Exploring the relationship between Gait Profile Scores and clinical characteristics of people with diabetic peripheral neuropathy

Jane S. S. P. Ferreira[1], Ronaldo H. Cruvinel-Júnior[1], Marcos Duarte[2], Isabel C. N. Sacco[1]
[1]Department of Physical Therapy, Speech, and Occupational Therapy, School of Medicine, University of São Paulo, São Paulo, Brazil
[2]Biomedical Engineering, Universidade Federal do ABC, São Bernardo do Campo, Brazil.

Email: janesuelen@gmail.com

Summary

This study investigated the gait patterns of participants with diabetic peripheral neuropathy (DPN) in comparison with healthy controls. We analyzed the 3D gait biomechanics of 102 participants with DPN and 42 healthy controls and calculated the Gait Profile Score (GPS) as an index of overall gait deviations. We also explored possible relationships between GPS and clinical characteristics. GPS showed significant gait deviations in individuals with DPN, with a mean RMS difference of 3.13±0.62°. Kinematic variables were positively correlated with quality-of-life scores ($r=0.29$, $p<.05$) and DPN severity ($r=0.30$, $p<.05$), suggesting an intimate relation between the clinical and biomechanical profiles in this population. The GPS has shown to be as a valuable tool for assessing gait alterations in DPN.

Introduction

Individuals with DPN evolve with severe sensorial and motor deficits, which in turn lead to impaired gait biomechanics[1]. GPS is a comprehensive measure of overall gait deviation, derived from kinematic data of the pelvis and lower limbs and it serves as a global score that quantifies the extent to which an individual's gait deviates from a normative reference, aiding in clinical assessment, monitoring of disease progression, and evaluation of treatment outcomes [2]. Although it has been widely used in clinical assessments in a wide range of populations with dysfunctions[3-4], it has not yet been explored in people with DPN. This study aims at describing gait patterns of people with DPN in a broader way using GPS and examining relationships between GPS and clinical characteristics: DPN symptoms and severity, foot pain, foot function and quality of life.

Methods

The study included 102 adults (54.6±9.5 yrs old) with type 1 or 2 diabetes and confirmed DPN, all able to walk independently, without any foot amputations or major neurological or vascular complications. Gait analysis was performed using an 8-camera Vicon Motion System and the Plug-in Gait marker set while participants walked barefoot on a 10-meter walkway. Control group data were obtained from 42 participants from a publicly available dataset [5]. Control group data were collected using 16-Camera Raptor-4 Motion Analysis System. The GPS reflected gait deviation by comparing participants' data to a reference population and was calculated from 9 kinematic variables: pelvic tilt, obliquity, and rotation; hip flexion, abduction, and internal rotation; knee flexion; ankle dorsiflexion; and foot progression for both sides. To address errors from marker placement and model misalignment, which can create constant offsets in joint angles, GPS was calculated with and without offset correction (GPSno) by standardizing angles and setting their mean to zero. DPN symptoms (Michigan Neuropathy Screening Instrument), DPN severity (Decision Support System for Classification of Diabetic Polyneuropathy), foot pain and function (Foot Health Status Questionnaire), and quality of life (EQ-5D-3L) were assessed. Approved by the Institutional Ethics Committee (CAAE: 90331718.4.0000.0065).

Results and Discussion

With offsets, hip rotation strongly influenced the GPS, revealing limitations of the Plug-in-Gait model in capturing gait patterns accurately. After correction (without offset), hip and ankle flexion had a greater impact on GPSno, better reflecting joint movements in DPN. GPSno showed a mean RMS difference of 3.13±0.62° between individuals with DPN and healthy controls, indicating a moderate deviation in joint angles in DPN relative to the controls. This difference suggests altered gait patterns associated with DPN. A positive correlation was found between ankle dorsiflexion and quality of life ($r=0.29$, $p<.05$), suggesting that gait alterations impact the well-being of individuals with DPN, with reduced dorsiflexion potentially increasing instability and fall risk. Similarly, pelvic obliquity correlated with DPN severity ($r=0.30$, $p<.05$), indicating compensatory adjustments due to gluteal weakness, which may worsen as the condition progresses. Moreover, GPSno was directly influenced by ankle dorsiflexion, knee flexion, and joint moments at the ankle and knee, reinforcing its sensitivity to biomechanical alterations associated with DPN.

Conclusions

The findings highlight GPS as a valuable tool for assessing gait abnormalities in DPN. Key joint movements, particularly at the ankle and knee, significantly influence GPS, which correlates with quality of life and DPN severity. This underscores its potential as an indicator of functional impairment and disease progression.

Acknowledgements

To the support of Sao Paulo Research Foundation (FAPESP: 2019/02522-0, 2021/00807-8, 2022/11379-0) and CNPq.

References

[1] Fernando M. et al (2013). *Clin Biomech* **28**: 831-45.
[2] Baker et al (2009). Gait & Posture, **30**: 265-269
[3] Hannah L. Jarvis et al (2022). *Gait & Posture*, **91**: 229-234
[4] Anniina JM Cansel et al (2021). *Gait & Posture*, **84**: 273-279
[5] Fukuchi C. A. et al (2018). *PeerJ*, **6**: e4640.