Eight-Week Wearable Ultrasound-Imaging Visual Feedback Training Improved Gait Performance of Chronic Stroke Survivors by Inducing Muscle Adaptations at Ankle Dorsiflexor : A Randomized Controlled Trial

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BACKGROUND

- Stroke frequently causes paretic ankle dorsiflexor weakness, impairing **gait function** and increasing **fall risk.**
- A single session of **wearable ultrasound visual feedback (UVF) training** improves isometric ankle dorsiflexion strength in chronic stroke survivors; however, whether multi-session UVF training. induces dorsiflexor muscle architectural adaptations and whether these relate to gait improvement remained unclear.
- **This randomised controlled trial** examined the effects of 8-week UVF training on dorsiflexor muscle architecture and its association with spatiotemporal gait changes.

METHODS

- **Participants:** Thirty-seven community-dwelling chronic stroke survivors were randomised to an experimental (EG, n=20) or control group (CG, n=17).
- **Protocol:** Both groups performed seated isometric tibialis anterior (TA) dorsiflexion training three times weekly for eight weeks; the EG additionally received real-time UVF of TA muscle contraction via a wearable wireless ultrasound device (Fig. 1).
- **Primary outcomes:** TA fascicle length (FL), pennation angle (PA), and torque during maximal voluntary isometric contraction (MIVC) were measured via ultrasound. Spatiotemporal gait parameters were assessed during overground walking.
- **Statistical analysis:** Two-way mixed ANOVA and Pearson/Spearman correlation tests.

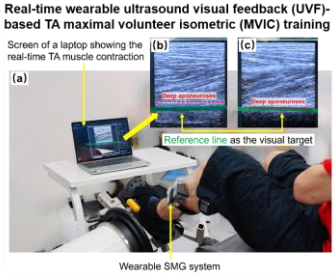

Fig 1. The UVF training setup.

ACKNOWLEDGEMENT

This work was supported by the Hong Kong Research Grants Council (RGC) - Early Career Scheme (ECS) (Reference number: 25100523).

RESULTS

- **MIVC assessment**: EG showed decreased minimum FL and increased maximum PA after training (group×time interaction, $p \leq 0.045$); CG showed no architectural changes. Torque improved in both groups (main effect of time, $p \leq 0.02$).

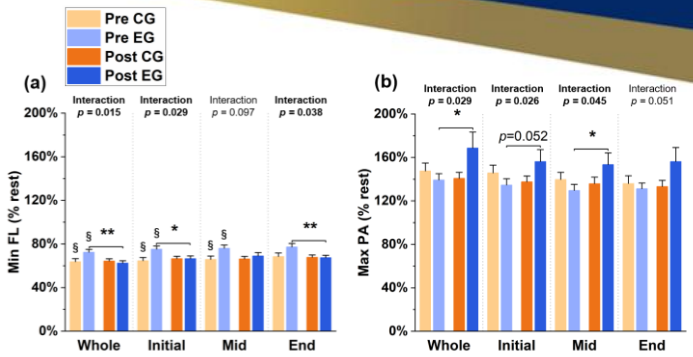

Fig 2. Changes in TA muscle architecture during MVIC test after eight weeks of training. (a) Minimum normalised fascicle length (FL) during the whole (0%-100%), initial (0%-33.3%), mid (33.4%-66.6%), and end (66.7%-100%) contraction phases**; (b)** Maximum normalised pennation angle (PA) during the whole, initial, mid, and end contraction phases.
EG, experimental group; CG, control group; Pre, pre-intervention; Post, post-intervention; FL, fascicle length; PA, pennation angle. Data: mean ± SE. §: Baseline difference. *: $p<0.05$; **: $p<0.01$.

- **Correlation**: In EG, maximal PA increases strongly correlated with faster speed (r=0.859) and shorter stride time (r=−0.766); minimal FL changes correlated with improvements in speed, cadence, step/stride time, and stride length (r=0.540–0.814, all $p<0.05$). Correlations were fewer and weaker in the CG.

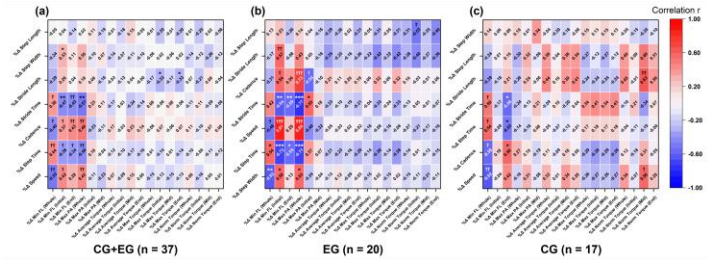

Fig 3. Heatmap matrix of correlations between changes in TA MIVC-derived outcomes and changes in spatiotemporal gait parameters. (a) Pooled sample (N=37); **(b)** Experimental group (EG, n=20); **(c)** Control group (CG, n=17).
Only MIVC variables that showed a significant ANOVA effect ($p<0.05$) were included. * Indicates a significant Pearson correlation (*: $p<0.05$; **: $p<0.01$; ***: $p<0.001$); † indicates a significant Spearman correlation (†: $p<0.05$; ††: $p<0.01$; †††: $p<0.001$).

DISCUSSION & CONCLUSION

- Eight-week UVF training induced dorsiflexor muscle architectural adaptations that were associated with spatiotemporal gait improvements.
- These findings might suggest a mechanistic link between UVF-induced muscle remodelling and functional walking gains in chronic stroke.