Letter

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On the benefits of wearable devices for Parkinson's disease

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Astract

Il Freezing of gait (FOG) viene definito come l'incapacità episodica di generare un movimento efficace senza alcuna causa nota diversa dal parkinsonismo o dai disturbi dell'andatura. Il FOG è uno dei sintomi più disabilitanti della malattia di Parkinson (PD), influisce sulla mobilità e aumenta il rischio di caduta nelle persone affette da PD, rendendolo una delle principali cause di ospedalizzazione e influenzando negativamente la qualità di vita. Negli ultimi anni sono state implementate nuove strategie di intervento non invasivo per ridurre i sintomi FOG. Grazie al progresso tecnologico, sono stati sviluppati diversi dispositivi come supporto per i pazienti durante la diagnosi, i trattamenti e anche la vita quotidiana. Questi tipi di interventi si basano su sistemi di cueing che si basano sulla stimolazione attiva. Questi dispositivi sono in grado di identificare gli stati FOG e di agire quando si verificano questi blocchi motori, fornendo stimoli esterni per superare questi episodi. Questo lavoro mira a fornire una revisione tecnologica della letteratura relativa ai dispositivi indossabili e si concentra sui sistemi di cueing di tipo uditivo, visivo, virtuale e somatosensoriale, affinché possano fornire un intervento adeguato per i pazienti con PD. Il documento descrive il funzionamento tecnico e l'efficacia dei diversi sistemi per superare gli episodi FOG. Verrà inoltre fornita una classificazione dei dispositivi esistenti, evidenziandone vantaggi e svantaggi, al fine di individuare quelli con le migliori prestazioni.

Freezing of gait (FOG) is defined as episodic inability to generate an effective movement without any known cause other than parkinsonism or gait disturbance. FOG is one of the most disabling symptoms of Parkinson's disease (PD), it affects mobility and increases the risk of falling in people with PD, making it a leading cause of hospitalization and of significantly worsening the quality of life (1). In recent years, new non-invasive intervention strategies have been implemented to decrease FOG symptoms. Thanks to technological progress, several devices have been developed as a support for the patients during diagnosis, treatments and also everyday life. These types of interventions are based on cueing systems that rely on active stimulation. These devices are able to identify FOG states and to operate when this motor blocks occur, providing external stimuli to overcome these episodes. Hence, this work aims to provide a technological review of the literature related to wearable devices and focuses on auditory, visual, virtual and somatosensory cueing systems, which can provide a suitable intervention for patients with PD. The paper describes the technical functioning and effectiveness of the different reporting systems in overcoming FOG episodes. Moreover, a classification of existing devices, highlighting their advantages and disadvantages, will be provided in order to identify the ones with the best performance. ***Clin Ter 2022; 173 (1):e???-???. doi: 10.7417/CT.2022.????***

Key words: ***Cueing, fog, freezing of gait, Parkinson's disease, wearable device***

PD is the second neurodegenerative pathology in terms of incidence in the world population and belongs to a group of pathologies concerning ''Movement Disorders''. Its main symptoms, such as bradykinesia, stiffness of the limbs, tremor and postural instability are caused by a degeneration of the neuronal cells used to produce dopamine. During the gait, the muscle groups that allow to maintain posture and balance must perform a complex synchronized action to carry out the movement. Growing up, people develop systems that automatically facilitate walking, so they learn to walk without being aware of the many movements to be carried out in a harmonious way (2). PD alters the function of the brain circuits that facilitate this synchronization of movements. FOG is a major motor symptom of PD which appears during the advanced stages of the disease. Initial symptoms, in patients with PD, are characterized by a reduction in stride length and speed during walking, with brief episodes of involuntary absence of locomotion, i.e., a sensation of being stuck in place, which is experienced by the patient especially when trying to initiate a movement or when navigating through or turning around obstacles (3). FOG is often described, by patients with PD, as having their feet "glued to the ground", despite their intention to walk. The ability to monitor and predict these motor blocks

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is fundamental, as FOG is correlated with a higher fall risk and worse prognosis. At the same time, the prediction of this motor disorder can be very complicated, as it shows a great variability in patients with PD. This transient inability to initiate locomotion is referred to as "initial hesitation", which is a sudden and transient inability to move, which lasts an average of 10s. When this "motor block" is overcome, the patient can continue their movement. Indeed, FOG most commonly affects the legs during walking, but the arms and eyelids can also be involved. The conventional medical treatments to prevent these motor blocking episodes are surgical or pharmaceutical solutions. The first are extremely expensive and invasive, meanwhile the latter can have important side effects and they might not always be effective or suited. During pharmacological treatment, indeed, fluctuating responses may occur or patients may manifest a drug addiction with the consequent need to change the dosage of the therapy, risking worse outcomes (4). Therefore, there has been a great commitment of the scientific community to identifying alternative techniques. Among these, the cueing strategies were highly appreciated. Indeed, when FOG episodes management cannot be achieved through drugs or surgery, non-pharmacological methods such as cueing play a fundamental role in patients with PD. Cueing strategies are compensating techniques able to improve motor performance, including increasing walking speed, stride length, cadence and reducing the number of FOG episodes, bypassing the deficit of internal stimuli generation through cues or external inputs (temporal and spatial) (5). New technological advantages have provided considerable support to the developments of new sensors, devices and treatments to reduce the effects of FOG. In fact, a large number of different studies is presented in literature aimed to define sensors and wearable devices that allow patients with PD to inhibit or limit movement disorders such as, above all, FOG or that allow progress assessment of the disease. Despite the inherent potential of these devices, their diffusion has been strongly limited due to the prevalent concentration of the scientific community in the definition of hardware and software systems capable of evaluating physical states in an extremely sophisticated and precise way but usable only in medical environments. The main problem in the diffusion of these devices lies in the difficulty encountered in implementing them in daily life as patient support. This is essentially due to discomfort problems in movement, which means that they cannot be worn for everyday activities. Moreover there are difficulties in use and usually these solutions have high costs. Currently there is a need, and there are means, to ensure that through technology, an improvement not only in knowledge of the disease, but also in patients' daily life, can be obtained. The technology is evolving in the definition of more sophisticated and easily wearable instruments that can be connected to smartphones and which allow to obtain a large amount of data. In this way the technology has the potential to significantly improve both the clinical diagnosis and the control of PD progression, as well as the patient's quality of life. The acquisition of such data, in fact, associated with the emerging sciences of the Internet of Things and Machine Learning, makes these devices extremely powerful because they are able to convert the acquired data into scientific and clinical databases of extreme importance. One of the biggest challenges today is to be able to collect enough data to perfectly model the motor symptoms of the disease for patients during daily activities. This information is essential, as patients with PD have an extremely unique experience with this pathology and moreover, even in the same patient, the motor symptoms show a great variability during the day. In particular, the aim is to translate the data acquired in the patient's daily life into opportunities for better care, better self-management of the disease and better assistance service. Those devices implement three main types of stimulation: visual; acoustic; somatosensory. Indeed, this type of stimulation has been shown to positively affect the motor skills of both healthy and pathological subjects. Thus, the use of certain strategies, such as acoustic and visual pacesetters during motor activity, has shown great effectiveness supporting subjects with motor problems, as in the case of FOG (6). To date, these devices can provide continuous stimulation during movement or operate only when needed (7). Several solutions include the use of FOG autonomous real-time sensing algorithms to start stimulation (8). Recently, comfortable wearable devices with a high accuracy monitoring strategies have been proposed. For instance, an upper limb tremor detection system, similar to a glove, was developed based on magnetic measurements, transmitting data in wireless, able to real-time monitor the disease course (9,10). This device can provide a database of fundamental information to define the right intervention methods to overcome motor difficulties linked to PD and with the future prospect of extension to the lower limbs, moreover, to evaluate the effectiveness of therapy. The study of the different advantages and disadvantages of these devices can be the starting point of new research to obtain a better understanding of the proprioceptive information of the mechanism that lies behind FOG episodes.

Conflict of interest statement

The authors declare that there are no conflicts of interest

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Ethical approval

Not required

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