Technology Advances in Parkinson’s Disease

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Overview

• Devices for symptom management
• Telemedicine
• Wearable devices and smartphone applications
• Penn Study of Wearable devices and Smartphone applications
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Tremor

- Liftware
- SpillNot
- Readi-Steadi Glove
- GyroGlove
Freezing of Gait

- Laser cane, U-Step walker
- Metronomes
- GaitAid
- Smartphone applications
  - SmartMOVE
  - CuPID
Overview

• Devices for symptom management

• Telemedicine

• Wearable devices and smartphone applications

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Telemedicine

- Delivery of healthcare services and information by electronic methods, mainly two-way video
- Improves patient access to specialty care
- Reduces medical costs
- In the past, required specialized equipment at clinics
- With advances in tele-communications technology, patients can now be seen at home
Telemedicine for PD

• Department of Veterans Affairs (VA) started telehealth in 1968 and has been expanding
  • Currently over 400 veterans with PD receive some form of care by telehealth
  • Large randomized controlled trial performed at Philadelphia VAMC
  • High levels of satisfaction with telehealth. Clinical outcomes were similar between controls and telehealth groups. Travel burden was reduced using telehealth.

• Kaiser Permanente uses virtual visits, including email, phone and video visits
  • 10.5 million in 2013
Overview

- Devices for symptom management
- Telemedicine
- **Wearable devices and smartphone applications**
- Penn Study of Wearable devices and Smartphone applications
Wearable devices

- Electronics worn on the body to collect a constant stream of data
- Sensors with accelerometers, gyroscopes, magnetometers
- Began in specialized movement laboratories studying gait and balance
- Now available for remote monitoring in the home or community
Advances in Wearables

- **Size** – much smaller than large machines used in the past. Allows for data collection in everyday life.

- **Data analysis** – improvements in computer technology, advent of machine learning and “big data” with ability to analyze enormous datasets.

- **Cost/ Accessibility** – Affordable for the everyday consumer compared to large, expensive machines used in the past; sync with smartphones.
How Data is Collected

- **3-axis accelerometer** – tracks movement in every direction
- **Gyroscope** – measures orientation and rotation
- **Magnetometer** – similar to compass, aids in orientation
- Collects 300+ data points per second
- **Signal processing** – cleans up raw data
- **Algorithms** – translate raw data into statistics
- **Application** – present data in user-friendly format
Objectives for Wearables in PD

- Provide objective measures of motor and nonmotor features
- Collect data in more naturalistic setting
- Improve treatment delivery and provide personalized care
- Provide feedback to improve patient engagement
Symptom tracking

- **Clinic visits** – Unified Parkinson’s Disease Rating Scale (UPDRS)
  - Subjective – user dependent
  - Snapshot of symptoms

- **Patient recall**
  - Difficult to accurately recall fluctuating events (falls, freezing of gait, etc)

- **Motor diaries**
  - Cumbersome to complete
Devices for Symptom Tracking

- Sensors can passively track motor fluctuations (OFF, ON, dyskinesias), tremor, falls, freezing of gait 24 hours a day
- Monitor response to treatment
- Contribute to precision medicine
Current Devices

- **Fox Insight Wearables and Mobile App** – Intel and Michael J. Fox Foundation
  - Wearable device and smartphone application
  - Algorithms to measure activity level, tremor, nighttime tracking and gait detection
  - Electronic diary
  - Pebble smartwatch large-scale deployment in Netherlands (Parkinson@Home study)
Global Kinetics Corporation

- Personal KinetiGraph
  - Worn for 7-10 days
  - No smartphone application
  - Medication reminder

- Provides information about bradykinesia, dyskinesia and sleep

- **APRISE study** – first US patient enrolled last month

- Assess device’s role in determining the best medication dosing and timing and evaluate how adjustments to medication regimens affect patient clinical outcomes
Great Lakes NeuroTechnologies

- **Kinesia 360™**
  - Wrist and ankle sensors and smartphone app
  - Measures tremor, dyskinesia and mobility
  - Electronic diary

- **Kinesia One**
  - Tablet and finger sensor (telemedicine)

- **Kinesia ProView**
  - Tablet and finger sensor (response to DBS)
Improving Treatment

**Medical**

- Available: gastrointestinal infusion pumps
- *Goal:* Smart, self-adjusting infusion systems

**Surgical**

- Available: STN and Gpi Deep Brain Stimulation
- *Goals:*
  - Closed-loop DBS systems that vary stimulation based on local field potentials or wearable sensors
  - ON/OFF testing at home
Improving Rehabilitation Interventions

• Sensors with accelerometers, gyroscopes and magnetometer

• Implement closed-loop cueing and feedback systems for home use

• Improve effectiveness and efficiency of physical therapy
Improve Research

- Improved sensitivity of outcomes means fewer participants required
- Improve representation in studies
Challenges

**Big Data**
- Storage
- Analysis

**User Engagement**
- Devices currently not as user friendly as they should be
- Without feedback, engagement is modest at best
- Studies of drop-out
  - 32% of users stopped using wearables after 6 months and 50% after a year
  - 26% of apps are used only once and 74% are not used more than 10 times

Ledger D. Inside wearables 2014
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XEED Devices

- Low-profile, comparable to Fitbit
- Lightweight, weighs about 1 once
- Made with skin sensitive medical compliant material
- Non-invasive, worn on wrists and ankles
- IRB approved for use inside and outside a clinical setting
- Designed to monitor symptoms of Parkinson’s disease
Data from XEED Devices

- Contains accelerometer, gyroscope, magnetometer (inertial measurement unit)
- Acceleration
- Angular velocity
- Limb position
- Body map
mPower Application

- mHealth research application that monitors motor, gait and speech symptoms of Parkinson’s disease
- Designed to help understand causes of variations in symptoms of PD
Study Goals

• Recognize gait and differentiate Parkinsonian gait from controls

• Correlate measures from devices with Unified Parkinson’s Disease Rating Scale (UPDRS)

• Use devices to recognize ON and OFF states
Gait Analysis

• 15 participants with PD, 5 controls

• Data collected: 115 walking hours

• Preliminary analysis:
  • Gait detection
  • Parkinson’s classification
Gait Analysis – Next steps

- Validate algorithms with a second set of data
- ~20 volunteer walkers at Penn Park
Extended Observation

• 8-10 hours of video-taped observation period

• Participants arrive after overnight “washout” of dopaminergic medications

• Measure UPDRS and perform mPower tasks multiple times to capture ON and OFF states

• Analyze data with machine learning algorithms to recognize ON and OFF states

• Determine how many sensors are needed to extract features
Motor Fluctuations

- Shorter visits
- Goal: enroll 100 participants
- Capture one OFF and one ON period with XEED devices, mPower app and UPDRS
- Use similar machine learning algorithms
Meet the research team...

XEED
A prize-winning Penn-based engineering startup

Penn Udall Center
An experienced clinical research team led by a PD doctor and Penn professor