

Sit-to-Walk predicts Freezing of Gait status over than cognitive load: an experimental study with Linear Discriminant Analysis.

Mezzarobba S^{1,2}, Sgubin G², Grassi M¹, Valentini R², Bernardis P¹

¹ Psychology Unit “Gaetano Kanizsa”, Department of Life Science, University of Trieste, Italy. ² Department of Surgical and Medical Sciences, University of Trieste.

Keywords: Freezing of Gait, Gait Analysis, Parkinson, Linear Discriminant Analysis, Cognitive control

Freezing of Gait (FoG) is one of the most debilitating symptom of patients with Parkinson Disease (PwP) as it could leads to fall and loss of independence. It is common in Parkinson’s disease but, interestingly, it doesn’t occur in all patients [1], suggesting that PwP with FoG are a subpopulation of PwP [2]. Known triggers for FoG include, aside to normal gait, challenging events that require precise regulation of complex motor sequences to control step length and gait timing, such as step initiation and raise to walk. Motor and cognitive models have been proposed to explain the potential mechanisms behind the episodic nature of FoG [3]. FoG is typically considered a motor deficit. However, recent researches suggest that declining cognitive/executive functions, in set-shifting and inhibition, may also contribute to FoG [4, 5]. Somewhat related, individuals with Parkinson’s disease who exhibit FoG have difficulty shifting their attention when performing online modification of a complex motor sequence [6].

Recent research show that FoG may be influenced by the difficulty of a voluntary switch within a task such as stepping [5, 7]. Moreover, augmented cognitive load (with an additional attentional focus) has a detrimental effects on gait in PwP with FoG [5, 8]. Therefore, it is important to ask whether motor-sequence planning is associated with FoG. FoG may be studied by finding those peculiar features of motor behavior which differentiate patients with and without FoG.

We evaluated the motor behavior in simple and complex gait movements with three groups of participants: PwP with and without FoG in ON state condition, and participants without neurologic and gait disorders. All participants were required to walk, to begin to walk (Step Initiation), and raise from a chair for walking (Sit-to-Walk). These tasks were performed by themselves or with a concomitant cognitive task in order to study attentional shifting. Aim of the study was to establish whether a subgroup of patients of Parkinson’s Disease and FoG, beyond freezing episodes, also show peculiar gait parameters. Such information, in fat, could be used, together with self reports, as a marker for phenotyping PwP with FoG.

Analysis of variance helped to identify task-specific kinematic and kinetic variables which differentiate among the three groups. Classification accuracy of such variables was obtained by training a Linear Discriminant Analysis – LDA algorithm on reduced sub-samples, and by testing it on the left out subjects. Accuracy pattern was extracted for all the possible training/testing subject combinations.

LDA results show that the three task can differentiate, with a reliable accuracy, among the three groups, both when considering gait only information and when considering gait and cognitive performance information. This is the first study showing that PwP with FoG exhibit changes

in the Sit-to-Walk task parameters compared to PwP without FoG and to healthy participants. Additional cognitive load improves the accuracy in the classification among groups, when considering the accuracy of the walking task [8], but not in Step Initiation and in Sit-to-Walk tasks [9].

1. Bartels AL, Balash Y, Gurevich T, Schaafsma JD, Hausdorff JM, Giladi N. (2003). Relationship between freezing of gait (FOG) and other features of Parkinson's: FOG is not correlated with bradykinesia. *Journal of Clinical Neuroscience*, 10:584-8.
2. Heremans E, Nieuwboer A, Verduyck S. (2013) Freezing of Gait in Parkinson's Disease: Where Are We Now? *Current Neurology and Neuroscience Reports*, 13:350
3. Nieuwboer A, Giladi N. (2013). Characterizing freezing of gait in Parkinson's disease: Models of an episodic phenomenon. *Movement Disorders*, 28:1509–1519.
4. Owen AM, James M, Leigh PN, et al. (1992). Fronto-striatal cognitive deficits at different stages of parkinson's disease. *Brain*, 115:1727-1751.
5. Knobl P, Kielstra L, Almeida Q. (2011). The relationship between motor planning and freezing of gait in Parkinson's disease. *Journal of Neurology, Neurosurgery & Psychiatry*, 83:98–101.
6. Schwab RS, Chafetz ME, Walker S. (1954). Control of 2 simultaneous voluntary motor acts in normal and in parkinsonism. *AMA Archives of Neurology Psychiatry*, 72:591e8.
7. Smulders K, Esselink RA, Bloem BR, Cools R. (2015). Freezing of gait in Parkinson's disease is related to impaired motor switching during stepping. *Movement Disorders*, 30:1090–1097.
8. Rochester L, Galna B, Lord S, Burn D. (2014). The nature of dual-task interference during gait in incident Parkinson's disease. *Neuroscience*, 265(C): 83–94.
9. Marsh AP, Geel SE. (2000). The effect of age on the attentional demands of postural control. *Gait and Posture*, 12:105-13.