Digital Innovations and Parkinson's Disease

Sharmi Haque

Parkinson's disease (PD) characterises intrinsically complicated condition that is marked by a diverse range of motor and non-motor symptoms. The impairment evaluation and progression are made more difficult because of this intricacy, which when combined with the absence of objective indicators of illness development, poses a problem(1). Possibilities have arisen to examine persons objectively, routinely, and remotely with movement disorders across an array of situations owed to digital technologies such as smartphones and wearable sensors. It holds the promise of earlier patient identification who are susceptible for or already have the condition, improved disease phenotyping, increased sensitivity for the detection of disease progression(2). It permits the development acceleration of new therapeutics, improved clinical management and patient outcomes(3).

Currently, smartphones, which possess sensors such as accelerometers, gyroscopes, and GPS, are readily available. Such technology is becoming more abundant and desirable as both clinical and research tools(4). Wearable gadgets, in contrast to smartphones, do not need the end- user active participation and may be worn in several places. It facilitates the use of electromyography, electrocardiography, temperature sensors, magnetometers, and other sensors may be included in wearable devices in the future. It proves to be beneficial in the capacity in the identification of unusual occurrences, recording of daily task, better detailing illness symptoms, and capturing non-motor aspects such as sleep. Prior research has found that even in large cohorts, investigations employed wearable sensors and smartphones have proved practical and well-accepted by patients and research participants(5).

Lima et al. used a wearable sensor to evaluate the frequency of falls in 2063 people with PD and 2063 individuals who served as matched controls. Sensors were able to accurately detect falls (occurrence nearly twice as frequently in those with PD as in controls)(6). Detecting falls and the assessment of the risk of falling is advantageous in patients with PD in their overall care. Wearable gadgets can offer a measurement that is both objective and accuracy of the fall detection(7).

Digital technologies extend beyond PD diagnosis; it may also be utilised to identify prodromal symptoms and assess the likelihood of photoconversion to manifest symptoms(8). The sooner PD symptoms are identified, the better the prognosis for people at high risk of the disease. Wearable sensors provide distinctive benefits over smartphones particularly in passive data collection. An example would be determining a patients' physical activity level and the amount of sleep can be further evaluated objectively(8). It eliminates recall bias as patient reports to differ from objective measurements of activity. Mantri et al. echoes these findings on veterans diagnosed with PD. It was reported that moderate-to-vigorous physical activity, measured by an Actigraph, was uncommon in the cohort and did not correlate with self-report(9). Abou et al. revealed that a single completion of a series of smartphone exercises may accurately predict the future development of falls, freezing of gait, and postural instability(10). Evaluation of a variety of gait metrics and clinical prognostication are two areas that might potentially benefit from the use of digital technologies. The tremor has also been examined and measured using apps for smartphones as well as wrist-worn devices like smartwatches(9).

Mirelman et al. established the capacity of wearable accelerometers to detect sleep interruptions and sleep turns and detected variations between those with advanced PD, early PD, and those without PD(11).

Smartphones and wearable sensors are also able to provide frequent data collected in- house on a finer scale, which may be optimised to guide clinical care(12). When it comes to the control of motor irregularities, a strategy like this one could be quite helpful(13). Integrated systems such as PD Manager, allows for both passive and active data collecting through a smartphone application, a wristwatch, and sensor insoles, patients with mild PD exhibiting motor fluctuations(13). It has been demonstrated that a sensor-based system can objectively and reliably determine if a medication is on or off(8,9,14). As smartphones become increasingly common, its ownership varies greatly within and within nations, with richer and more educated individuals more likely to possess one(1,9,12). Numerous studies have shown, over and again, that users' adherence to the terms and conditions of smartphone apps decreases with time(15). The first mPower application research had over 10,000 participants with informed consent to the wide dissemination of their data. However, less than 10 percent of those people supplied data on at least five days each month over a period of six months(5).

The implementation and integration into clinical practice presents considerable barriers(1,12). Digital technologies must be optimised to allow clinicians to understand and make use of digital data(2). It is further exemplified where for 50 (79 percent) of 63 people with Parkinson's disease, a wrist-worn gadget gave meaningful information to guide treatment regimens(16). With smartphone application and wristwatch coupled together; clinicians participated in the iterative construction of a clinician dashboard that could be used to guide process changes in management(16,17).

Digital technologies have potential to serve as replacements for patient diaries that are often difficult to use and highly subjective(12). Currently, the Movement Disorders Society is working on developing an electronic version of the diary(15). Smartphones may be used to monitor the reaction to medication and evaluate daily fluctuation(9). Variable sample rates and algorithms in consumer and research-grade wearable devices make comparisons difficult and restrict findings generalisability(5,17). Refining simple and accurate methods to monitor dyskinesias is also required(6–8). While most gadgets are well-accepted and viable to use in neurodegenerative disease patients, application and usage grow increasingly complicated at home and with time(14). Although most patients are excited to use wearable sensors; many have little prior experience(1,12,14). Patients often have a high learning curve and rely on research coordinators for technological setup and troubleshooting(1,14). A care partner may assist manage these hurdles, but persistent difficulties can lead to frustration(9). Internet connectivity and speed may hinder effective technology usage, and certain devices may have streaming issues(1,12). Data streaming fell by 23% in the 13-week cohort and 27% in the 6-week cohort of a smartwatch-smartphone feasibility study(2,5).

Self-management and improved accuracy in therapy may also be achieved via the use of digital technologies(2,5,14). Access to educational materials, self-tracking and medication modifications may all be done through smartphone apps(9). However, digital technologies do have limitations(14). In a randomised controlled study, PD participants who used a smartphone workout software did not improve in gait, speech, or dexterity compared to the control group, demonstrating that access alone is inadequate(10). A smartphone app and sensor-equipped belt for PD balance training is viable(5). To discover whether such technologies enhance results, further research is required(5,17). A combination of clinical scales, imaging, biospecimens and computer technologies is expected to be the most comprehensive method of characterising illness(3). Patients may benefit from better clinical care owing to smartphones and wearable gadgets(3,12,14).

It is necessary to validate new digital outputs and technologies in a more thorough and vigorous manner. Further work needs to conduct on monitoring larger samples sizes with longer remote surveillance periods and follow- up(1,2,5,12). Existing work needs to be extrapolated with the assessment to new advanced diseases populations and comparison with patient- reported outcomes(1,2). Digital device data standardisation and the development of data sharing platforms to enable cross-study comparisons need to be established(2,3,10). Deeper assessment of more non-motor features towards the development of more holistically comprehensive models needs to be investigated to improve patient outcomes(1,3,12).

References

1. *Adams JL, Lizarraga KJ, Waddell EM, Myers TL, Jensen-Roberts S, Modica JS, et al. Digital Technology in Movement Disorders: Updates, Applications, and Challenges. 1910 [cited 2022 May 31]; Available from: https://doi.org/10.1007/s11910-021-01101-6*
2. *Espay AJ, Bonato P, Nahab FB, Maetzler W, Dean JM, Klucken J, et al. Technology in Parkinson's disease: Challenges and opportunities. Mov Disord [Internet]. 2016 Sep 1 [cited 2022 May 31];31(9):1272–82. Available from: https://pubmed.ncbi.nlm.nih.gov/27125836/*
3. *Corrà MF, Warmerdam E, Vila-Chã N, Maetzler W, Maia L. Wearable health technology to quantify the functional impact of peripheral neuropathy on mobility in Parkinson's disease: A systematic review. Sensors (Switzerland). 2020 Nov 2;20(22):1–34.*
4. *Ossig C, Antonini A, Buhmann C, Classen J, Csoti I, Falkenburger B, et al. Wearable sensor-based objective assessment of motor symptoms in Parkinson's disease. Journal of Neural Transmission. 2016 Jan 1;123(1):57–64.*
5. *Oung QW, Muthusamy H, Lee HL, Basah SN, Yaacob S, Sarillee M, et al. Technologies for Assessment of Motor Disorders in Parkinson's Disease: A Review. Sensors (Basel) [Internet]. 2015 Aug 31 [cited 2022 May 31];15(9):21710–45. Available from: https://pubmed.ncbi.nlm.nih.gov/26404288/*
6. *Lígia A, de Lima S, Smits T, Darweesh SKL, Valenti G, Milosevic M, et al. Home-Based Monitoring of Falls Using Wearable Sensors in Parkinson's Disease. 2019;*
7. *Lígia Silva de Lima A, Hahn T, W Evers LJ, de Vries NM, Cohen E, Afek M, et al. Feasibility of large-scale deployment of multiple wearable sensors in Parkinson's disease. 2017; Available from: https://doi.org/10.1371/journal.pone.0189161.t001*
8. *Pierce A, Ignasiak NK, Eiteman-Pang WK, Rakovski C, Berardi V. Mobile phone sensors can discern medication-related gait quality changes in Parkinson's patients in the home environment. Computer Methods and Programs in Biomedicine Update. 2021 Jan 1;1:100028.*
9. *Little MA. Smartphones for Remote Symptom Monitoring of Parkinson's Disease. Journal of Parkinson's Disease [Internet]. 2021 [cited 2022 May 31];11(Suppl 1):S49. Available from: /pmc/articles/PMC8385528/*
10. *Abou L, Peters J, Wong E, Akers R, Mauricette ·, Dossou S, et al. Gait and Balance Assessments using Smartphone Applications in Parkinson's Disease: A Systematic Review. Journal of Medical Systems [Internet]. 1:3. Available from: https://doi.org/10.1007/s10916-021-01760-5*

11. *Mirelman A, Hillel I, Rochester L, del Din S, Bloem BR, Avanzino L, et al. Tossing and Turning in Bed: Nocturnal Movements in Parkinson's Disease. Mov Disord [Internet]. 2020 Jun 1 [cited 2022 May 31];35(6):959–68. Available from: https://pubmed.ncbi.nlm.nih.gov/32080891/*
12. *van Wamelen DJ, Sringean J, Trivedi D, Carroll CB, Schrag AE, Odin P, et al. Digital health technology for non-motor symptoms in people with Parkinson's disease: Futile or future? Parkinsonism Relat Disord [Internet]. 2021 Aug 1 [cited 2022 May 31];89:186–94. Available from: https://pubmed.ncbi.nlm.nih.gov/34362670/*
13. *Tsiouris KM, Gatsios D, Rigas G, Miljkovic D, Korouš Ićseljakićseljak B, Bohanec M, et al. PD_Manager: an mHealth platform for Parkinson's disease patient management. Available from: http://creativecommons.*
14. *Klingelhoefer L, Jitkritsadakul O, Bhidayasiri R. Objective Measurement and Monitoring of Nonmotor Symptoms in Parkinson's Disease. International Review of Neurobiology. 2017 Jan 1;133:347–87.*
15. *Espay AJ, Hausdorff JM, Sánchez-Ferro Á, Klucken J, Merola A, Bonato P, et al. A roadmap for implementation of patient-centered digital outcome measures in Parkinson's disease obtained using mobile health technologies. Mov Disord [Internet]. 2019 May 1 [cited 2022 May 31];34(5):657–63. Available from: https://pubmed.ncbi.nlm.nih.gov/30901495/*
16. *Arroyo-Gallego T, Ledesma-Carbayo MJ, Sanchez-Ferro A, Butterworth I, Mendoza CS, Matarazzo M, et al. Detection of Motor Impairment in Parkinson's Disease Via Mobile Touchscreen Typing. IEEE Trans Biomed Eng [Internet]. 2017 Sep 1 [cited 2022 May 31];64(9):1994–2002. Available from: https://pubmed.ncbi.nlm.nih.gov/28237917/*
17. *Delrobaei M, Memar S, Pieterman M, Stratton TW, McIsaac K, Jog M. Towards remote monitoring of Parkinson's disease tremor using wearable motion capture systems. Journal of the Neurological Sciences. 2018 Jan 15;384:38–45.*