# Effects of body weight support on muscle synergies: identifying key transitions for neuromotor training

**Pablo Ortega-Auriol**[1], Angus J. C. McMorland[1,2], Thor Besier[1]
[1]Auckland Bioengineering Institute, University of Auckland, Auckland, New Zealand
[2]Department of Exercise Sciences, University of Auckland, Auckland, New Zealand
Email: p.ortegaauriol@auckland.ac.nz

**Summary:** We investigated how lower body positive pressure (LBPP) treadmill support influences muscle synergies in children. Gait synergies were extracted from eight lower limbs across 0–80% body weight support (BWS). As BWS increased, synergy count declined, with notable transitions near 20% and 55%. These thresholds may be optimal unloading levels for gait rehabilitation and offer potential benefits for children with neurological conditions.

**Introduction:** LBPP uses air pressure to reduce body weight during gait training. In adults, this unloading decreases the number of muscle synergies during running compared to unsupported conditions (1). However, children may exhibit distinct synergy patterns, both in number and structure, that could respond differently to LBPP (2). Although evidence is limited, identifying an optimal level of body weight support might encourage a more typical, adaptive synergy profile in rehabilitation (3), potentially benefiting children with cerebral palsy (CP). This study investigated the influence of body weight support on muscle synergies in healthy children.

**Methods:** 18 healthy children (8–15 years, mean (SD) 11.5 (2.3) years) participated, with ethical approval from HDEC (#25549). Participants walked on an LBPP treadmill (AlterG) at their self-selected speed under increasing BWS from 0% to 80%. Each condition lasted one minute or 25 gait cycles per leg. EMG signals were recorded bilaterally from 8 lower limb muscles, pre-processed (demeaning, band-pass filtering, rectification, and envelope extraction), and random gait cycles were concatenated for synergy extraction. Synergies were extracted using non-negative matrix factorisation, with the number of synergies determined by a VAF > 90% criterion for each level of BWS. Our analysis will expand on structure and activation coefficients.

**Results and Discussion**: A global linear model showed a significant overall decline in the number of synergies with increasing BWS (Fig 1, $p<0.001$, $\eta^2 = 0.29$, slope $=-0.011$, $p = 0.002$), similar to prior findings in adults (1). Post-hoc comparisons were not significant, but the largest synergy transition occurred at 20% BWS ($\Delta=0.44$), and the greatest change in synergy decline occurred at 55% BWS (Fig 2).

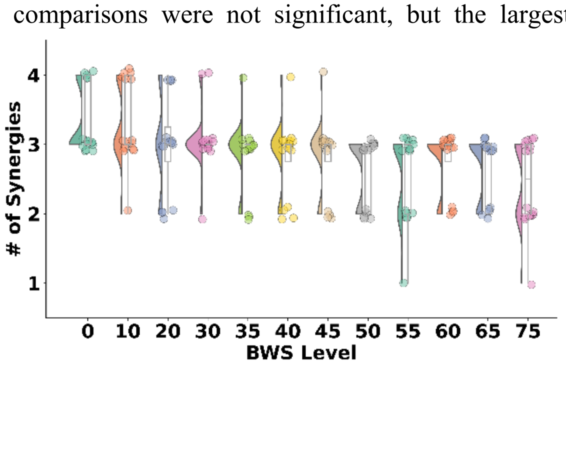


**Figure 1** | Mean synergy count decreases as BWS increases.

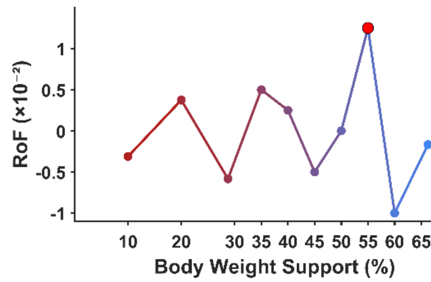


**Figure 2** | Rate of synergy change (RoF) across BWS levels. The highest change occurs around 55% BWS (red marker).

BWS reduces mechanical constraints, allowing typically developing individuals to adopt a simplified control strategy, leading to fewer synergies. The identified points at 20% and 55% may reflect transitions where those biomechanical constraints allow qualitative changes in control strategy.

In contrast, children with CP inherently use fewer synergies than typically developing children due to impaired motor function (4), and the number of synergies may increase with BWS. The identified transition points at 20% and 55% BWS could be relevant training zones for children with neurological conditions. Training at these levels could help children with CP by providing enough support to eliminate postural synergies while still requiring active neuromuscular effort, improving motor adaptability (4). By gait training, where movement can be explored with fewer physical requirements, LBPP may promote neuromuscular coordination and motor learning, potentially leading to typical gait patterns or the emergence of new synergies. Further work will explore transition points in children with cerebral palsy and investigate how synergies are influenced across BWS levels and with training in neurological populations.

**Conclusions:** LBPP reduces the number of muscle synergies that occur non-linearly across different support levels. Two transition points were identified where synergies exhibited the largest shifts, potentially guiding targeted gait rehabilitation, particularly for children with cerebral palsy.

**Acknowledgments:** Thanks to the Friedlander Foundation for supporting our research.

## References

1. Fazzari (2024). Sci Rep. 1;14:2707.
2. Bach (2021). Front Hum Neurosci;15.
3. Ebihara (2024). Front Hum Neurosci.;17.
4. Steel (2015) Dev Med & Ch Neur.;57(12).