

Title	Noisy Interlimb Coordination Can Be a Main Cause of Freezing of Gait in Patients with Little to No Parkinsonism
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論 文 内 容 の 要 旨
Synopsis of Thesis

氏 名 Name	棚橋 貴夫
論文題名 Title	Noisy Interlimb Coordination Can Be a Main Cause of Freezing of Gait in Patients with Little to No Parkinsonism (パーキンソニズムを伴わないか軽微な症例では、両下肢間協調運動におけるノイズの大きさがすくみ足の主要な原因となりうる)
論文内容の要旨	
〔目的(Purpose)〕	
Freezing of gait (FOG) in patients with Parkinson's disease (PD) is associated with several factors, including interlimb incoordination and impaired gait cycle regulation. However, gait analysis in patients with PD is confounded by rigidity and 'wearing off' phenomena such as dyskinesias that directly affect gait. To understand the mechanisms underlying FOG, we studied gait patterns in patients with FOG but little to no parkinsonism to alleviate the influence of these confounding factors.	
〔方法ならびに成績(Methods/Results)〕	
We compared gait patterns during straight walking between 9 patients with FOG but little to no parkinsonism (freezing patients) and 11 patients with PD (non-freezing patients). The freezing group was not comprised of patients with a single disease, but of patients with a heterogeneous syndrome including pure akinesia, primary progressive freezing gait, and PD, among others. Wireless sensors were attached to the respective heels of nursing shoes worn by the patients to detect foot contact and toe-off events. Patients walked 20 m in a straight line, turned 180° around a chair clockwise or counter-clockwise, and walked 20 m to return to the start at their preferred speed. They performed this two times for each turn direction. The straight-walking data were analyzed separately for the 'Go' and 'Back' portions of the walking task. To assess interlimb coordination between the legs, the step phase of each foot contact was calculated by defining one stride cycle of the other leg as 360°. Phase-resetting analysis was performed, whereby the relation between the step phase of one leg and the subsequent phase change in the following step of the other leg was quantified using regression analysis. A small slope of the regression line indicates a forceful correction (phase reset) at every step of the deviation of step phase from the equilibrium phase, usually at around 180°. The slope of this relation was smaller in freezing patients than in non-freezing patients, but the slope exhibited larger step-to-step variability. This indicates that freezing patients executed a forceful but noisy correction of the deviation of step phase, whereas non-freezing patients made a gradual correction of the deviation. Moreover, freezing patients tended to show more variable step phase and stride time than non-freezing patients. The deviation of step phase was similar in the two groups, which is in contrast to previous reports showing greater asymmetry in PD patients with FOG than PD patients without FOG. Dynamics of a model of two coupled phase-oscillators interacting through a phase resetting mechanism were examined, and indicated that forceful phase reset reduced step phase variability, but the deterioration of phase reset by noise provoked variability in step phase and stride time. That is, interlimb coordination can affect regulation of the gait cycle.	
〔総括(Conclusion)〕	
FOG patients with little to no parkinsonism showed forceful and noisy interlimb coordination during straight walking, which was probably due to dysfunction of the brainstem locomotor center or central pattern generators in the spinal cord. This interlimb coordination was associated with high stride time variability, which may have caused gait festination and FOG during turning. These findings were supported by a model of coupled phase-oscillators that used the phase resetting mechanism. Interlimb coordination during turning and leg rhythmicity during repetitive movements should be investigated in FOG patients to more precisely understand the mechanisms of FOG.	

論文審査の結果の要旨及び担当者

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<p>論文審査の結果の要旨</p> <p>すくみ足は、パーキンソン病をはじめとする様々な疾患で認められ、筋強剛や振戦などのパーキンソニズムと相関がなく、そのメカニズムは明らかになっていない。歩行中には直線やターンなどの状況に応じて左右下肢の交互運動を制御する必要があり、これは両下肢間協調運動と呼ばれている。本論文では両下肢間協調運動障害とすくみ足との関連につき検討するとともに、両下肢間協調運動の制御メカニズムに対する新たな歩行解析手法を確立し、両下肢間協調運動の数理的モデルを構築することでこの解析手法の有用性を示している。また、先行研究とは異なり、すくみ足が中核症状となりパーキンソニズムはないか軽微の症例を対象とすることで、パーキンソニズムが歩行に与える影響を最小限にしている点に特徴がある。結果として、両下肢間協調運動障害が歩行周期の変動や加速歩行を引き起こし、最終的にすくみ足をきたす、というメカニズムを提唱しており、学位に値するものと認める。</p>	