GMFCS level I = 10, level II = 4) participated in this randomized controlled trial. Participants were assigned to either a control group treated with AFOs for 23 h/day or an intervention group using the same AFOs at night and for 6 hours during the day, combined with a foot stabilizing orthosis 10 h/day to allow ankle mobility. The 8 weeks control phase, 8 weeks intervention with 4 weeks of follow-up were assessed at four time points (familirarization (week 0)/pre-intervention (week 8)/post-intervention (week 16)/follow-up (week 20)) using a 3D ultrasound imaging technique and dynamometry [5]. Ankle joint function, isometric muscle strength, and muscle-tendon properties of the gastrocnemius medialis (GM) muscle-tendon unit (MTU) (e.g., muscle belly and tendon lengths, fascicle lengths, muscle thickness and volume, tissue length changes) were assessed at each time point. We used repeated measures ANOVA for statistical analysis.

Results

Within the intervention group, significant increases were observed in normalized MTU length at 0 Nm ($p = 0.032$, $\eta^2 = 0.446$) and 4 Nm ($p < 0.001$, $\eta^2 = 0.611$), as well as in tendon length at both 0 Nm ($p = 0.041$, $\eta^2 = 0.319$) and 4 Nm ($p = 0.014$, $\eta^2 = 0.389$). However, no significant group × time interaction effects were found for any parameter.

Discussion

Although time-dependent improvements in selected morphological parameters (e.g. MTU length) were observed in both groups, there was no statistically significant interaction effect indicating that the addition of daytime activity would result in superior outcomes compared to continuous immobilization only. On the other hand, these findings suggest that prolonged immobilization may not be essential to achieve structural adaptations in spastic muscle. Allowing periods of mobility and calf muscle strengthening could reduce disuse-related effects and support more individualized and potentially more tolerable orthotic treatment approaches [6]. Further research with larger sample sizes is warranted to evaluate long-term functional implications and to optimize orthotic strategies in children with cerebral palsy.

References

[1] M. Hösl, A. Kruse, M. Tilp, M. Svehlik, H. Böhm, A. Zehentbauer, A. Arampatzis, Impact of altered gastrocnemius morphometrics and fascicle behavior on walking patterns in children with spastic cerebral palsy, Front. Physiol. 11 (2020) 518134. https://doi.org/10.3389/fphys.2020.518134.

[2] M.A. Mathewson, S.R. Ward, H.G. Chambers, R.L. Lieber, High-resolution muscle measurements provide insights into equinus contractures in patients with cerebral palsy, J. Orthop. Res. 33 (2015) 33–39. https://doi.org/10.1002/jor.22717.

[3] H.K. Graham, P. Rosenbaum, N. Paneth, B. Dan, J.P. Lin, D.L. Damiano, et al., Cerebral palsy, Nat. Rev. Dis. Primers. 2 (2016) 15082. https://doi.org/10.1038/nrdp.2015.82.

[4] M. Hösl, H. Bohm, A. Arampatzis, L. Doderlein, Effects of ankle-foot braces on medial gastrocnemius morphometrics and gait in children with cerebral palsy, J. Child Orthop. 9 (2015) 209–219. https://doi.org/10.1007/s11832-015-0664-x.

[5] A. Habersack, M. Svehlik, B. Guggenberger, M. Tilp, A. Kruse, Gastrocnemius medialis and Achilles tendon properties do not differ between children with unilateral or bilateral spastic cerebral palsy, J. Biomech. 166 (2024) 112041. https://doi.org/10.1016/j.jbiomech.2024.112041.

[6] B.M. Kalkman, L. Bar-On, T.D. O'Brien, C.N. Maganaris, Stretching interventions in children with cerebral palsy: Why are they ineffective in improving muscle function and how can we better their outcome?, Front. Physiol. 11 (2020) 131. https://doi.org/10.3389/fphys.2020.00131.

https://doi.org/10.1016/j.gaitpost.2025.07.254

The effects of a prosthetic walking practice using virtual reality on gait kinematics: A pilot study

Ryoya Takaue *[1], Satoshi Arima [1], Tsubasa Tashiro [1], Takumi Nagao [1], Yuki Tamura [1], Tatsuyoshi Hara [1], Noriaki Maeda [1]

[1] *Hiroshima University, Graduate School of Health Sciences, Hiroshima, Japan*

Introduction

Prosthetic limbs play a crucial role in preserving the mobility and quality of life among individuals with lower limb amputations [1]. Recent advancements suggest that virtual reality (VR)-based training using simulated transfemoral prostheses may outperform conventional rehabilitation in promoting motor learning and symmetry [2]. However, the biomechanical effects of VR-assisted prosthetic gait training remain unexplored. This pilot study employed three-dimensional (3D) motion analysis to examine the impact of VR-based simulated prosthetic walking on gait kinematics and kinetics.

Research Question

How do VR-assisted simulated prosthetic walking influence joint angles and ground reaction forces during gait?

Methods

Six healthy adults (four men and two women) with no experience of using simulated prostheses were recruited. A transfemoral prosthesis featuring a 3R80 knee joint (Ottobock, Japan) was used on the right leg to simulate amputation. Participants were randomly assigned to either the VR group (n = 3) or the control group (n = 3), each comprising two men and one woman. Both groups performed five minutes of in-place stepping training twice with parallel bars. The VR group viewed a first-person walking video using a head-mounted display, whereas the control group practiced the video without any visual input. Gait performance was evaluated using the 10-meter walk test, administered immediately before and after the training. Motion data were captured using a 3D motion analysis system (Vicon, UK) equipped with 10 infrared cameras. One gait cycle per participant was analyzed to calculate the stride length (normalized to the lower limb length), prosthetic-side hip joint angle, pelvic rotation, and vertical ground reaction force (vGRF) on both sides. Due to the small sample size, the outcomes were descriptively compared using graphical analysis.

Results

After training, both groups showed an increased walking speed. The VR group demonstrated a more pronounced improvement in stride length. Additionally, only the VR group exhibited increased prosthetic-side hip flexion from late swing to early stance, along with greater leftward pelvic rotation during the swing phase. Early stance vGRF increased bilaterally in both groups, whereas only the VR group showed a further increase in late stance vGRF on the non-prosthetic side (Results).