Kinematic Gait Parameters to Describe and Detect Phenotype-Specific Alterations in Parkinson's Disease: Interpretative Hypotheses on the Freezing of Gait Phenomenon.

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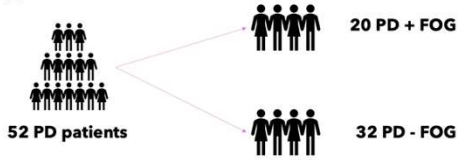
Introduction

Gait disturbances in Parkinson's disease (PD) patients can significantly increase disability, impacting on quality of life, particularly for those suffering of Freezing of Gait[1] (FOG).

We aim to distinguish PD phenotypes based on presence/assence of FOG, referring to parameters that are potentially informative about postural tendencies, such as kinematic variables[2] (relationships between body segments in terms of joint angles during gait). To date, only few scientific studies focused on kinematic measures, since movement analysis has historically focused on spatio-temporal variables.[3]

Methods

52 PD patients - 20 with Freezing of Gait (PD-FOG) and 32 without (PD-noFOG), based on a score ≥ 1 on item 13 of the MDS-UPDRS II - were evaluated through MDS-UPDRS, Hoehn and Yahr scale (H&Y) and gait analysis. Exclusion criteria were dementia, gait needing assistance, relevant concomitant medical conditions and other neurological disturbances.



Kinematic variables were extracted, and univariate statistical analysis (t-test for independent samples or Mann-Whitney U-test, as appropriate) was conducted to compare groups.

Furthermore, to classify patients as PD-FOGvsPD-noFOG, kinematic variables have been used as input for various Machine Learning (ML) algorithms including Decision Tree (DT), Random Forest (RF), XGBoost (XGB), Support Vector Machine (SVM), Linear Regression (LR) and K-Nearest Neighbour (KNN).

Results

Demographic and clinical variables

- PD-FOG patients exhibited worse non-motor symptoms, greater difficulties in activities of daily living and more complications of therapy, as revealed by higher scores on MDS-UPDRS I, II and IV.
- It is worth noting that there were no significant differences in disease duration, H&Y stage, or L-Dopa equivalent daily dose .

Spatio-temporal and Kinematic variables

- When comparing gait features, spatio-temporal variables showed no statistical differences, whereas kinematic ones were indicative for distinction between the two groups (Fig. 1).

In particular, PD-FOG versus PD-noFOG showed:

1. In the frontal plane, a higher trunk obliquity (p=0.035)
2. In the sagittal plane, a reduced retroversum and antiversum of the pelvic tilt (p<0.001), a reduced knee flexion angle and a reduced hip flexion (p=0.004)
3. In the transverse plane, a greater extra-rotation of the pelvis (p=0.047) and more intra-rotation of the knee (p=0.009) and reduced ROM rotation (p= 0.003)

- ML algorithms achieved nearly 80% accuracy in predicting if PD patients reporting FOG (Fig. 2).

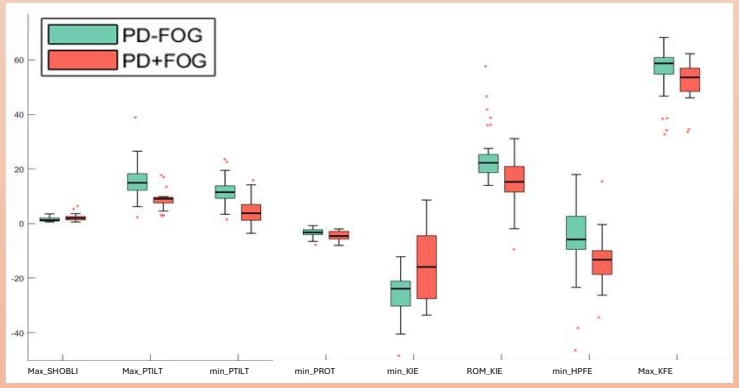


Fig. 1 Kinematic variables PD-FOG vs noFOG
maxSHOBLI = trunk high obliquity; maxPTILT = pelvis antiversum tilt; minPTILT = pelvis retroversum tilt; minPROT = pelvis internal rotation; minKIE = knee external rotation; ROMKIE = range of motion of knee internal-external rotation; minHPFE = hip extension; maxKFE = knee flexion.

Fig. 2 ML algorithms

Conclusion

- PD-FOGvsPD-noFOG exhibit distinct kinematic patterns, indicating differing postural configurations during gait. Specifically, FOG patients show a tendency toward reduced angular range at pelvis (i.d. reduced both antiversum and retroversum, reduced knees flexion in the sagittal plane), while assuming more curved and fixed postures through transverse and coronal plane (knee intrarotated, pelvis extrarotated and oblique trunk).
- In clinical setting, precocious identification of FOG patients through ML approach may contribute to early access to behavioural and rehabilitative strategies that could have an impact on FOG progression.
- Finally, our findings may help to shed light on the biomechanical features associated with FOG thus contributing to better disentangle the complex pathophysiology underlying such phenomenon.

References

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