P46

Wearable devices for gait and posture monitoring in telemedicine in people with movement disorders and multiple sclerosis: a systematic review of literature

Francesca Salaorni, G. Bonardi, F. Schena, M. Tinazzi, M. Gandolfi

Department of Neuroscience, Biomedicine and Movement Sciences, University of Verona, Verona, Italy

Introduction: Movement disorders, Functional Motor Disorders (FMDs), and Multiple Sclerosis (MS) are highly disabling conditions characterized by gait and postural control impairments, along with other highly disabling motor and non-motor symptoms. Healthcare access and availability are becoming an issue for these patients that need continuous care, and the arrival of the Covid 19 pandemic has spurred telemedicine to be considered a valuable tool for them [1]. Telemedicine refers to the set of technologies and methods used to carry out remote diagnosis and treatment, and telerehabilitation is a part of it [1].
Physical therapy is considered a crucial element in managing these patients, and it can reduce functional disability and improve mobility; and is also an essential part of the treatment, mainly in FMDs [2].
Thanks to the increasing availability and usability of wearable technologies (such as inertial measurement sensors, accelerometers, smartwatches, and baropodometric insoles), by providing patients with such devices to perform specific rehabilitative exercises independently, physicians and physical therapists can manage more patients while maintaining continuity of care through telemonitoring and collecting essential clinical data to provide oversight and tailor therapy to the patient's needs [3].
However, to date, patients are not receiving the amount of evidence-based rehabilitation they need due to the lack of rehabilitation professionals, and the rehabilitation setting is inadequate for their long-term management and monitoring.

Objective: This review aims to evaluate the evidence of the use of wearable sensors in combination with telemedicine that can be used in a home-like environment to monitor the gait and balance performance in patients with movement disorders, FMDs, and MS. We would provide state-of-the-art on clinical population investigated, the type of devices used, and the aim set by clinicians in using such devices in the management of patients with movement disorders and MS.

Methods: The protocol of this systematic review was registered in the PROSPERO database (CRD42022355460). Literature research was conducted in PubMed, SCOPUS, COCHRANE LIBRARY, and SPORTDiscus databases considering only studies published in the last ten years and focused on adult patients affected by Movement Disorders, FMDs, and MS. All the studies had to consider any wearable devices used for monitoring gait and posture in the ecological setting combined with telemedicine. From 527 records obtained, after removing duplicates and according to the exclusion criteria, 426 were excluded. So, 27 studies were included.

Results: Among all records, 15(55,5%) studies were observational, 4(14,81%) pilot, 3(11,1%) clinical, 2(7.4%) evaluation, 1(3,7%) exploration, 1(3,7%) comparative and 1(3,7%) prospective. Of the 27 evaluated papers, 6(22,2%) were published from 2011 to 2014, 2(7.4%) in 2015, 3(11,1%) in 2016, 1(3.7%) in 2017, 6(22.2%) in 2018, and 9(33.3%) during the last four years. Indeed, 23(85,18%) studies evaluated patients in free-living conditions, while the remaining 4(14.82%) during specific tasks (i.e., Time-Up and Go Test). In particular, 22(81.48%) articles focused on body motion analysis in PD patients, 4(14.81%) on MS patients, and the remaining 1(3.7%) on Huntington

patients. No studies in FMD patients were found. Only 4(14,81%) studies used two sensors, and the remaining 23(85,19%) used only one sensor. The sensors used were mainly triaxial accelerometers (58.1%), followed by IMUs (29,03%), smart shoes and pressure insoles (6.45%), and smartwatches (3.22%). We recognized wearables relevant to patients and clinicians to provide accurate, objective, and real-time assessment of gait and activity in a real-world setting and their integration into telerehabilitation systems toward a digital rehabilitation transition. We highlighted the lack of studies on telemedicine programs using wearables, especially MS and FMD. These results encourage reflections to improve the home monitoring of these patients.

Conclusions: This review provides a comprehensive overview of the current technological solutions for PD, MS, and Huntington applications to monitor gait and balance in the ecological setting. Digital technology provides a means to objectively and remotely assess multiple different sides of movement disorders in a natural environment. Wearable devices can provide new insights into disability and progression to integrate the standard clinical assessments and enable deep clinical phenotyping of neurodegenerative diseases. Wearables may also enable more personalized treatment and improved clinical management. However, better validation of new digital outcomes and tools is needed. Moreover, appropriate digital and technological solutions hold enormous potential for improving the management of motor disorder patients, enhancing the QoL, and monitoring the effects and the outcomes of the therapy and rehabilitation during the disease progression.

References:

[1] Schneider RB, Biglan KM. The promise of telemedicine for chronic neurological disorders: the example of Parkinson’s disease. Lancet Neurol. 2017;16(7):541-551. doi:10.1016/S1474-4422(17)30167-9.

[2] Truijen S, Abdullahi A, Bijsterbosch D, et al. Effect of home-based virtual reality training and telerehabilitation on balance in individuals with Parkinson's disease, multiple sclerosis, and stroke: a systematic review and meta-analysis. Neurol Sci. 2022;43(5):2995-3006. doi:10.1007/s10072-021-05855-2.

[3] Keogh A, Argent R, Anderson A, Caulfield B, Johnston W. Assessing the usability of wearable devices to measure gait and physical activity in chronic conditions: a systematic review. J Neuroeng Rehabil. 2021;18(1):1-17. doi:10.1186/s12984-021-00931-2.