

Function of Gait in Movement Disorders

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International Parkinson and
Movement Disorder Society
Asian & Oceanian Section

A new objective assessment of Freezing of Gait

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Freezing of gait (FOG) - clinical impact

Perceived cause of falls, N=225; #falls = 805

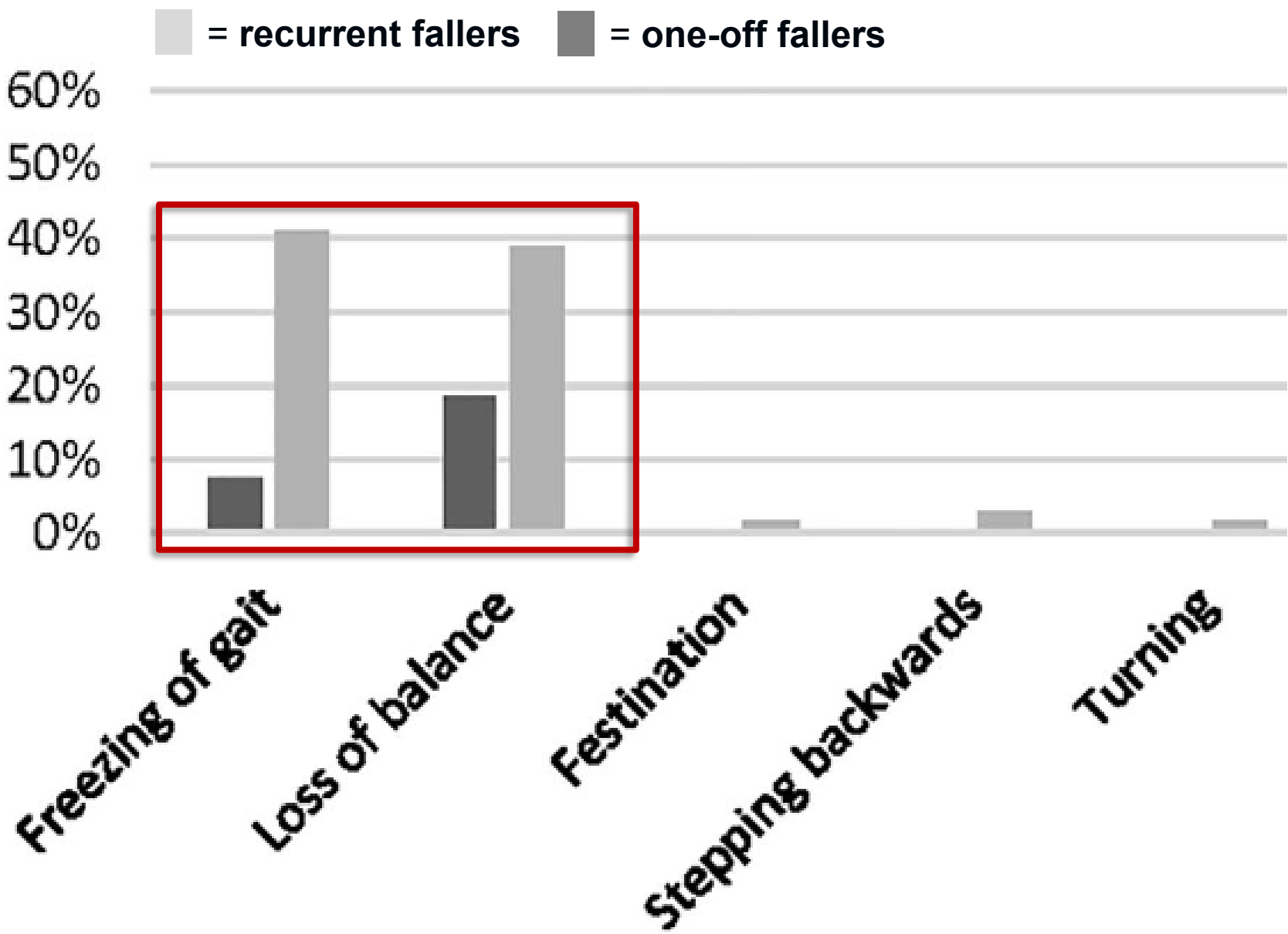


Table 3 Correlations between FOG measures and PDQ-39 subscales

	FOG-Q total	FOG-Q question 3
Mobility	0.801**	0.665**
Activities of daily living	0.560**	0.526**
Emotional well-being	0.352**	0.278**
Stigma	0.254**	0.210**
Social support	0.352**	0.303**
Cognitions	0.279**	0.250**
Communication	0.424**	0.441**
Bodily discomfort	0.369**	0.309**

* $p \leq 0.05$

** $p \leq 0.01$

Urgent need for robust assessment tools

Challenges of FOG assessment



1. Lack of a solid definition of freezing



2. Recall of self-reported freezing severity

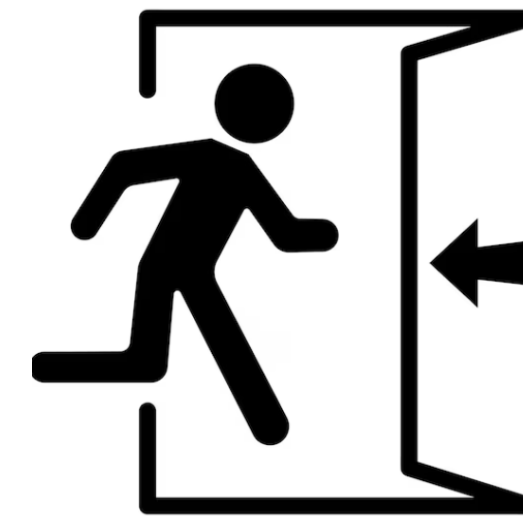


3. Robust rating of observed freezing severity



4. Many validity issues with automated freezing detection

Freezing is elusive



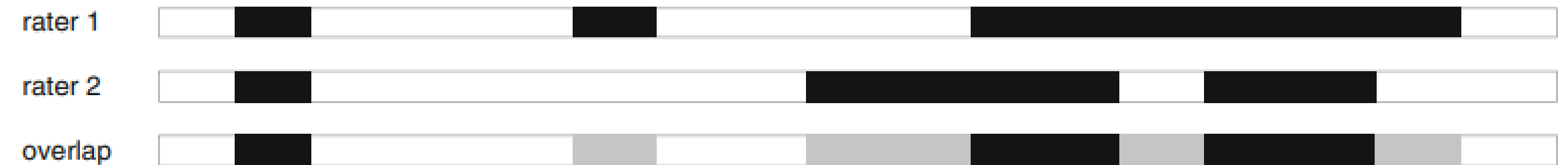
Definition → what is freezing?



→ % Time Frozen

Video annotation → poor interrater reliability

→ time consuming



Challenges

1. Heterogeneity of the episodes
2. Absence of stepping? Concurrent motor phenomena?
3. Lack of standardization

Self-reported freezing severity



FOG-Q



NFOG-Q



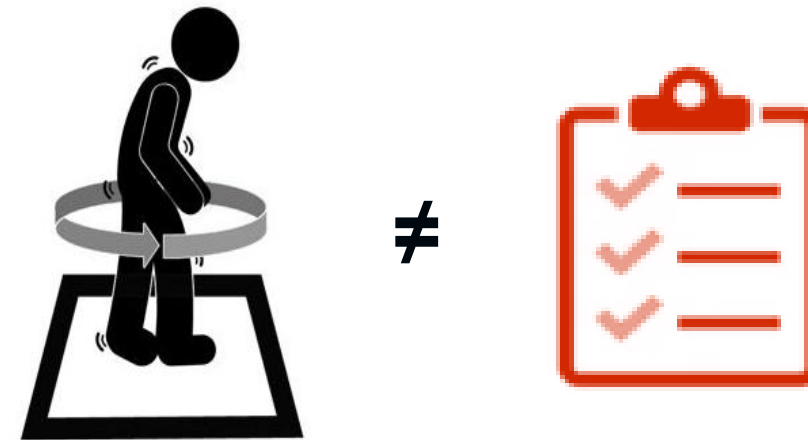
C-FOG

3 patient-reported questionnaires

Researchers → item selection

Test-retest reliability modest to good

Minimal detectable change → 35%



Mismatch between self-report & observed FOG → 79% unaware

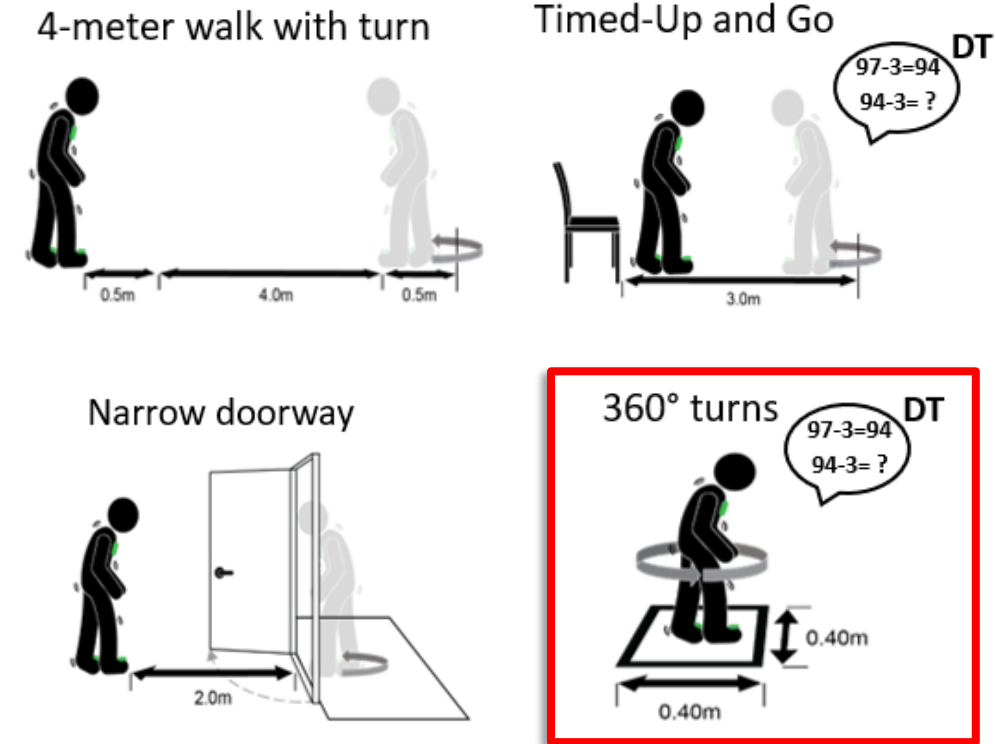
Challenges

1. Patient meaningfulness?
2. FOG impact daily life & emotional state
3. Psychometric validation

Observed freezing severity



14 clinician-rated protocols, real-time or video



Testing both ON & OFF → consistent triggering of FOG in 95.8%

Different protocols – difficulty of triggers?

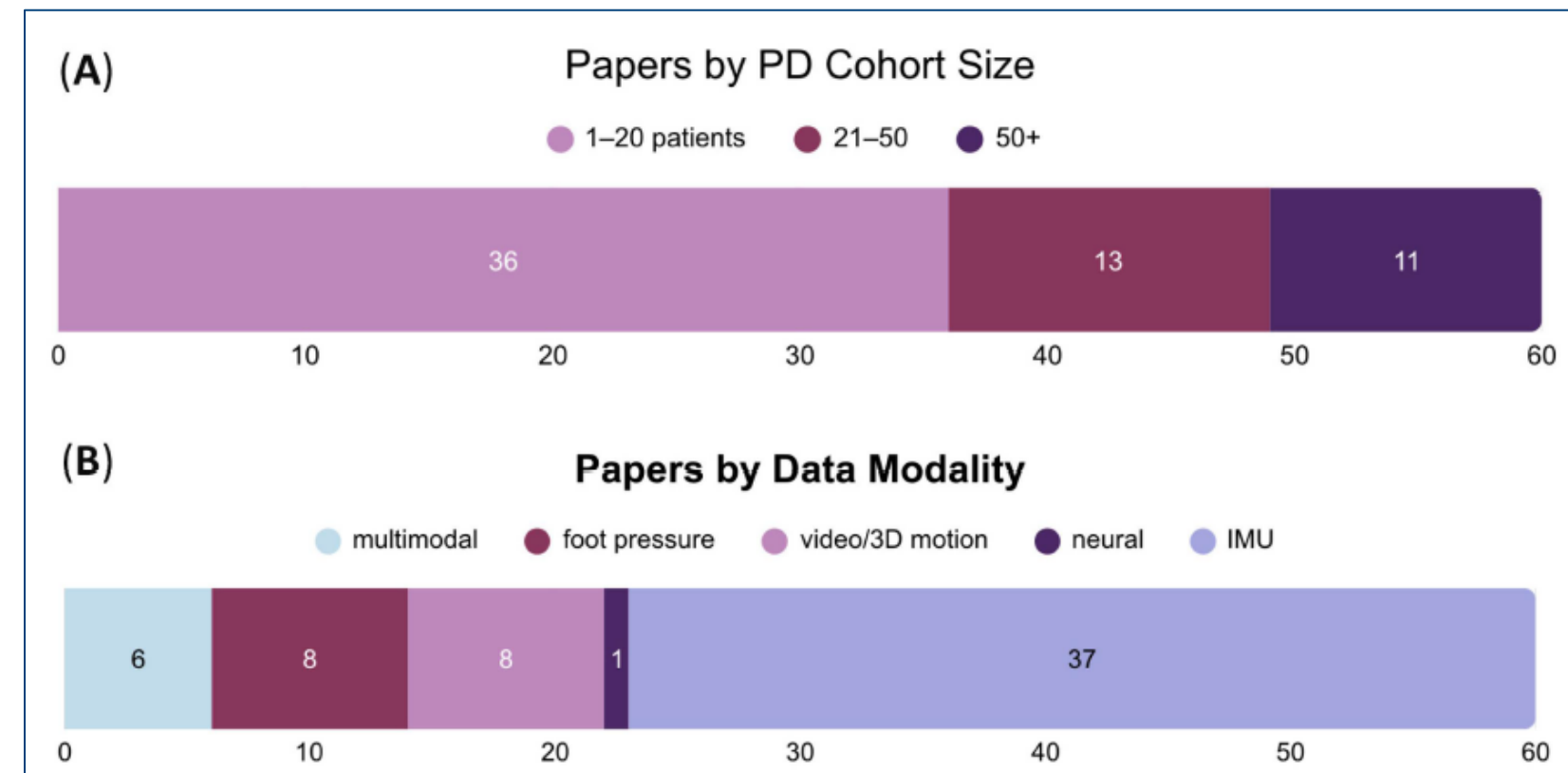
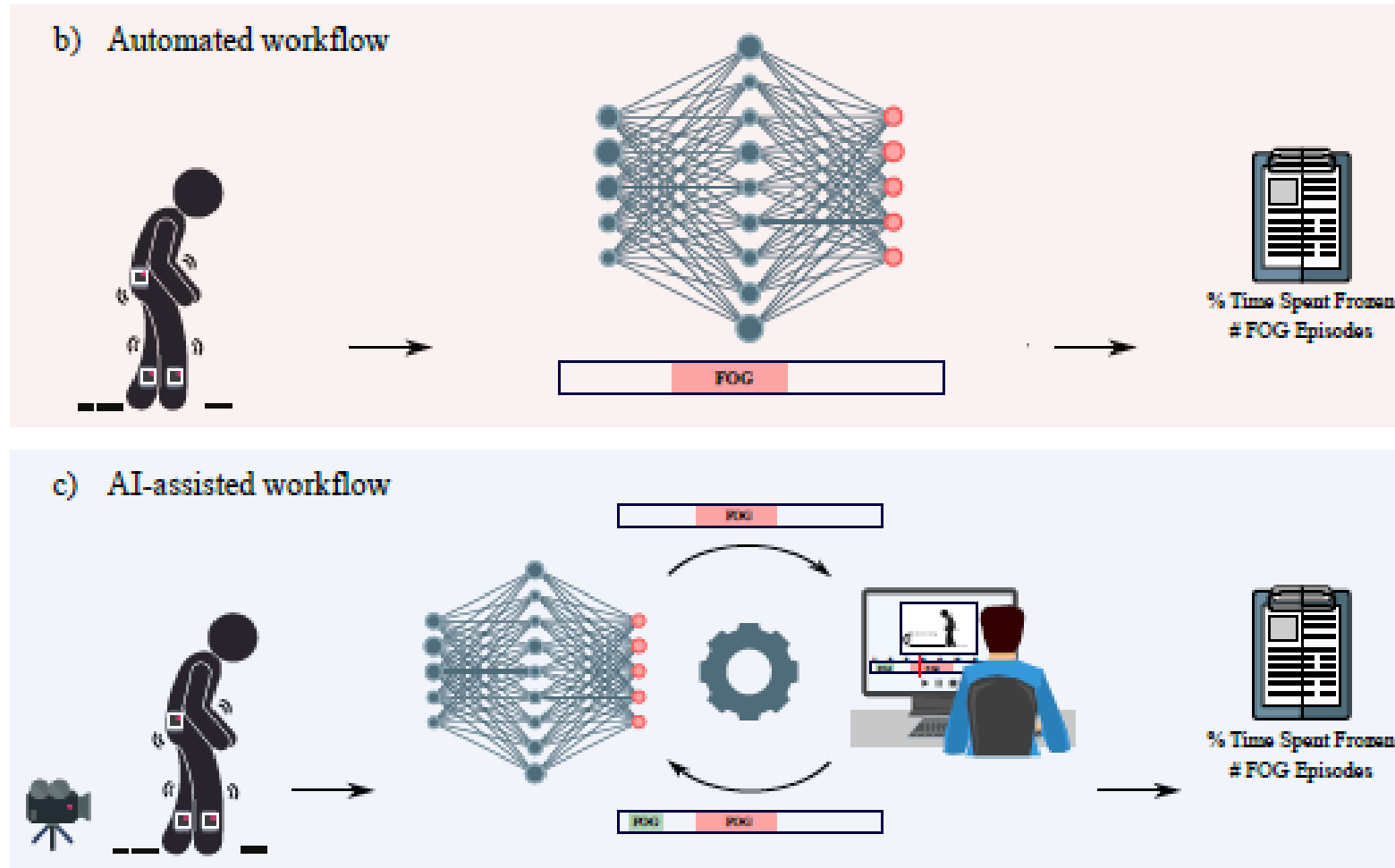
Different constructs of severity (phenotype? ...)

Different rating systems

Challenges

1. Task-dependent reliability → best protocol?
2. Best metric - frequency or duration?
3. Responsiveness of 'in-clinic' testing
4. Fit for purpose – trial endpoint?

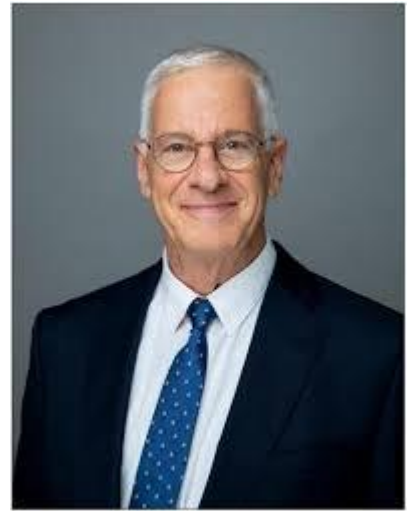
Automated freezing detection



Challenges

1. Validation against 'the' gold standard
2. External validity → different data sets?
3. Transfer from machine learning environment to other settings?

Scoping review - 60 machine learning algorithm papers
↓
Diversity of models: 22/60 based on a pre-labeled dataset



< **Funded Studies**  **Save for later**

Developing Outcome Measures for Assessing Freezing of Gait: A Multi-Center Study

- 7 consortium partners in 5 countries
- N=107 people with FOG and 43 without FOG
- Both ON and OFF testing – 2X

New clinical outcome assessments of FOG



1. Definition of FOG → validity video annotation



2. New patient reported outcome → PRO



3. New clinical Giladi-protocol → ClinRO



4. Algorithm validation of technology-based detection



1. New clinical definition of FOG

Paroxysmal episodes wherein there is an inability to step effectively, despite attempting to do so



Sudden occurrence



‘Effectively’ = judged by the assessor
against benchmark of typical, or quasi-
normal stepping in the same individual



Attempt = observable by the
human eye or sensor technology
or verified by self-report

Manifestations

Akinetic → No clinically observable movements in the lower limbs

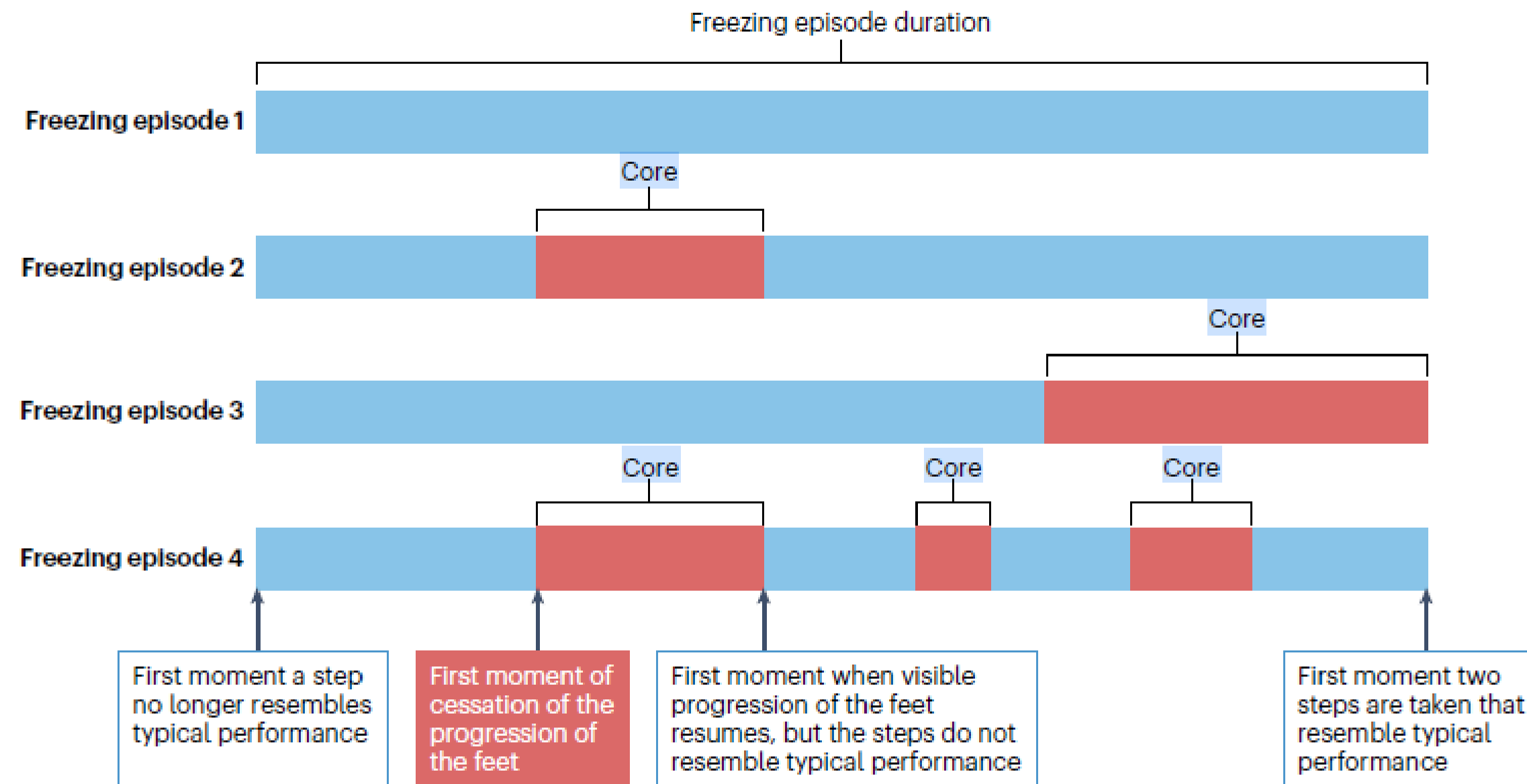
Kinetic-trembling → Fast oscillatory movements in the lower limbs

Kinetic-no-trembling → Other non-trembling ineffective movements, including paroxysmal shuffling and festination



1. New technical definition of FOG

An episode can include cores and periods of ineffective stepping

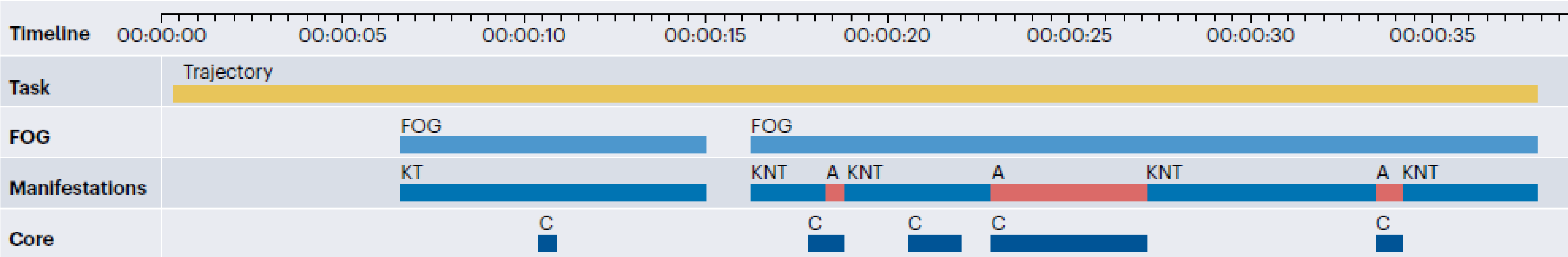




1. Annotation based on technical definitions

Towards standardized video annotation → onset, termination, manifestation

Training & certification →reliability study ongoing



Towards a harmonized FR/NFR classification → possible, probable, definite

2. New FOG-QoL questionnaire - PRO



Cognitive Interviews

N = 41

People with Parkinson's
disease and FOG

Phase 1 survey → mapping concept of interest and context of use

Phase 2 interview

1. Patient characterization of FOG experience
2. Assessing comprehension, completeness en relevance
3. Mapping FOG-experience on FOG-QoL items

Develop strong contents
and construct validity

Freezing of gait negatively affects my emotions

0 = never

1 = rarely

2 = sometimes

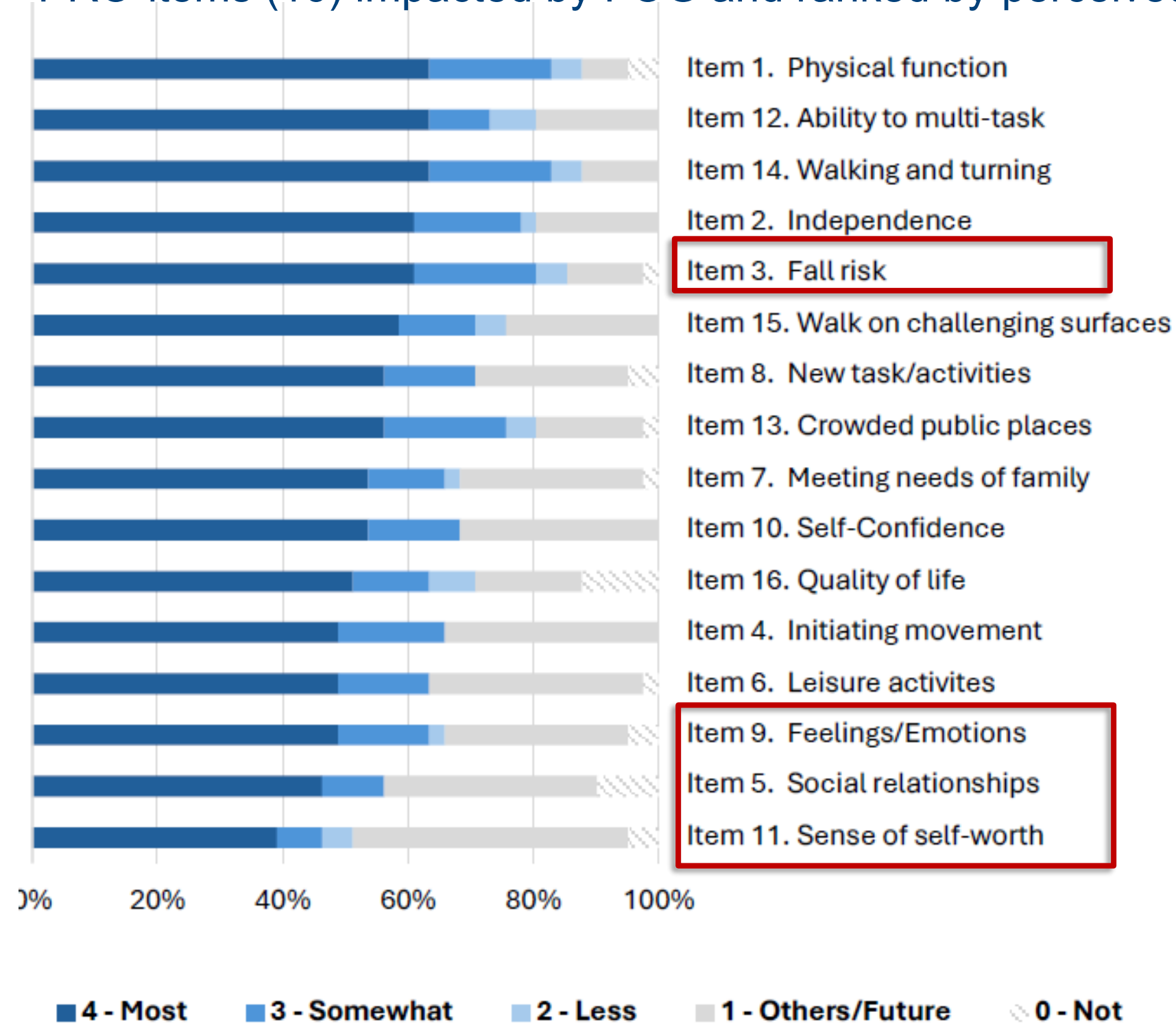
3 = often

4 = almost always



2. New FOG-QoL questionnaire - PRO

PRO-items (16) impacted by FOG and ranked by perceived relevance of patients



Convergent validity

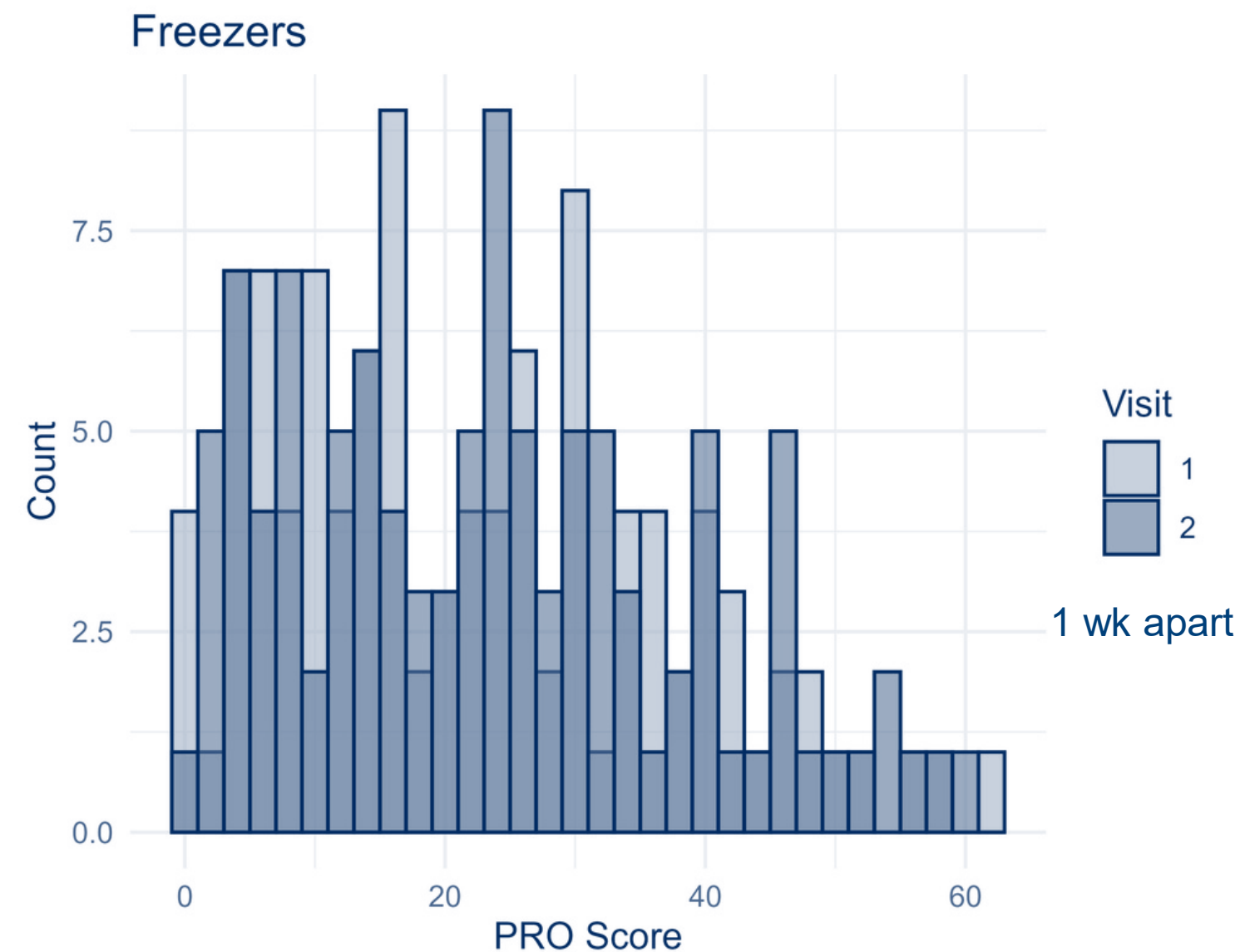
NFOG-Q → $\rho = 0.75$ $p < 0.001$

PDQ-8 → $\rho = 0.49$ $p < 0.001$

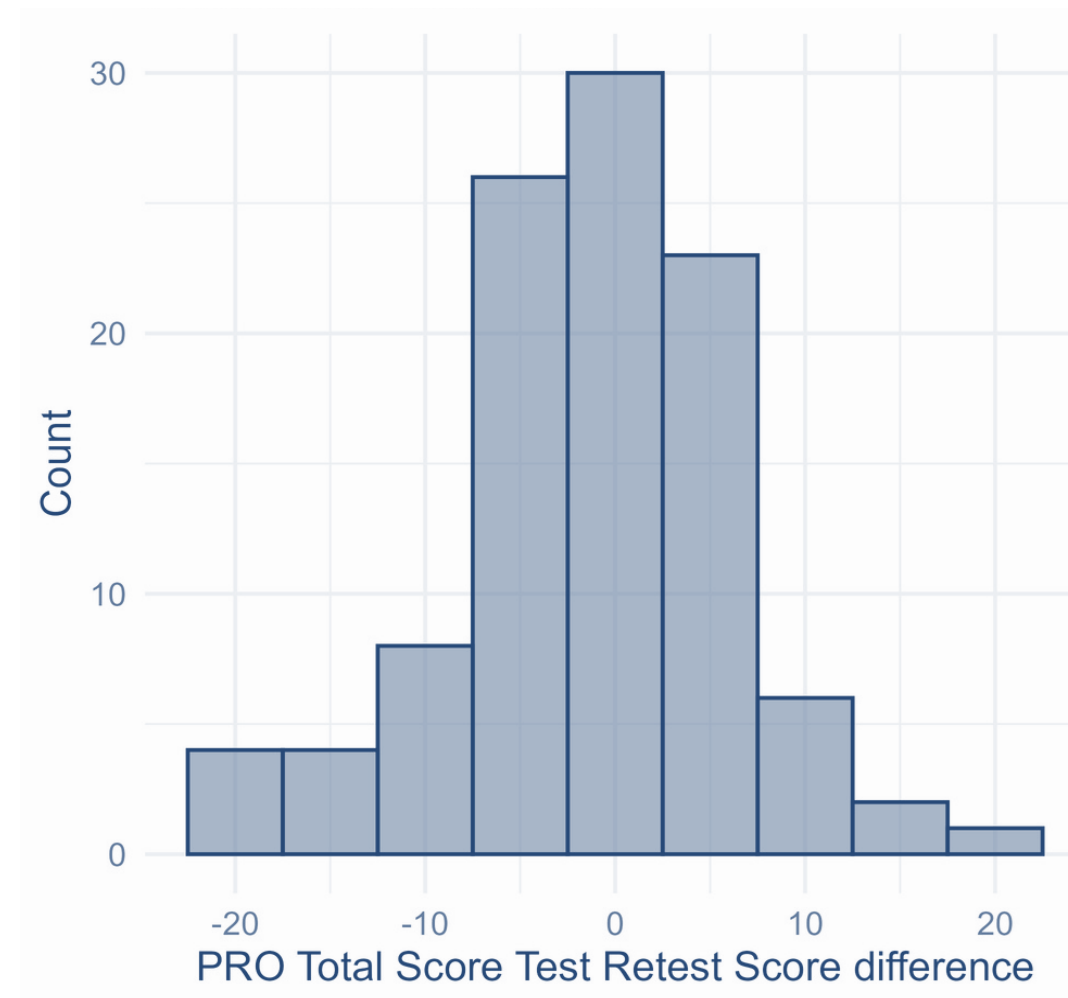
Divergent validity

Tremor → $\rho = 0.01$ NS

The FOG-QoL test-retest reliability



ICC3,1= **0.87** (CI% 0.82-0.91)

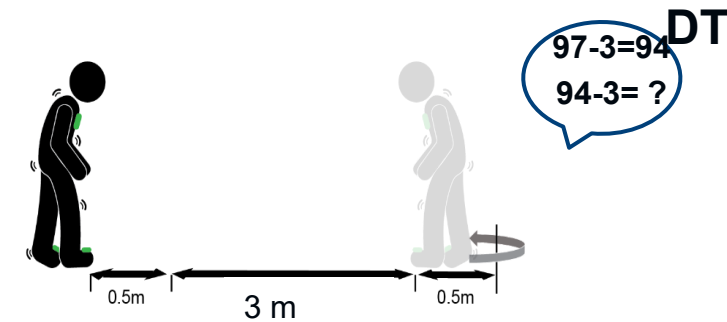


FOG-QOL is a **reliable** PRO — strong construct and content validity, **captures** the **patient perspective**

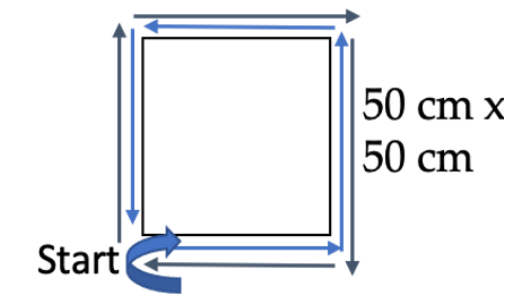
3. New Giladi protocol (GP-FOG) - ClinRO



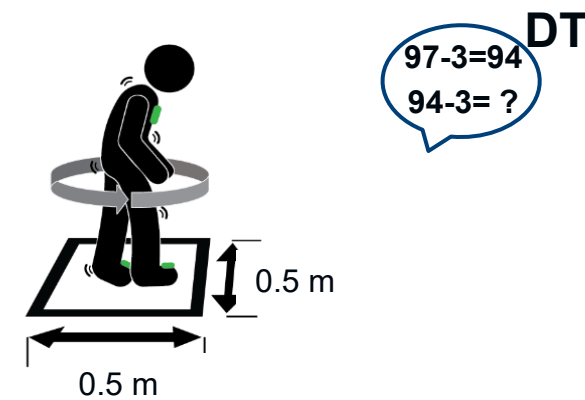
- 1. Normal Walk 180°
- 2. Normal Walk + Mental DT



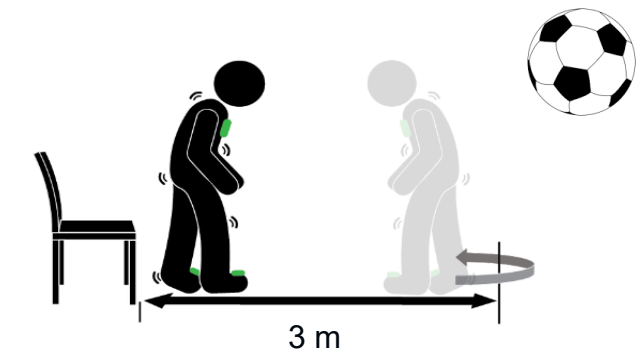
- 6. Box shuffling
- 7. Box agility



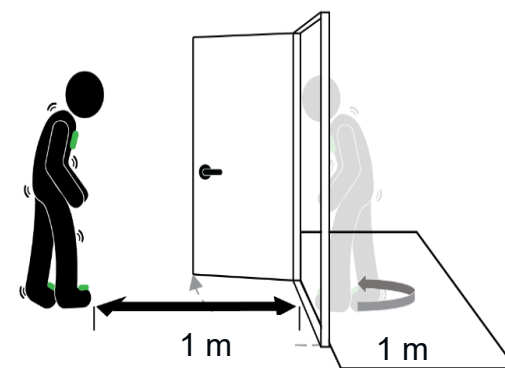
- 3. Alternating Turning 360°
- 4. Turning + Mental DT



- 8. Walking while carrying



- 5. Walk through a door & turn





3. Giladi protocol (GP-FOG) - ClinRO

Standardized tasks, performed separately and lasting 60 s. each



Frequency of episodes	Estimated cumulative duration
0 = No freezing	0 = No freezing;
1 = 1 brief FOG episode (lasting <1 s.)	1 = Mild (<10% trial frozen)
2 = Many brief episodes (>1 episode) OR 1 long-lasting (>2 s.)	2 = Moderate (>10% and <50% trial frozen)
3 = Many long FOG episodes (>1 long-lasting episode)	3 = Severe (>50% trial frozen)
4 = Unable/ assistance required	4 = Unable/ assistance required



3. New Giladi protocol - validity & responsiveness

Convergent validity

OFF NFOG-Q $\rightarrow \rho = 0.59, p < 0.001$

ON NFOG-Q $\rightarrow \rho = 0.52, p < 0.001$

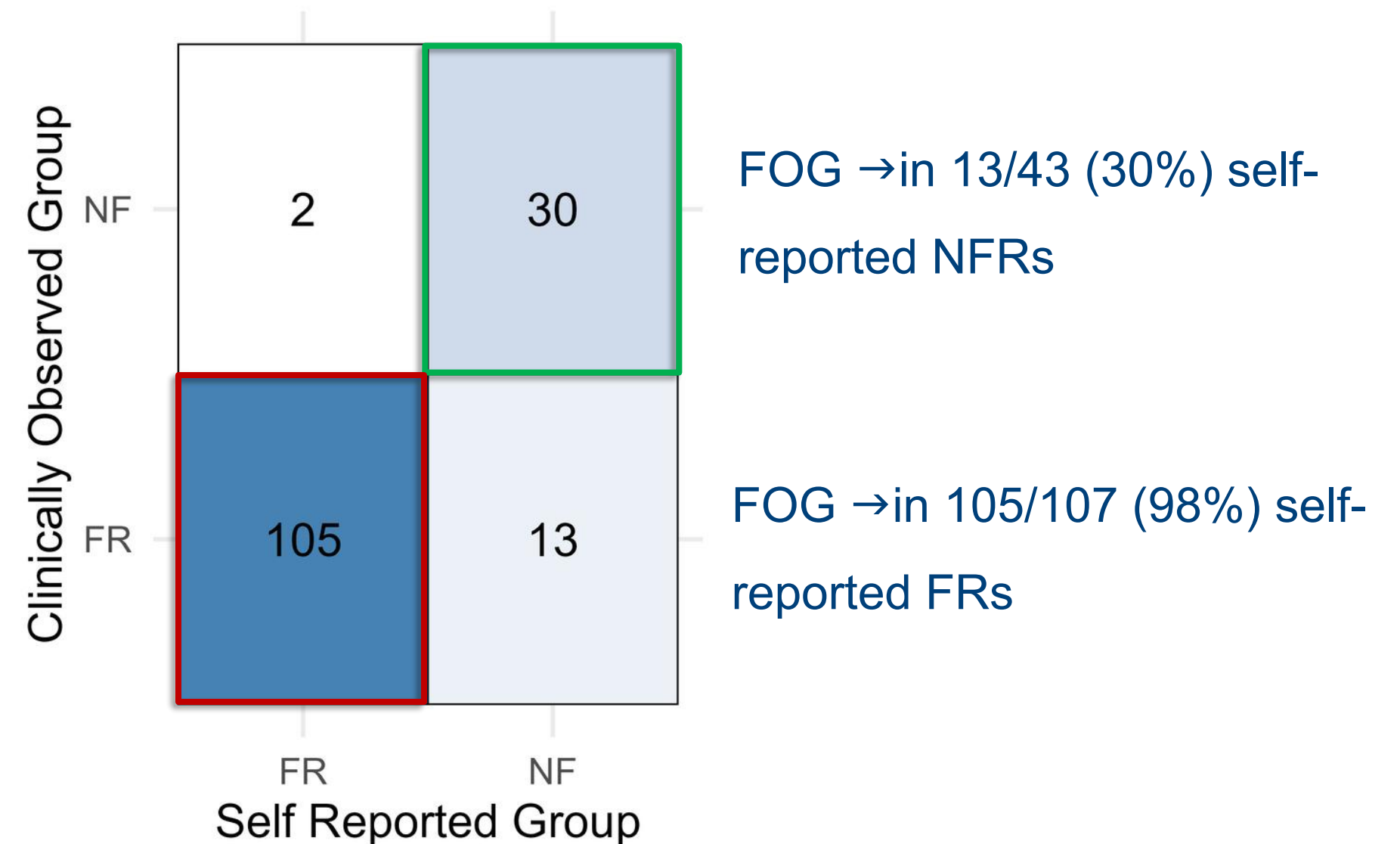
Divergent validity

Tremor $\rightarrow \rho = -0.03$ -0.06, NS

Responsiveness to medication

Freezers: SRM = -0.7 [-0.92;-0.51]

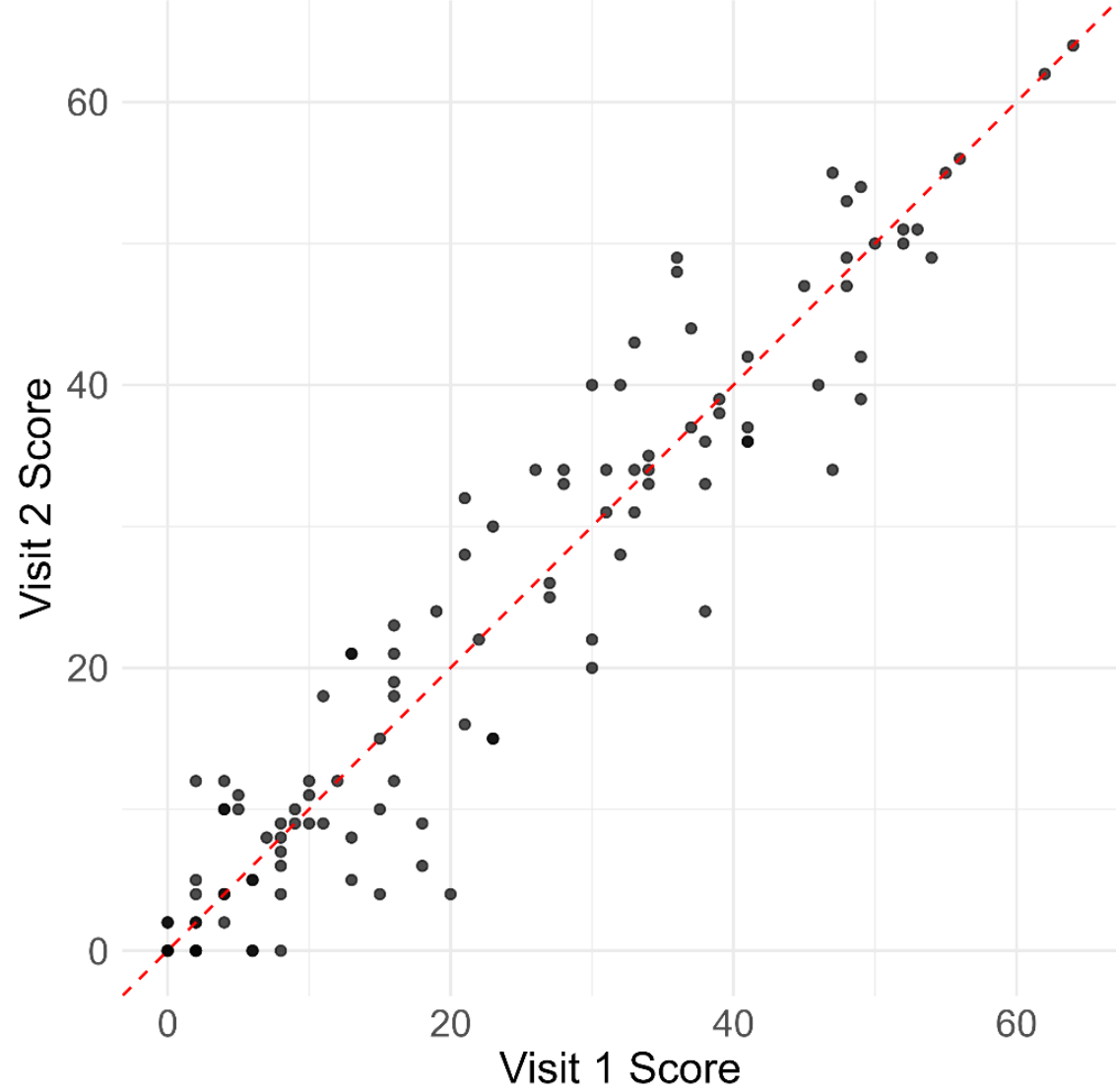
GF-FOG Δ correlated with self-rated $\Delta \rightarrow \rho = 0.6, p < 0.001$



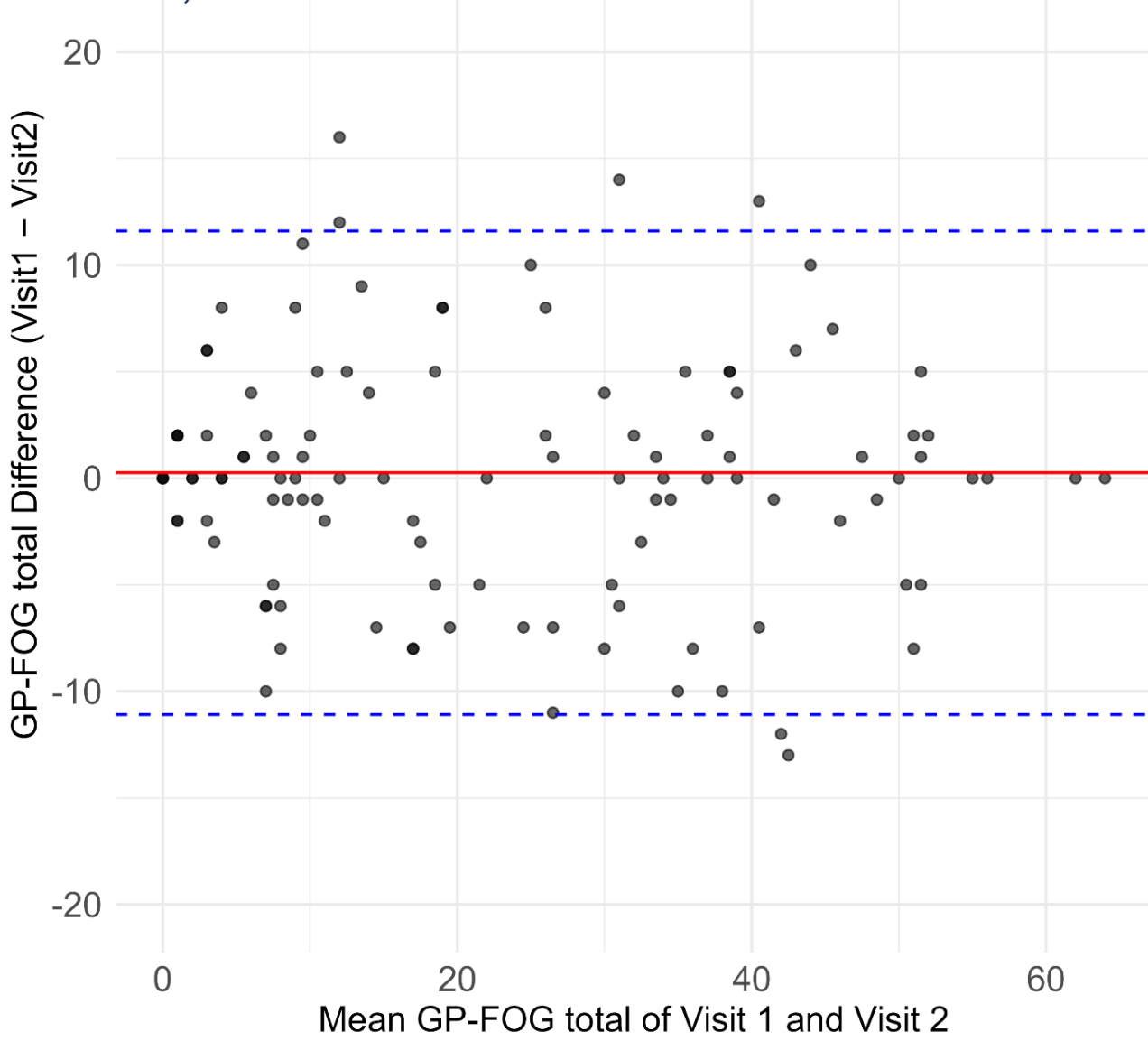


3. New Giladi-protocol - reliability

$ICC_{3,1} = 0.95$ (CI% 0.92-0.96) **OFF**



$ICC_{3,1} = 0.91$ (CI% 0.87-0.94) **ON**

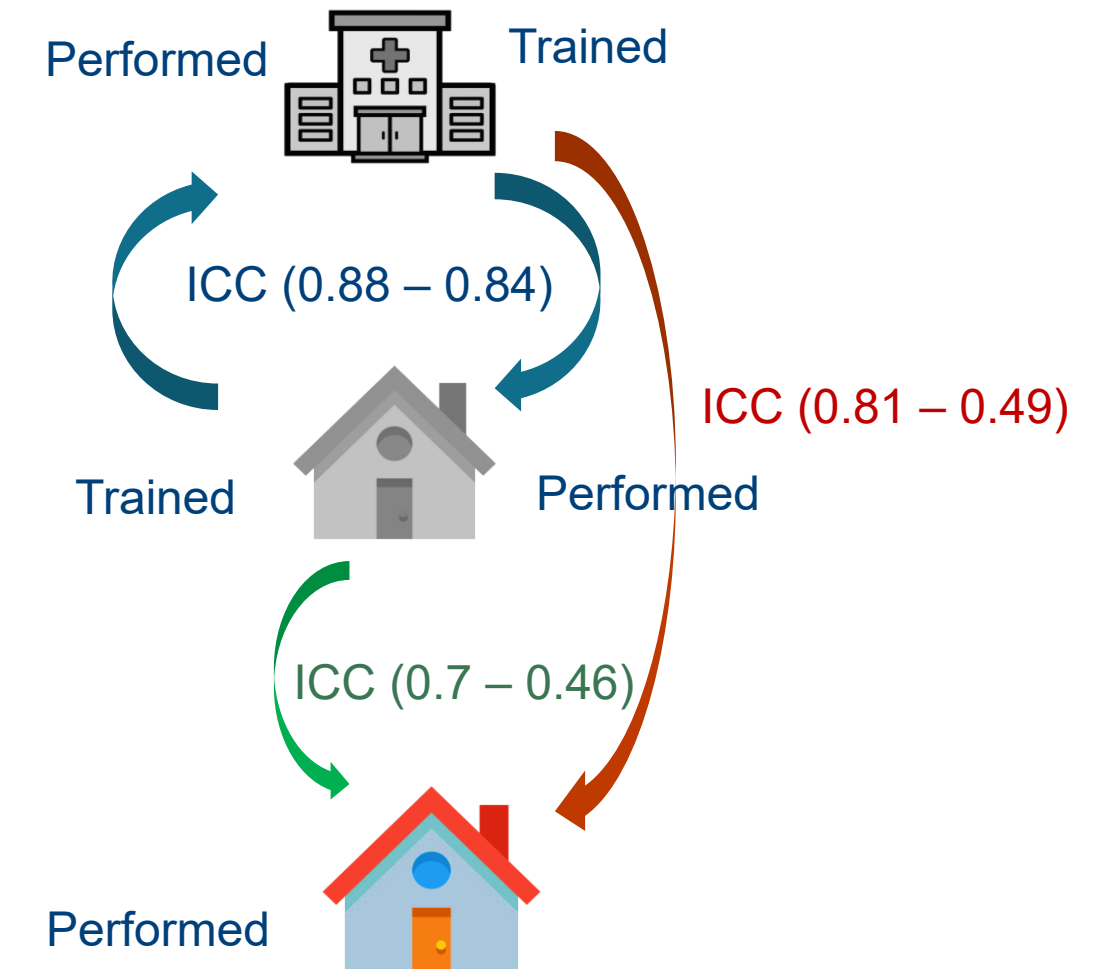
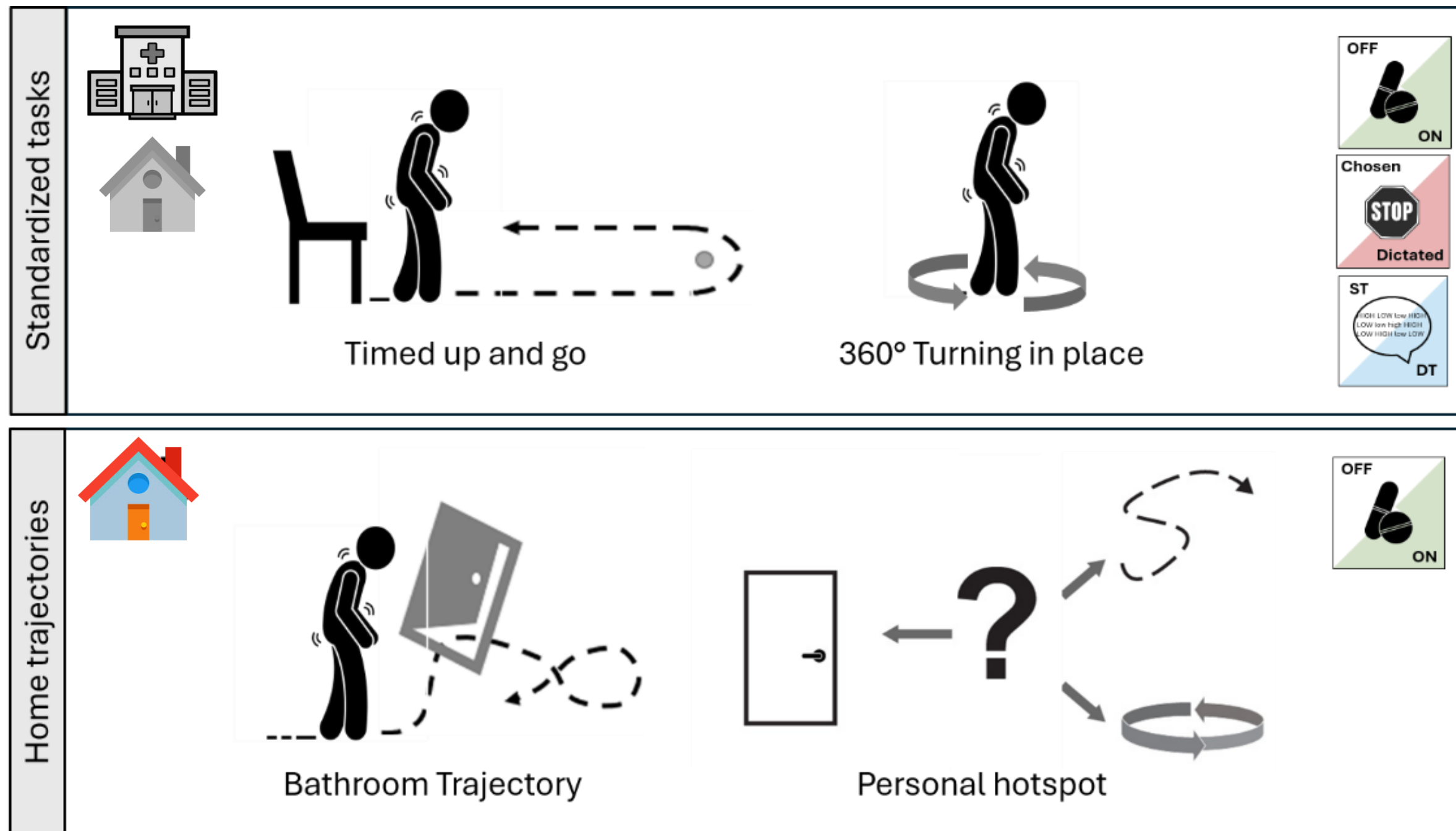


GP-FOG is a valid, reliable and responsive ClinRO

4. Automated freezing detection - generalization

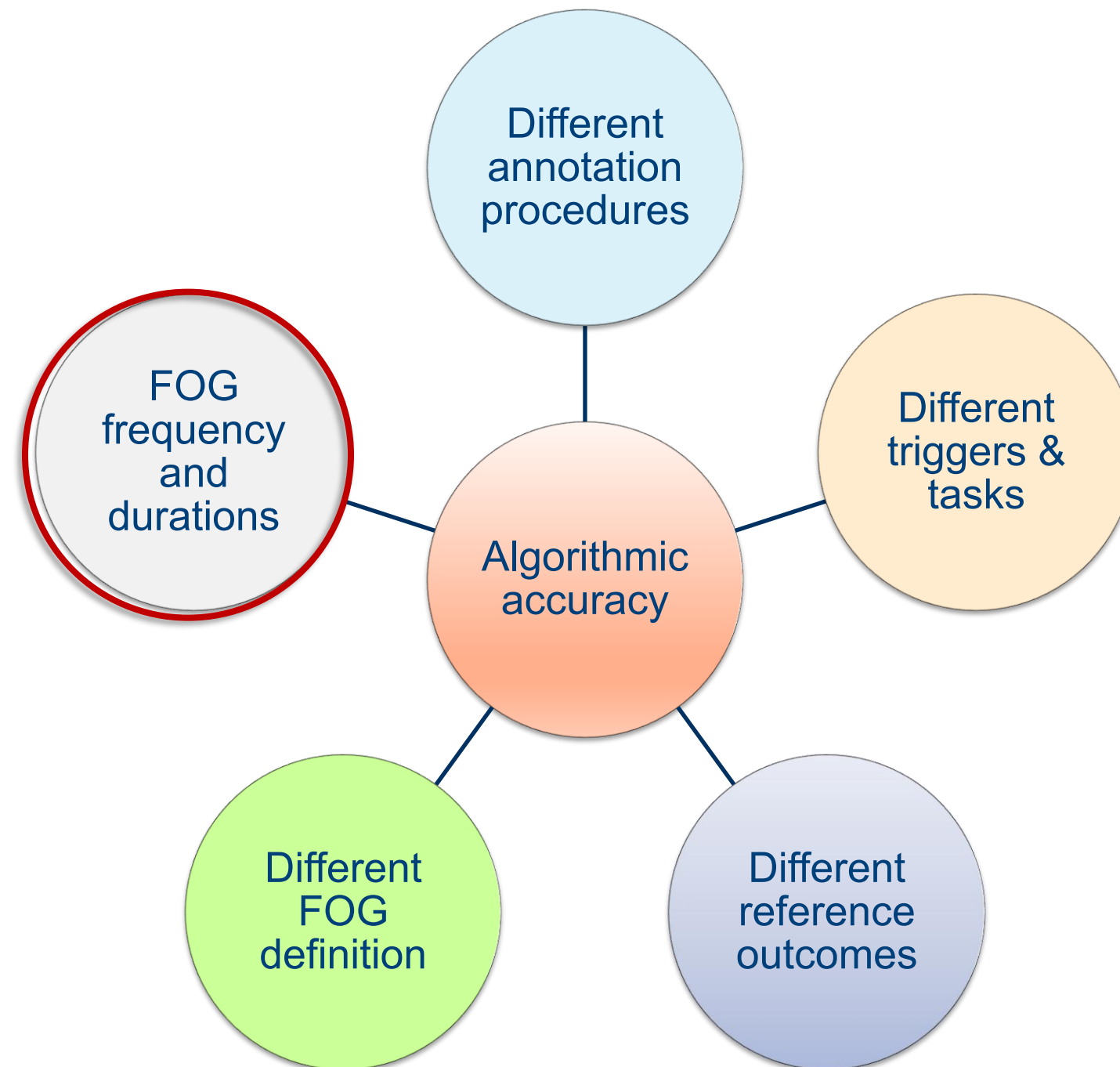


Algorithm performance in 3 different settings against expert annotation for %TF and # episodes

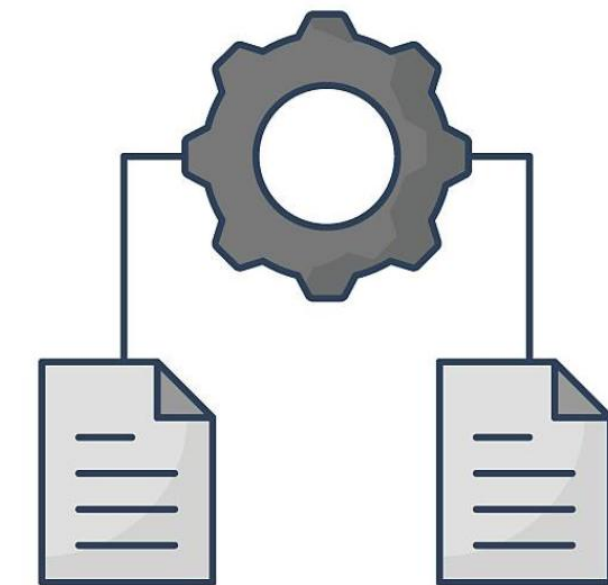


FOG ↓ and FOG duration ↓

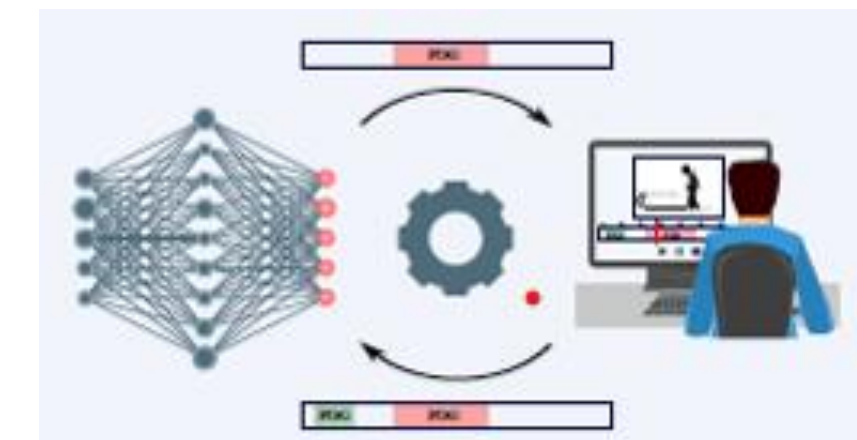
4. Automated freezing detection – optimization



Methodological &
data harmonization
→ generalization



Individualized
algorithm finetuning
→ Generalization ↑



To do list for the consortium



Analyze criterion validity → %TF



Individual task/item analysis, refinement and reduction



Evaluate training modules for annotation & GP-FOG

Reliability of FOG assessment critically depends on use of high demand conditions

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Welcome

The International Consortium for Freezing of Gait (ICFOG) is an international academic society aimed at improving our understanding of FOG as it appears in Parkinson's disease (PD) and other movement disorders. ICFOG was initially proposed at the Jerusalem Conference on Freezing of Gait in Jerusalem, Israel, March 2023. Initial by-laws and inaugural leadership were established in early 2024. This site provides more information about ICFOG, including the first annual meeting – ICFOG2025 – in Atlanta, Georgia, June 3-6, 2025.

