Parkinson's Disease and Wearable Technology: An Indian Perspective

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Abstract

Parkinson's disease (PD) is the second most prevalent neurodegenerative disorder. In India, an accurate number of PD patients remains uncertain owing to the unawareness of PD symptoms in the geriatric population and the large discrepancy between the number of PD patients and trained neurologists. Constructing additional neurological care centers along with using technology and integrating it into digital healthcare platforms will help reduce this burden. Use of technology in PD diagnosis and monitoring started in 1980s with invasive techniques performed in laboratories. Over the last five decades, PD technology has significantly evolved where now patients can track symptoms using their smartphones or wearable sensors. However, the use of such technology within the Indian population is non-existent primarily due to the cost of digital devices and limited technological capabilities of geriatric patients especially in rural areas. Other reasons include secure data transfers from patients to physicians and the general lack of awareness of wearables devices. Thus, creating a simple, cost-effective and inconspicuous wearable device would yield the highest compliance within the Indian PD patient population. Implementation of such technology will provide neurologists with wider outreach to patients in rural locations, remote monitoring and empirical data to titrate medication.

Keywords: India, Parkinson's disease, technology

Introduction

Parkinson's disease (PD), a neurodegenerative disease, is characterized by bradykinesia, rigidity, tremor, postural instability, and non-motor symptoms that significantly reduce the quality of life in patients. It is the second most prevalent neurodegenerative disorder with approximately 10 million people suffering from it globally.[1] PD is more common in higher age groups, thus, affecting at least 1% of the population aged more than 60.[2] An exponential growth in PD prevalence is expected with a predominantly ageing population worldwide.[3] Studies suggest that India has a distinctly lower number of PD cases than European countries.[4] However, this could be an underestimation because of unawareness of PD as many elderly individuals attribute its symptoms to normal ageing.[5] Second, the few PD epidemiological studies conducted in India have looked at particular communities such as the Parsi community in Mumbai[6] or specific geographical locations such as Kolkata, Bengaluru, Kashmir, and rural Gujrat.[7-10] Thus, an accurate account of the total number of PD patients in India still remains unknown.

A glaring issue India faces with this growing chronic disease burden is the discrepancy between the number of trained neurologists and PD patients. Indian neurologists treat up to four times the number of patients examined in the United Kingdom and the Unites States of America.[11] Furthermore, these neurologists are concentrated in large cities. A study stated that 30.09% of neurologists practice in one of the four major cities and only 2.67% practice in rural areas that cater to 84.59 million people. It also revealed that no neurologists practice in a geographical area that covers a population of 934.8 million.[12] Patients in rural areas have less access to health care and neurodegenerative diseases often remain undiagnosed or highly neglected. Merely constructing additional neurological facilities will not curb an issue of this magnitude. But the use of technology and its integration into digital health care platforms is a more feasible option.

Technology in the Indian Health care System

The role of technology has shown remarkable success in the Indian health care system. Government initiatives such as universal health care, digitization of medical records, and immunization programs rely completely on technology. Health care workers are more productive with a digitally skilled workforce and the use of data analytics. For example, a digital technology-enabled maternal clinical assessment tool was provided to frontline accredited social health activists (ASHAs). The pilot implementation of this technology

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Submitted: 29-Jun-2022 **Revised:** 20-Aug-2022 **Accepted:** 23-Aug-2022 **Published:** 31-Oct-2022

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DOI: 10.4103/aian.aian_653_22

reduced information disparity between physicians and ASHAs as well as enabled early identification of maternal risks.[13] The age of the internet with the era of smartphones has increased India's tele-density. This has widened the outreach of health care services to rural populations via telemedical consultations, telemonitoring of patients, and even tele-education.

In response to COVID-19 pandemic, India saw a surge in telemedicine because of country-wide lockdowns as well as new policies regarding it from the Ministry of Health and Family Welfare. This government initiative for telemedicine was called "eSanjeevani" and it connected doctors to each other as well as doctors to patients via its eSanjeevani out-patient department service. It used a hub and spoke model to connect larger hospitals to smaller ones in remote locations. It was reported that approximately 3 million teleconsultations were conducted using this platform for even non-COVID-19 cases as of March 2021.[14] A study reported that 51% of patients had a satisfactory neurological consultation via telemedicine experience during the pandemic.[15] In the private sector, medical technology companies are developing devices that enable remote patient monitoring. For example, contactless ballistocardiograph sensors that monitor heart rate variability were developed locally and implemented in intensive care units, reducing the otherwise required manpower of health care workers.[16] In the neuro-realm, smartphone applications are increasingly being adopted in neurosurgery.[17] Tele-stroke care is also being used by neurologists where rapid treatment protocols are deployed in rural emergency rooms for patients with an acute infarct.[18]

PD and Technology

Globally, research in the use of technology in PD diagnosis, early detection, monitoring, and titrating therapeutics has been ongoing for the last five decades [Figure 1]. Early techniques included laboratory-based invasive needle electromyogrpahy (EMG) and surface EMG that quantified PD tremors, gait, and bradykinesia.[19-21] Less invasive potentiometer was developed to map multiple PD symptoms.[22] The creation of inertial measurement units (IMUs) in the form of accelerometers and gyroscopes enabled accurate identification, classification, and characterization of the aforementioned PD symptoms.[23-25] Accurate assessment of motor fluctuations is crucial for physicians to create a clinical management plan. In-laboratory wearable devices first assessed motor symptoms and their fluctuation via uniaxial accelerometers.[26] Their further development into triaxial accelerometers along with gyroscopes and magnetometers as wearable devices created digital biomarkers for these symptoms[27] and quantified other symptoms such as postural instability[28] and freezing of gait.[29] A study conducted used convolutional neural network techniques demonstrated distinct fluctuations between ON, OFF, and dyskinetic states.[30]

Continuous monitoring became more possible with the use of smartphones as they contain IMU and temperature sensors, wireless communication, global positioning system location, microphones, and customized applications.[31] A recent study tested accelerometers in smartphones and other commercially available devices to report that they were equally effective as laboratory-grade accelerometers in assessing tremor severity in PD patients.[32] Smartphone-based monitoring could be in the form of active tasks the subjects are instructed to do[33] or passively monitoring through the day.[34] Innovative usage of features such as the front camera has led to the detection of hypomimia via selfie photographs.[35] Similarly, using the inbuilt microphone, recent studies employing machine learning techniques have analyzed voice data to study symptoms of hypophonia to predict diagnosis and monitor PD.[36,37] Non-motor symptoms such as REM sleep behavior disorder have been objectively characterized using smartphone sensors.[38]

Arguably, the ultimate goal of technological advancements for PD is continuous, remote, or home-based monitoring via wearable devices, smartphones, or a combination of the two.

This is predominantly because this disease severely hampers patients' quality of life and affects their activities of daily

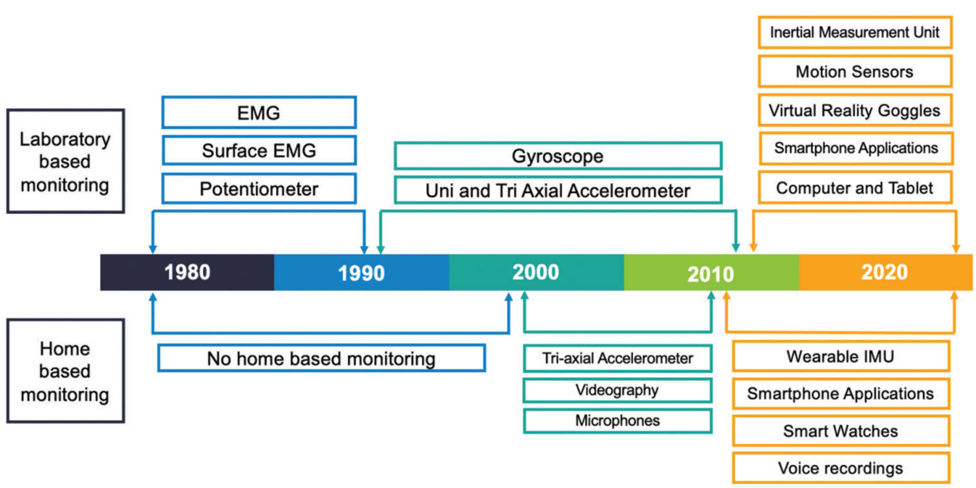

Figure 1: Evolution of Parkinson's disease (PD) technology. The illustration represents the evolution of PD technology during the last five decades in both laboratory-based and home-based environments. EMG = electromyography, IMU = inertial measurement unit

living.[39] Rare or unpredictable events such as falls many times remain uncaptured. A study conducted with home-based wearable devices monitored falls in PD patients.[40] Motor symptoms fluctuations are best understood over a period of time. Therefore, remote wearable devices along with smartphone applications have been used in several studies to monitor ON/OFF fluctuations[41] along with tremors and bradykinesia.[42] The data collected from these devices are vital for physicians to understand disease progression and symptom triggers. They use this information to titrate the patient's medication based on empirical data. Most home-based and free-living studies on technology developed for PD have been well summarized in a systematic review by Morgan and colleagues.[43]

India and PD Technology

The question that remains then is why is the usage of PD technology nonexistent in India? Clinical adoption of digital PD monitoring is still a while away here. This is primarily because of three reasons – lack of research specific to the PD population in India, cost of the digital devices, and limitation of technological capabilities of patients especially in rural areas. A literature review revealed only two studies have been conducted in India in this sub-field. One was a laboratory-based wearable device to analyze turn angles in PD gait. However, the sample size of study was very small ($n = 25$ with 20 healthy controls and 5 PD patients). It was a laboratory-based study where the walkway was level and did not represent the terrain accurately. The device was large and required experts to make the participants wear it. Last, this study only examined gait and knee flexion as a parameter.[44] The other is based on deep learning techniques to classify PD.[45] Secondary reasons for the non-usage of PD technology in India are unawareness of such wearable devices by both physicians and patients as revealed in a study conducted in 2018,[46] low compliance in wearing devices by patients, and unwillingness of physicians to adopt these methods of monitoring.

Current Challenges and Future Directions

Efforts have previously been made in creating low-cost home-monitoring devices for PD.[47] The real challenge, however, remains in creating a cost-effective and simple device. Although smartphones and technology have reached rural areas in India, PD patients are usually a geriatric population who are not as comfortable as young people in using these devices. It is essential to make them user-friendly and integrate them into patients' lives. To avoid non-compliance, sensors are already non-invasive but have the potential to become non-obtrusive so PD patients become more willing to wear such devices. Small, portable, and well-hidden devices with easy charging ports would be ideal in terms of acceptability among patients [Figure 2]. Exceptional success has been seen in devices such as hearing aids as they adhere to these principles.

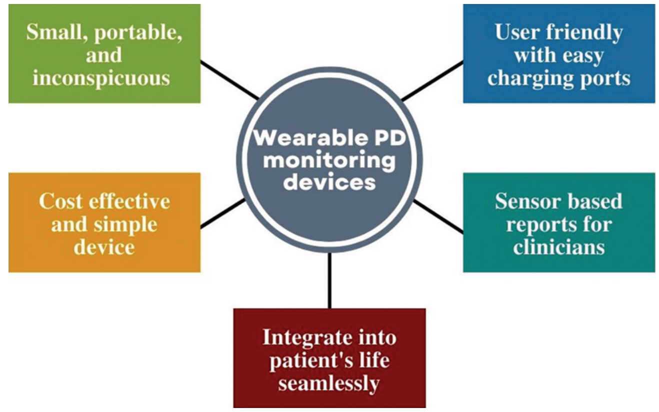

Figure 2: Key features in an ideal Parkinson's disease (PD) wearable device. This schematic represents the key features and ideal qualities of a wearable PD device that will result in high compliance in the Indian population

Another significant issue that would need to be addressed before these digital technologies can be implemented in India is the secure transfer of data from the patient to the physician. However, there are exponential growth opportunities in this field if these concerns are eradicated while creating this home-based monitoring device. It will benefit both patients and physicians. Sensor-based electronic diaries can assist physicians to adjust medications based on objective data resulting in patients having lesser side effects as they would know exact timings of motor fluctuations. This will pave the way for precision medicine in PD. Furthermore, with digital remote monitoring, neurologists will have a wider outreach to the population and be able to treat patients rurally from urban settings. Thus, lessening the burden on the few neurologists practicing in rural areas. It would also reduce the strain of travelling, sometimes very long distances for doctor's visits, and the cost associated with it on both the patient and primary caregiver. With this form of data-based information coupled with telemedicine, the consultations can be more efficient for physicians and regular for patients.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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