# 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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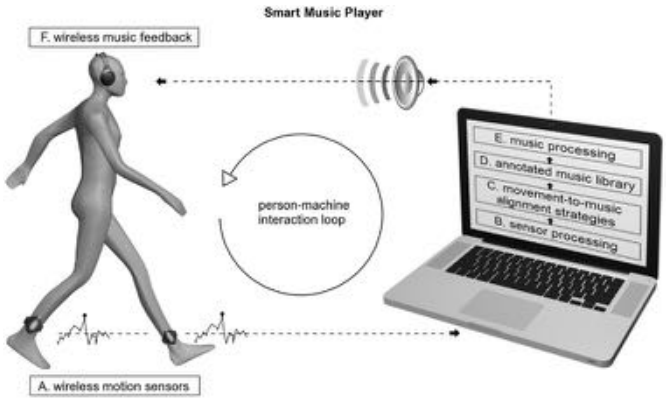
# Tremor

- Liftware
- SpillNot
- Readi-Steadi Glove
- GyroGlove

# Freezing of Gait

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

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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

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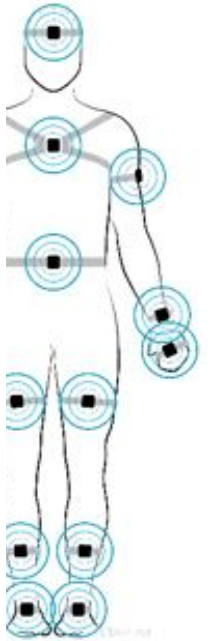
# Wearable devices

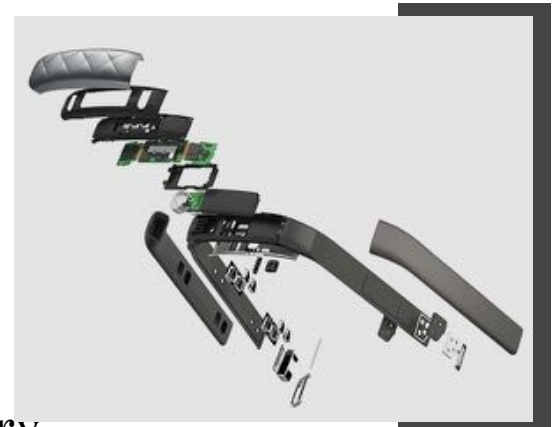
- Electronics worn on the body to collect a constant stream of data
- Sensors with accelerometers, gyroscopes, magnetometers
- Began in specialized movement laboratories studying gait and balance
- Now available for remote monitoring in the home or community



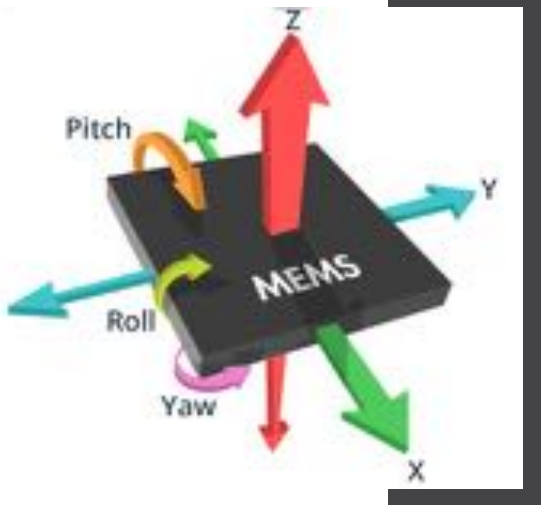
# Advances in Wearables

- **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 forma

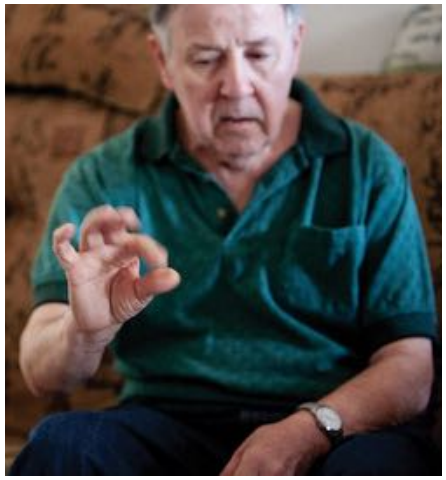


# Objectives for Wearables in PD

- 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



**PARKINSON'S DISEASE DIARY**

NAME_____ DATE_____

Instructions: For each half-hour time period place one check mark to indicate your predominant status during most of that period.
**ON** = Time when medication is providing benefit with regard to mobility, slowness, and stiffness.
**OFF** = Time when medication has worn off and is no longer providing benefit with regard to mobility, slowness, and stiffness.
**Dyskinesia** = Involuntary twisting, turning movements. These movements are an effect of medication and occur during ON time.
**Mild dyskinesia** is non-bothersome (present but causes no difficulty). **Moderate dyskinesia** is troublesome (causes some difficulty with function). **Severe dyskinesia** is disabling (causes great difficulty with function).
Tremor is shaking back and forth and is not considered dyskinesia.

| time | asleep | OFF | ON without dyskinesia | ON with mild dyskinesia | ON with moderate dyskinesia | ON with severe dyskinesia |
|---|---|---|---|---|---|---|
| 6:00 AM | | | | | | |
| :30 | | | | | | |
| 7:00 AM | | | | | | |
| :30 | | | | | | |
| 8:00 AM | | | | | | |
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| 9:00 AM | | | | | | |
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| 10:00 AM | | | | | | |
| :30 | | | | | | |
| 11:00 AM | | | | | | |
| :30 | | | | | | |
| 12:00 PM | | | | | | |
| :30 | | | | | | |
| 1:00 PM | | | | | | |
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| 2:00 PM | | | | | | |
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| 4:00 PM | | | | | | |
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| time | asleep | OFF | ON without dyskinesia | ON with mild dyskinesia | ON with moderate dyskinesia | ON with severe dyskinesia |
|---|---|---|---|---|---|---|
| 6:00 PM | | | | | | |
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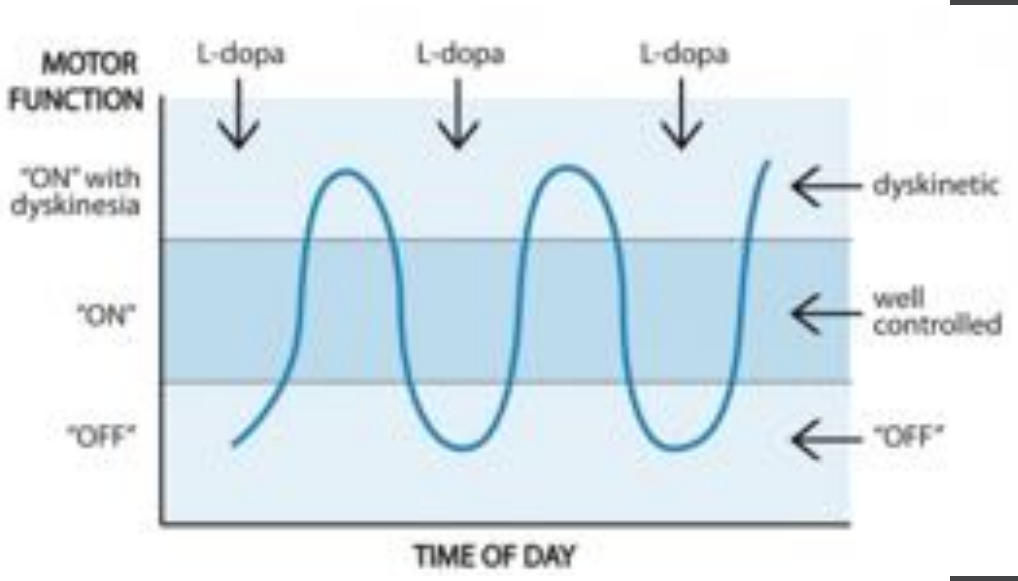
# Devices for Symptom Tracking

- 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)

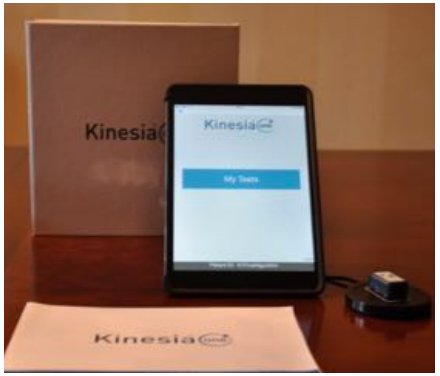

# Global Kinetics Corporation

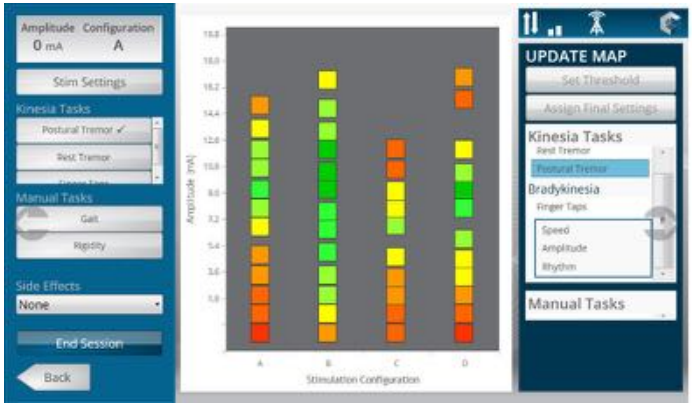
- Personal KinetiGraph
  - Worn for 7-10 days
  - No smartphone application
  - Medication reminder

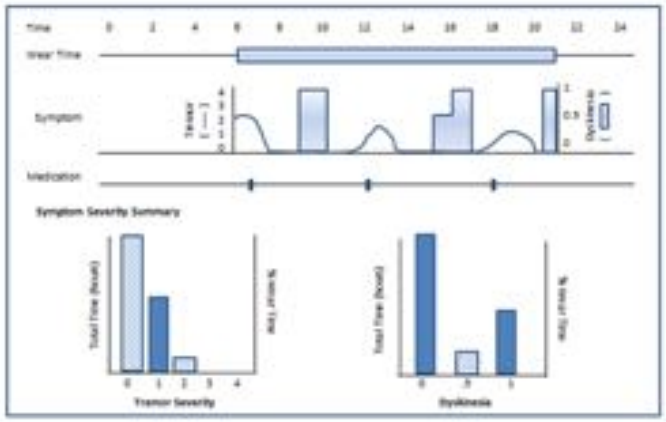
- Provides information about bradykinesia, dyskinesia and sleep
- **APRISE study** – first US patient enrolled last month
- Assess device's role in determining the best medication dosing and timing and evaluate how adjustments to medication regimens affect patient clinical outcomes

# 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**

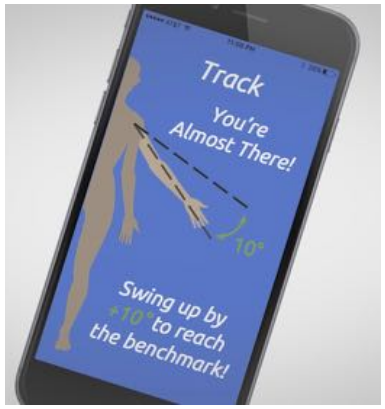
- Available: gastrointestinal infusion pumps
- *Goal:* Smart, self-adjusting infusion systems

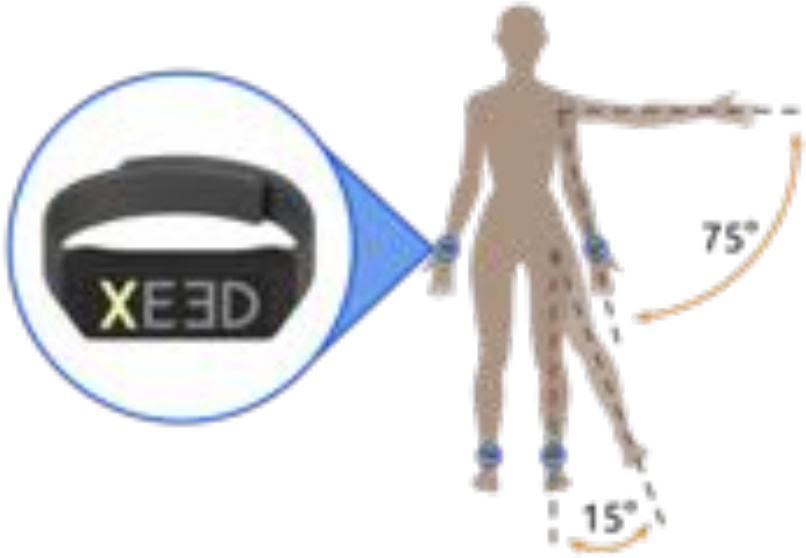
**Surgical**

- 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
Consumer Intelligence Series: The WearableFuture http://www.pwc.com/us/en/retail-consumer/publications/assets/pwc-cis-wearable-future.pdf

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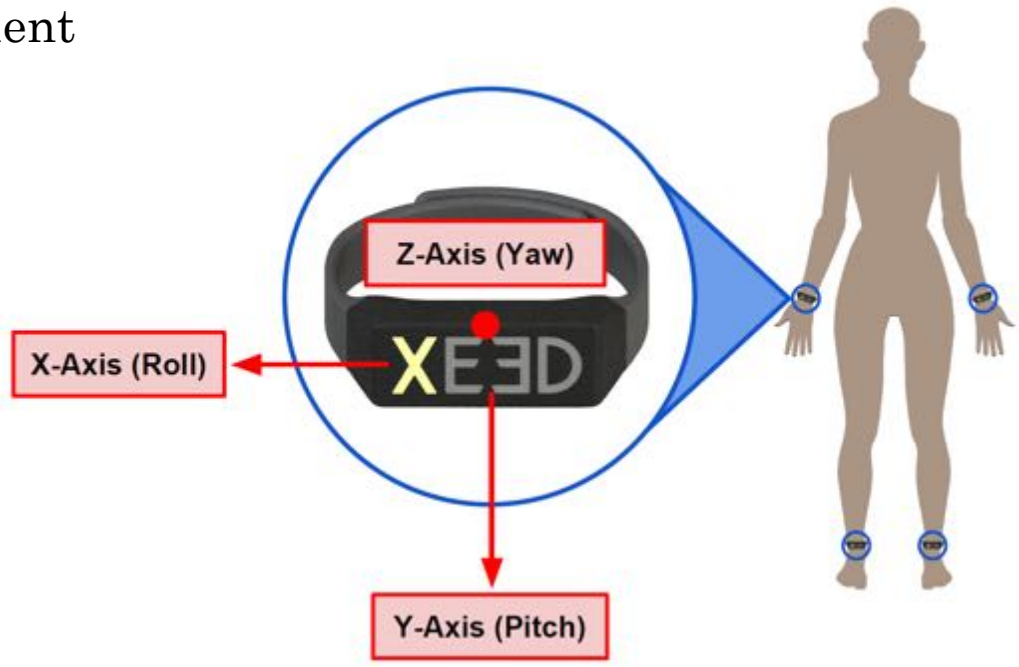
# XEED Devices


- 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

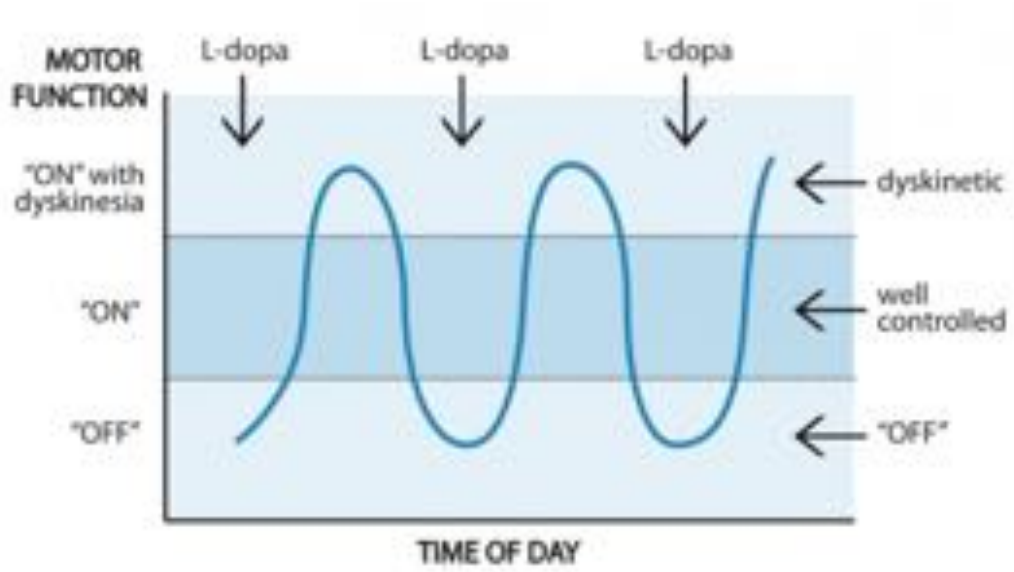


# mPower Application

- 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

PRESIDENT'S INNOVATION PRIZE
UNIVERSITY of PENNSYLVANIA

Created by Penn President Amy Gutmann to strengthen the University of Pennsylvania's commitment under the Penn Compact 2020 to innovation, the President's Innovation Prize will provide a graduating Penn senior, or team of graduating seniors, $100,000 (plus a $50,000 living stipend per team member) to envision and implement an innovative, commercial venture that makes a positive difference in the world.

Morris K. Udall Centers of Excellence for Parkinson's Disease Research

NIH

## Penn Udall Center

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