

Results

Fig.1a is an example of the mean TA scalogram for PD and controls. Fig.1b reports frequency band energy distributions across methods and groups.

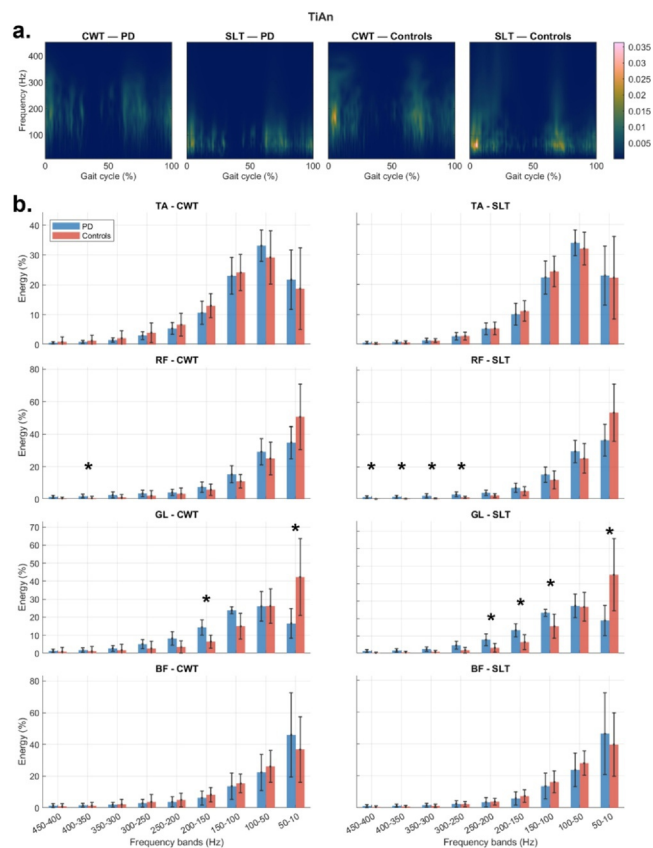


Fig.1.a.Representative mean TA scalograms for PD and controls, computed using CWT and SLT. b.Frequency-band energy distributions across methods, muscles and groups, shown as mean $\pm$ standard deviation(* $p < 0.005$).

CWT identified significant differences in RF (350–400 Hz) and GL (10–50 Hz, 150–200 Hz). SLT revealed additional differences, extending RF alterations to higher bands (250–450 Hz) and identifying further GL differences (100–250 Hz). SPM showed significant differences only in IMNF for RF and GL, indicating a shift toward higher frequency content in PD, particularly across the gait cycle in RF and during swing in GL.

Discussion

Similarly to what has been observed in healthy individuals[9], PD patients also show compensatory recruitment of faster muscle fibers in response to reduced muscle efficiency.

RF showed increased high-frequency activity, while GL exhibited increased intermediate-frequency and reduced low-frequency content, consistent with impaired slow fiber recruitment and increased fatigability.

Increased fatigability may also be related to mitochondrial dysfunction associated with fast-twitch MF recruitment, usually happening in PD[10].

Both methodologies provided comparable results. However, SLT detected more significant differences, likely due to improved TF resolution and reduced variability, enhancing statistical power.

These findings suggest that frequency-based characterization of MFR may serve as a biomarker for monitoring neuromuscular alterations and rehabilitation outcomes in PD.

References

- De Lau, L. M., & Breteler, M. M. (2006). Epidemiology of Parkinson's disease. *The Lancet Neurology*, 5(6), 525-535.
- Islam, A., Alcock, L., Nazarpour, K., Rochester, L., & Pantall, A. (2020). Effect of Parkinson's disease and two therapeutic interventions on muscle activity during walking: a systematic review. *NPJ Parkinson's disease*, 6(1), 22.
- Spolaor, F., Beghetti, F., Piatkowska, W., Guiotto, A., Polli, R., Bettella, E., & Sawacha, Z. (2025). Children With Fragile X Syndrome Display a Switch Towards Fast Fibres in Their Recruitment Strategy During Gait. *Journal of Intellectual Disability Research*, 69(7), 582-591.
- Matsumoto, T., Takamaru, Y., Nakayama, C., Sawada, S., & Machida, S. (2025). Muscle Fiber Recruitment Characteristics in Trained Older Adults: An EMG Frequency Analysis During Voluntary Contraction. *Journal of Functional Morphology and Kinesiology*, 10(3), 355.
- Garcia-Retortillo, S., & Ivanov, P. C. (2022). Inter-muscular networks of synchronous muscle fiber activation. *Frontiers in Network Physiology*, 2, 1059793.
- Moca, V. V., Bârzan, H., Nagy-Dăbăcan, A., & Mureșan, R. C. (2021). Time-frequency super-resolution with superlets. *Nature communications*, 12(1), 337.
- Romanato, M., Piatkowska, W., Spolaor, F., To, D. K., Volpe, D., & Sawacha, Z. (2022). Different perspectives in understanding muscle functions in Parkinson's disease through surface electromyography: Exploring multiple activation patterns. *Journal of Electromyography and Kinesiology*, 64, 102658.
- Pataky, T. C. (2012). One-dimensional statistical parametric mapping in Python. *Computer methods in biomechanics and biomedical engineering*, 15(3), 295-301.
- Bogdanis, G. C. (2012). Effects of physical activity and inactivity on muscle fatigue. *Frontiers in physiology*, 3, 142.
- Kverneng, S. U., Stige, K. E., Berven, H., Mostafavi, S., Lunder-vold, K., Brischigliaro, M., & Tzoulis, C. (2025). Mitochondrial complex I deficiency occurs in skeletal muscle of a subgroup of individuals with Parkinson's disease. *Communications Medicine*, 5(1), 141.

<https://doi.org/10.1016/j.gaitpost.2026.110307>

Clinical applications of sEMG assessment of gait in Parkinson's disease: Preliminary results from a systematic review

Amani Alrikabi^{1,2}, Lorenzo Cavazzuti³, Isabella Campanini³, Andrea Merlo³, Giuseppe Biagini^{2,4}

¹ University of Modena and Reggio Emilia, PhD Program in Health Technologies and Innovative Products- Department of Life Sciences., Modena, Italy

² University of Modena and Reggio Emilia, Department of Biomedical- Metabolic- and Neural Sciences., Modena, Italy

³ Azienda USL-IRCCS di Reggio Emilia- San Sebastiano Hospital, LAM – Motion Analysis Laboratory- Neuromotor and Rehabilitation, Correggio Reggio Emilia, Italy

⁴ University of Modena and Reggio Emilia, Center for Neuroscience and Neurotechnology, Modena, Italy

Introduction

Gait impairment is one of the most common disabling symptoms of neuromuscular dysfunction in patients with Parkinson's disease (pwPD), affecting quality of life [1]. Surface Electromyography (sEMG) has been used in gait analysis to detect functional changes associated with PD [2]. This systematic review aims to critically appraise the use of sEMG in the gait of pwPD and identify gaps hindering its translation into clinical routine.

Research Question

How is sEMG used in gait analysis in individuals with Parkinson's disease? What is the clinical added value of the existing literature?

Methods

A systematic research was designed, registered on PROSPERO (CRD420261350087), and conducted on Medline, Web of Science, Embase, and Scopus. Two reviewers screened the retrieved articles independently. Full papers that used sEMG to assess muscle activation during gait in PD patients were included. A tailored set of 22 quality questions for the critical appraisal process was designed, encompassing five different domains: study methodology, clinical aspects, assessment protocol, technical aspects, and transferability to clinical practice. This was adapted from the CEDE checklist [3] and built by a previous review published on the topic [4]. Each question was scored on a three-level basis (i.e., 1 for "yes", 0.5 for "limited details", and 0 for "no"), plus a "not applicable" score. This allowed computing the domain-related and total percentual score and classifying studies as high-, medium-, and low-quality. The scoring procedure is ongoing; preliminary summarizing results are presented here.

Results

From 1,645 records, 49 studies met the inclusion criteria. Of these, 59% were published in Journals categorized as clinical (Scimago) and the remaining 41% in engineering or multidisciplinary journals. Most studies were observational and aimed at describing muscle activation patterns in PD patients with different levels of impairment or walking conditions (e.g. prior to FOG). A few intervention studies used sEMG as an outcome to address the effect of drugs or rehabilitation treatments on muscle activation. The sample size was, in general, limited to 10-20 patients. The most frequently studied muscles were the Tibialis Anterior and Gastrocnemius Medialis; the protocol for electrode placement was rarely reported. EMG envelopes and muscle onsets were the most used analysis techniques. Coactivation indices and muscle synergies were also used in the last years.

Discussion

In general, the clinical literature on the use of sEMG in Parkinson's disease is limited, with common methodological issues in several areas (e.g., sample size and electrode placement). Despite these limitations, the most relevant finding of this preliminary analysis is that sEMG can be reliably used as an outcome measure in clinical intervention studies.

References

1. Mirelman, A., Bonato, P., Camicioli, R., Ellis, T.D., Giladi, N., Hamilton, J.L., Hass, C.J., Hausdorff, J.M., Pelosin, E., and Almeida, Q.J., *Gait impairments in Parkinson's disease*. The Lancet Neurology, 2019. 18(7): p. 697-708.
2. Agostini, V., Ghislieri, M., Rosati, S., Balestra, G., and Knaflitz, M., *Surface electromyography applied to gait analysis: How to improve its impact in clinics?* Frontiers in Neurology, 2020. 11: p. 994.
3. Besomi, M., Devecchi, V., Falla, D., McGill, K., Kiernan, M. C., Merletti et al. *Consensus for experimental design in electromyography (CEDE) project: Checklist for reporting and critically appraising studies using EMG (CEDE-Check)*. Journal of Electromyography and Kinesiology, 2024. 76: p. 102874.
4. Merlo, A., Cavazzuti, L., Bò, M.C., Cavallieri, F., Bassi, M.C., Damiano, B., Scaltriti, S., Fioravanti, V., Di Rauso, G., Portaro, G., Valzania, F., Lusuardi, M., and Campanini, I., *Instrumental balance assessment in Parkinson's disease and Parkinsonism: A systematic review with critical appraisal of clinical applications and quality of reporting*. Frontiers in Neurology, 2025. 16: p. 1528191.

<https://doi.org/10.1016/j.gaitpost.2026.110308>

Comparison of gait biomechanics in children using minimalist versus cushioned footwear

Luciana Jesus¹, Adriane Mara de Souza Muniz², Maria Clara Maia Gomes¹, Mateus Ferreira Resende¹, Beatriz Oliveira Silva¹, Arthur de Souza da Cunha¹, Tainá Amaral Luiz Medeiros¹, Julia de Oliveira Santo¹, Ana Martins Vieira da Silva¹, Luciano Luporini Menegaldo¹

¹ Federal University of Rio de Janeiro, Biomedical Engineering Program, Rio de Janeiro, Brazil

² Army School of Physical Education, Brazilian Army, Rio de Janeiro, Brazil

Introduction

For hundreds of thousands of years, humans have walked barefoot, whereas only in the past few decades has footwear been designed to enhance impact absorption. The literature suggests that children who habitually walk barefoot exhibit improved foot development [1]. Minimalist footwear can be proposed as an alternative that more closely mimics barefoot conditions, supporting musculoskeletal and functional foot development. However, its effects on children's gait biomechanics remain insufficiently investigated.

Research Question

How do minimalist footwear and cushioned footwear influence the gait biomechanics in children aged 8 to 11 years?

Methods

This cross-sectional study included 20 typically developing children (9.1 ± 0.8 years; 55% boys; 35.7 ± 5.7 kg; 1.4 ± 0.06 m). Gait was assessed using eight retroreflective cameras (Vicon, UK) synchronized with two force platforms (AMTI, EUA). Participants walked at a controlled speed (4.5 ± 0.5 km/h) for seven trials. Reflective markers were placed according to the Conventional Gait Model 2.3. Children were evaluated under two randomized