Using technology to assess, understand and treat gait impairments in Parkinson's disease – a review of recent studies

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BACKGROUND

- Gait disturbances play a major role in the motor manifestation of Parkinson's disease (PD). Alterations in the gait pattern can already be detected in recently diagnosed, de novo patients, even before any visible or symptomatic gait disturbances are reported and these tend to deteriorate over time with a wide range of gait impairments apparent among persons with PD.

- In recent years, technological advancements enabled a more sensitive and objective gait assessment in the real-world providing more insight into how gait impairments affect function and the quality of life of people with PD. The mechanism of gait disorders has also been further explored increasing the understanding of the complexity of gait impairments while many studies investigated the utility of technology as intervention tools to enhance gait in PD.

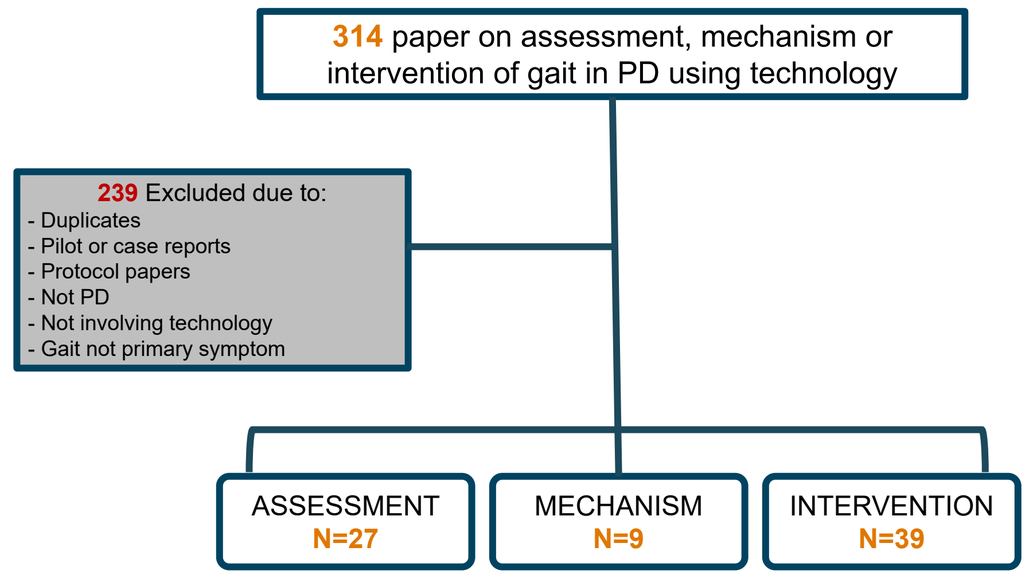
OBJECTIVES

- **To summarize the evidence published in the past year (Jan 2022-May 2023) on the promise of technology on three fields of gait research: Assessment; Mechanism and Interventions.**

METHODS

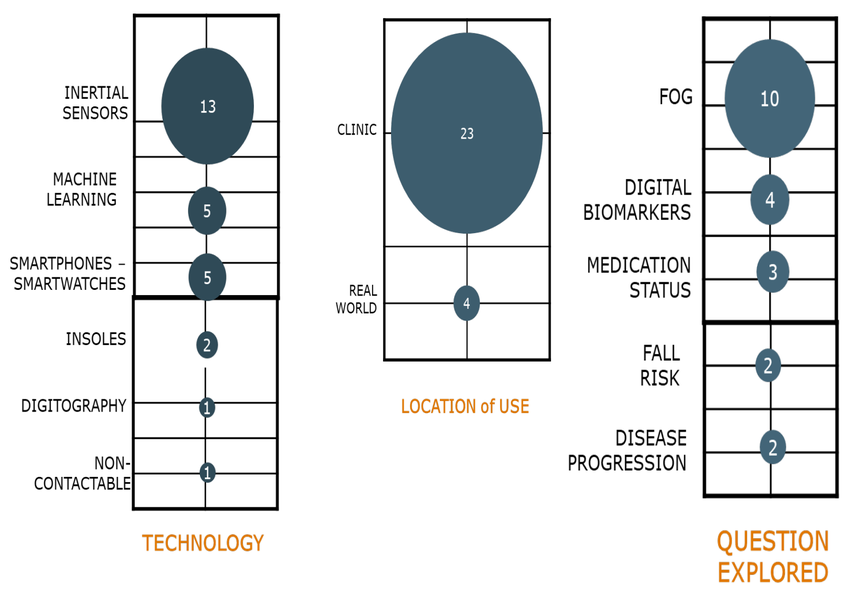
- We selected papers which addressed the promise of technology to facilitate precise and objective assessment and better understanding of mechanism of gait impairments and on technologies that foster personalized treatment approaches.

- We searched pubMed, cinahl and google scholar using mesh words: “digital”, “wearable sensors”, “technology” assessment”, “mechanism”, “intervention”, “exercise”, “gait”, “Parkinson’s disease”.

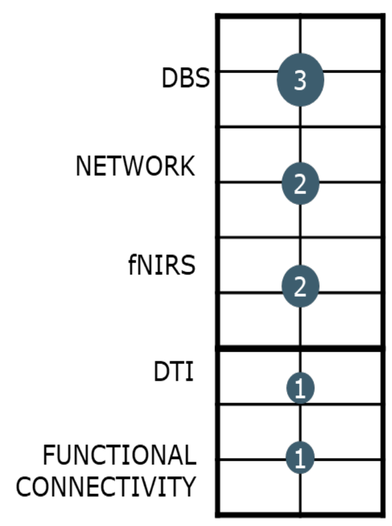


RESULTS

ASSESSMENT



MECHANISM



INTERVENTION

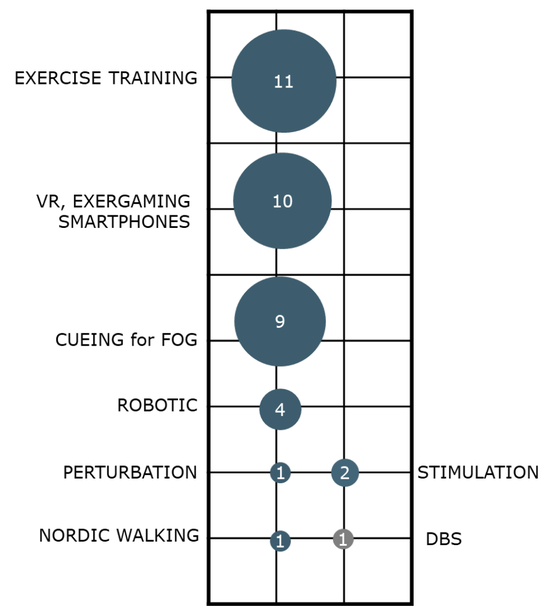


Figure: The circles in the graphs represent the number of papers reviewed in each category.

The complete list of references used in this mini-review is detailed in the below QR code.

SUMMARY AND CONCLUSIONS

ASSESSMENT

- Some quantitative measures of gait and balance in PD, obtained with wearable sensors are reliable and valid, and can be used to characterize motor impairments in PD.

- Machine-learning approaches may be used to differentiate disease stages in cross-sectional studies, but cautiously.

- Longitudinal studies monitoring gait and balance are scarce.

- Technology not based on wearable sensors, such as 2D video and foot insoles, are also emerging as unobtrusive methods to measure gait. However, larger studies are needed.

- There is a growing body of work on the use of technology to derive digital biomarkers that are meaningful for the clinical management of persons with PD, however:

  1. Need studies on specificity of gait changes with respect to ageing
  2. Aggregated data points and use of imputations obscure possible interpatient variance and may lead to false conclusions
  3. Need of sizeable longitudinal datasets
  4. Need for “personalized models” accounting for different phenotypes of PD

MECHANISM

- Support for the association of non-motor and neuropsychiatric symptoms (e.g., depression, anxiety and fear of falling) with gait changes.

- Specific cognitive features, (e.g., task switching / dual task decrements) are associated with gait features. Whether these associations are related to distinct or share a common neural basis is not clear.

- Gait training may modify functional connectivity improving compensatory processes in PD gait control.

Deep Brain Stimulation (DBS) and Freezing of gait (FOG)

- Evidence of beneficial long-term effects of STN-DBS on gait measures with some initial evidence on improvement of FOG.

- Moderate evidence of improved neuromuscular robustness after bilateral STN-DBS in a small group of individuals with PD.

- Digital measures of freezing characterize freezing severity and % time spent frozen. However, they are mainly used in research settings.

- Assessment of turning- in-place with wearable sensors may identify prodromal FOG prior to clinically-observable or patient-perceived FOG.

- Disruption of global and local topological organization in structural brain networks and functional connectivity density in several brain regions involved in action planning, motion processing, emotion, cognition, and object recognition was related to FOG.

INTERVENTIONS

- Non-pharmacological interventions show beneficial effects on gait and postural control with evidence of profound effects on brain physiology.

- Exergaming, Dual Task and non-immersive virtual reality rehabilitation show favorable effects over conventional therapy. Robotics training can improve specific gait measures, but gains were not transferred to function and were not superior to active control interventions.

- Studies evaluating cueing showed effects on gait but not on overall FOG symptoms at group-level highlighting the need for a personalized approach for the treatment of FOG.

- Spinal cord stimulation, single session tDCS, and perturbation training reported negative or minimal effects for improving gait and balance.

- Split-belt treadmill gait training proved to have better effects on gait adaptation than traditional treadmill training. Split-belt treadmill gains are predicted by better cognition.

- The GALOP committee is an advisory committee to the Michael J. Fox Foundation for Parkinson's research. The committee comprises a person with PD living with gait issues and experts in the field of gait, from academia and clinical care, who aim to progress research and treatment of gait impairments.

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