Wearable Sensors for Balance and Mobility in Adults with Parkinson's Disease: A Systematic Review

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Objectives

- Present background and purpose of the use of wearable sensors in detecting balance and mobility for adults with Parkinson’s Disease.
- Provide an overview of materials and methods.
- Discuss the results and drawn conclusions of research.
- Highlight the significance and clinical relevance of sensor use for adults with Parkinson's disease.

Background

- Parkinson's disease is a progressive neurological disorder in which dopamine levels are decreased, causing a broad range of motor and non-motor impairments.[1]
- Common motor impairments include tremor, bradykinesia, gait dysfunction and dyskinesia.[1]

Background

- Recent advancements in wearable technology have allowed for:
  - Easier accessibility[1]
  - Increased precision[1]
  - Increased accuracy of these devices[1]
- Many possible applications in PT clinical practice. [1]

Background

- No systematic reviews exist exploring the described topic.[1]
- Numerous studies exist assessing the use of wearable technology in evaluation and management of impairments and functional activity limitations in patients with Parkinson's disease.[1]

Background

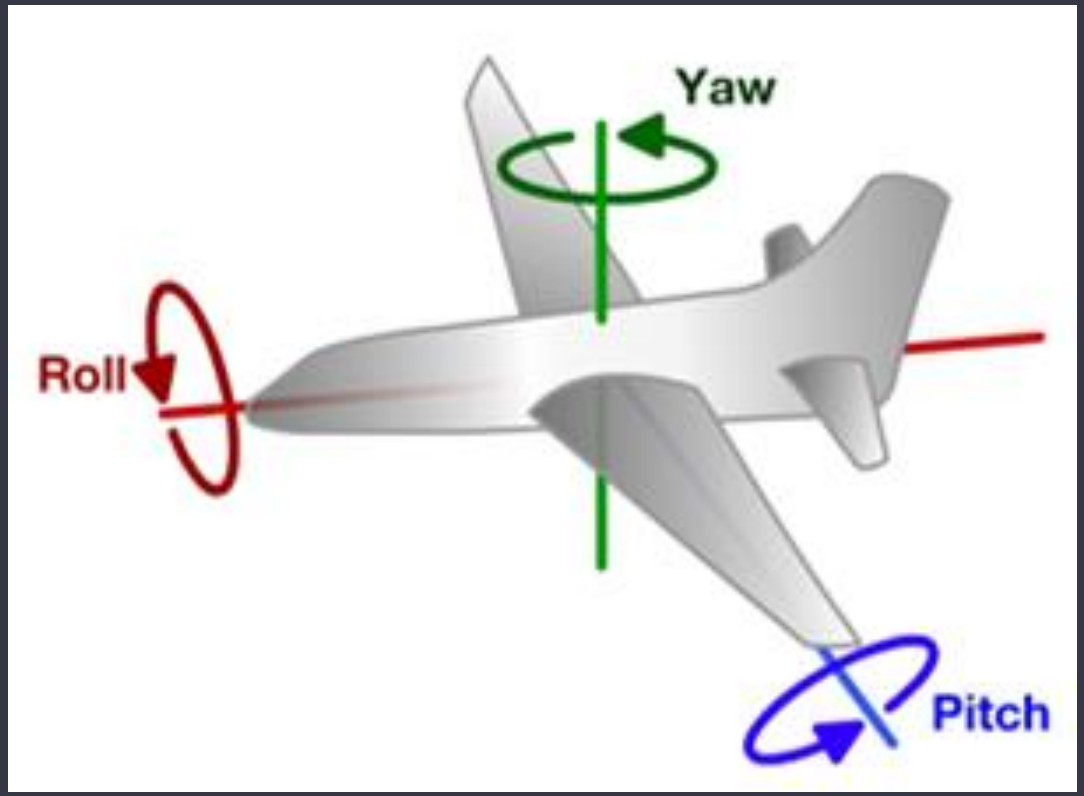


Image from: https://www.touringmachine.com/Articles/aircraft/6/

Figure 1: Depiction of roll, yaw, and pitch demonstrates the data collected by gyroscope
sensors.

Background

Figure 2: Depiction of body worn sensor for accelerometer data collection on a patient with stroke.

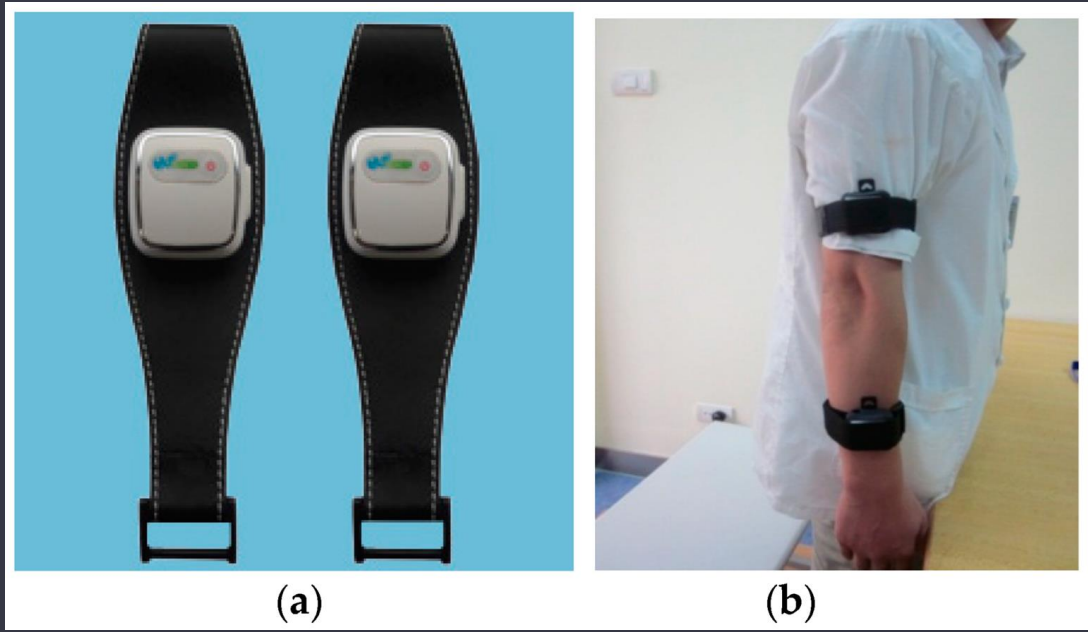


Image from: https://www.mdpi.com/1424-8220/16/2/202/htm

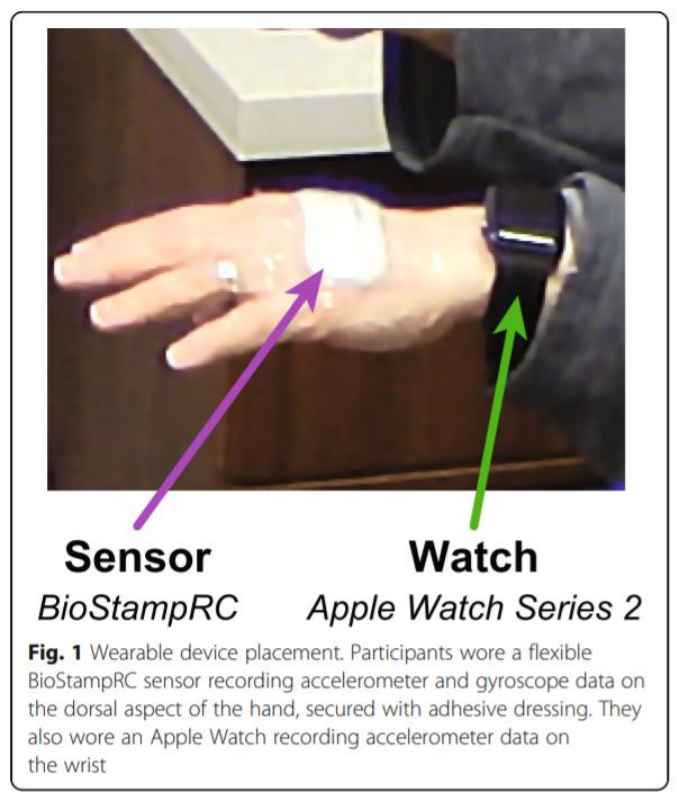


Fig. 1 Wearable device placement. Participants wore a flexible BioStampRC sensor recording accelerometer and gyroscope data on the dorsal aspect of the hand, secured with adhesive dressing. They also wore an Apple Watch recording accelerometer data on the wrist

Image from: Shawen, et. al.[9]

Figure 3: Depiction of body worn sensor for accelerometer and gyroscope data collection on a patient with PD.

Materials and Methods

Purpose

The purpose of this systematic review was to evaluate use of wearable sensors during examination and intervention for balance and mobility in adults with Parkinson's Disease (PD).

Materials and Methods

Databases:

- CINAHL
- Cochrane Library
- MEDLINE/PubMed
- ProQuest Central
- Wiley

Materials and Methods

Search Terms:

(Parkinson's OR Parkinson's Disease OR Parkinson Disease OR Parkinsons OR Parkinsons Disease OR PD)
AND (smart sensors OR smart wearable sensors OR wearable movement sensors OR wearable technology OR wearable sensor OR wearable body sensor OR body worn sensor OR accelerometer)
AND (Physical Therapy OR PT)

Materials and Methods

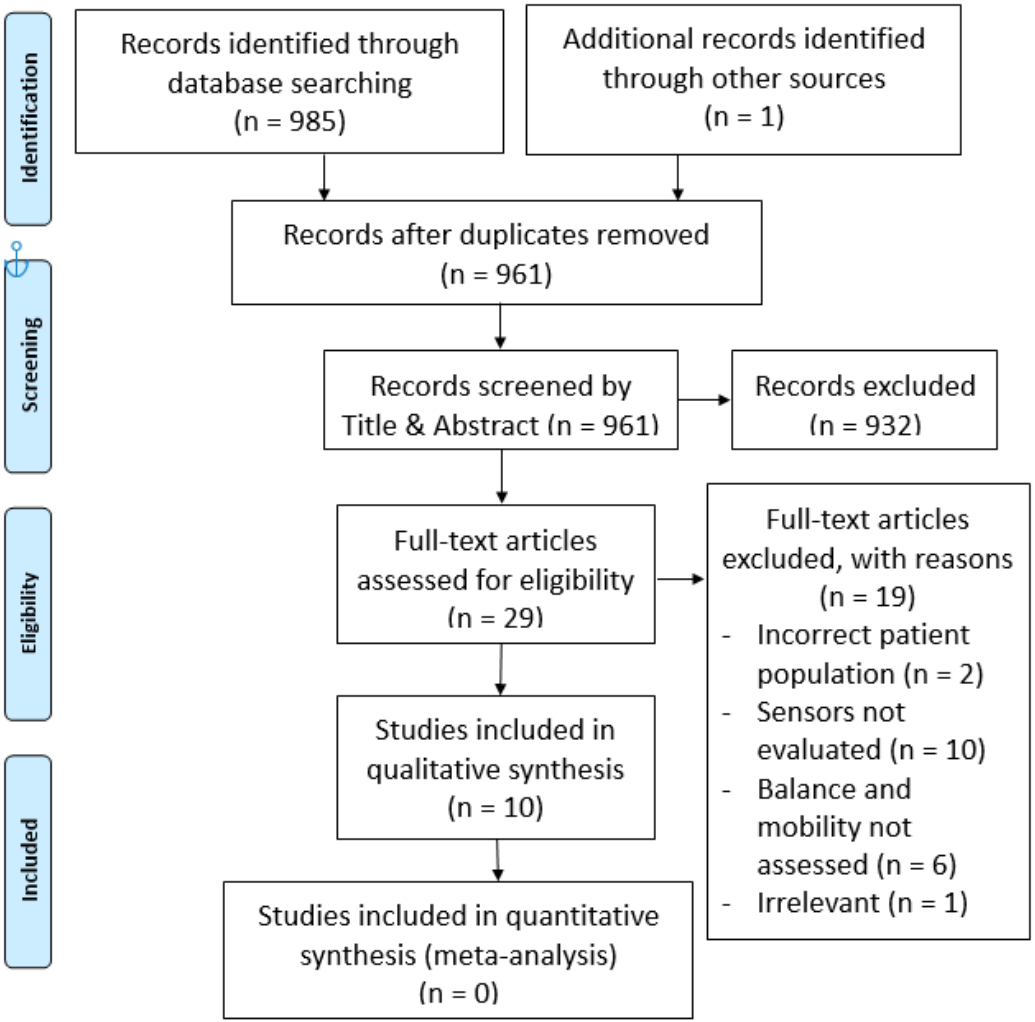
Search limits: human, English, peer-reviewed

Selection criteria:

- Diagnosis of PD
- Presence of ≥1 outcome for balance and/or mobility
- Use of body worn sensors to analyze movement kinetics and kinematics

Methodological quality: two independent reviewers, consensus using Oxford CEBM Levels of Evidence (2011)

PRISMA


Identification
Screening
Eligibility
Included
Records identified through database searching (n = 985)
Additional records identified through other sources (n = 1)
Records after duplicates removed (n = 961)
Records screened by Title & Abstract (n = 961)
Records excluded (n = 932)
Full-text articles assessed for eligibility (n = 29)
Full-text articles excluded, with reasons (n = 19)
- Incorrect patient population (n = 2)
- Sensors not evaluated (n = 10)
- Balance and mobility not assessed (n = 6)
- Irrelevant (n = 1)
Studies included in qualitative synthesis (n = 10)
Studies included in quantitative synthesis (meta-analysis) (n = 0)

Results

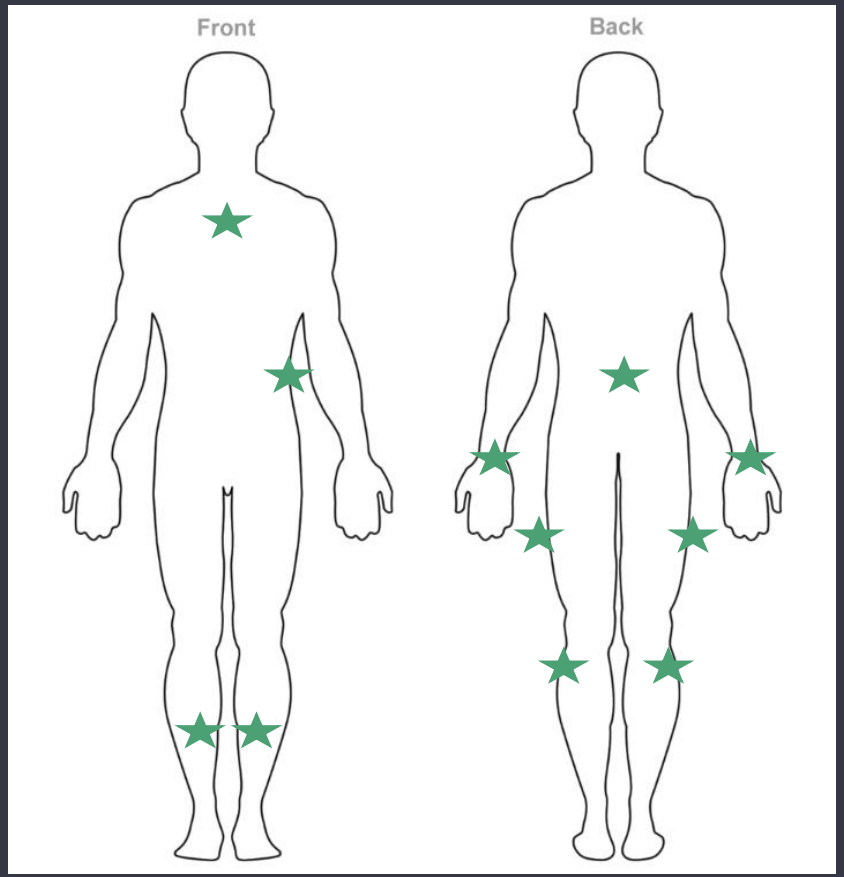
Results

- Total articles screened: 986
- Articles meeting selection criteria: 10
- Levels of evidence: II - IV
- Sample sizes: 10-263 (926 total)
- Age range: 40-85 y/o when provided
- Hoehn & Yahr: I-IV

Results

- Types of body worn sensors:
  - Triaxial accelerometers (n=10)[2-11]
  - Gyroscopes (n=8)[2-3, 5-10]
- Sensor positions:
  - Trunk and pelvis (n=9)[2-8, 10-11]
  - LEs (n=2)[7,11]
  - Dorsal hand (n=1)[9]

Figure 4: Depiction of locations of body worn sensors used in the reviewed studies.



Results

- Categories of articles:
  - Differentiation between PD subtypes (n=2)[2,3]
  - Assessment of fall risk (n=2) [4,5]
  - Assessment of movement strategies (n=3) [6-8]
  - Assessment of tremor and bradykinesia (n=1) [9]
  - Interventions using sensors (n=2) [10-11]

Results

- Two studies (Level II-III):
  - The studies differentiated between Postural Instability Gait Difficulty (PIGD) and Tremor Dominant (TD) subtypes of PD.[2,3]
  - PIGD group had significantly greater duration, number of steps, and turning yaw during the iTUG (Level III)[3] Significantly decreased daily-living physical activity (Level II).[2]

Results

- Two studies (Level II-III):
  - Both studies compared fallers to non-fallers.[4,5]
  - Significant differences seen in gait quality, but not quantity (Level II).[5]
  - Sensors provided early detection of fall risk for non-fallers (Level II).[5]
  - Dual-task walking data showed significant between-group differences in gait speed and stride length (Level III).[4]

Results

- Three studies (Level III-IV):
  - Sensors detected mobility impairments in individuals with PD compared to healthy groups.[6,7,8]
  - Differences were seen in sit - to - stand and sit - to - walk transitions, overlapping turning strategy during the TUG, and decreased postural control.[6,7,8]

Results

- One study (Level III):
  - This study assessed the capability of sensors to detect tremor and bradykinesia.[9]
  - Bradykinesia is best assessed with an accelerometer and gyroscope combination.[9]
  - Accelerometers alone are sufficient to assess tremor.[9]

Results

- Two studies (Level II-IV):
  - Use of sensors provided no significant advantages in enhancing:
    - Balance interventions[10,11]
    - Mobility interventions[10,11]

Conclusions and Clinical Relevance

Conclusions

- There is moderate to strong evidence to support the use of sensors to enhance examination of patients with PD.[2-11]

Conclusions

- Body-worn sensors were effective in:
  - Examination of balance and mobility in patients with PD to define subgroup differences (Level II-III)[2,3]
  - Prediction of fall risk (Level II-III)[4,5]
  - Measurement of movement strategies (Level II-IV)[6,7,8]

Conclusions

- Strong conclusions cannot be made about assessment of tremor (Level III).[9]
- Sensor use during intervention did not provide an advantage (Level II-IV).[10,11]

Conclusions

Further research should include:

- Comparison of sensor diagnostics to Hoehn and Yahr stages
- Evaluation of sensor clinical utility

Limitations

- Small, heterogeneous sample sizes
- Sensor application variations
- Repeated authors through accepted studies

Clinical Relevance

- Healthcare professionals treating patients with PD may consider utilizing body worn sensors to improve objective measurements of balance and mobility.
- Sensor data collection was more accurate, sensitive, and specific in detecting PD severity than clinical outcome measures.

Clinical Relevance

- Current research supports feasibility of sensor use in clinical settings; but cost may limit adoption.
- Sensors are easy to attach, lightweight, and small, and have the potential to enhance long-term management of PD.

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Questions?