P1-081 Impact of Walking Speed, Perturbation Direction, and Arm Constraints on Perceived Balance Capacity and Fall Risk

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Introduction

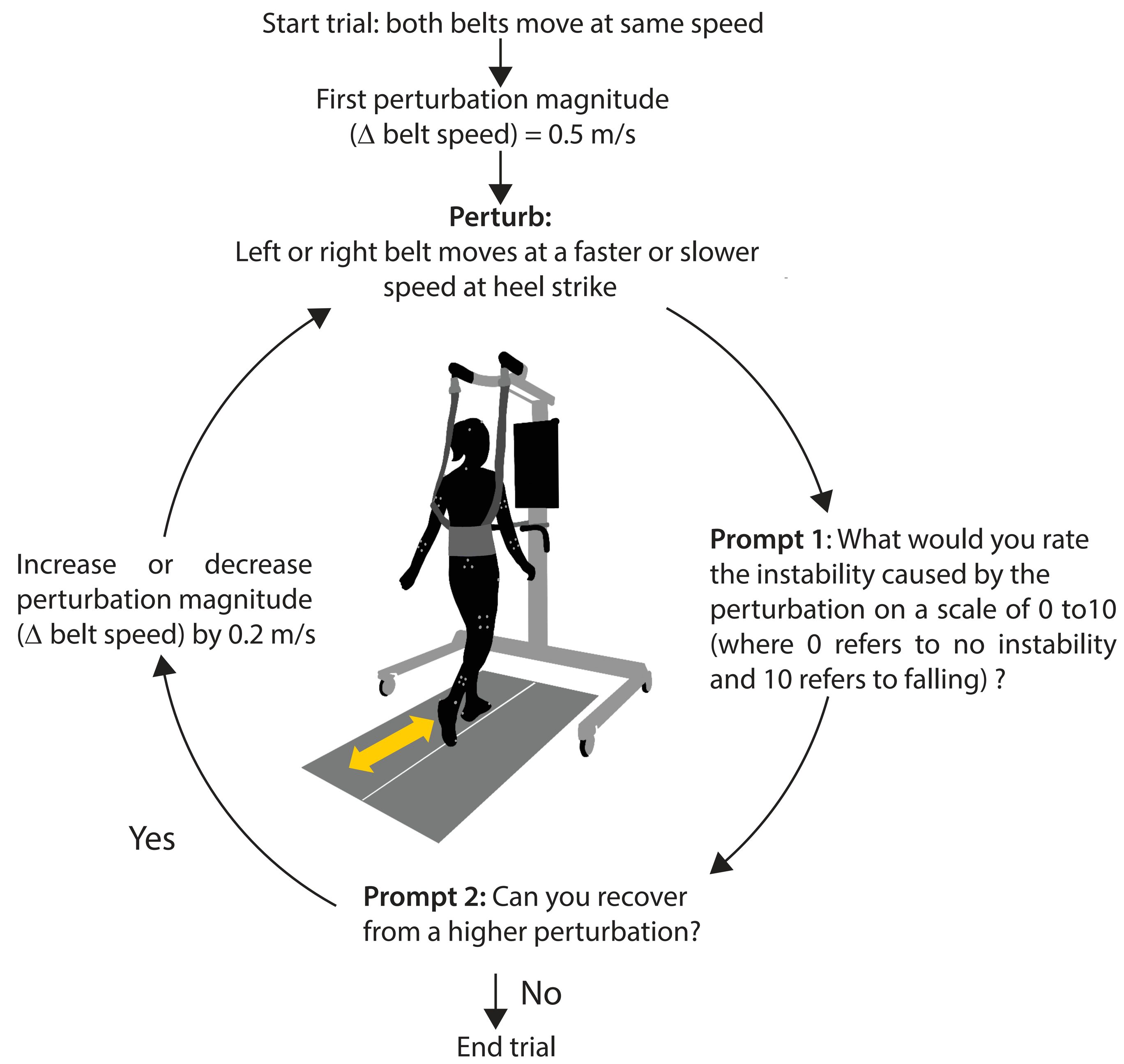
- Aging and movement disorders (Ex, stroke, Parkinson's, MS, etc.) put people at higher risk of falls that might lead to injuries.[1-4]
- Falls often occur while walking in risky environments that have balance-threatening features (e.g., slippery or uneven surfaces or obstacles).
- People's decisions to walk in risky environments are often influenced by their perceptions of fall risk and balance capacity (their perceived ability to recover from a disturbance).[5-7]
- We dont know how people perceive fall risk and balance capacity during walking and how it varies with factors that are know to affect balance such as walking speed, direction of disturbance or perturbation and arm use.

Objective: Quantify the influence of walking speed, perturbation direction (slip vs trip) and arm constraint (free vs tied) on perceived fall risk and perceived balance capacity.

Methods

Experimental Paradigm

- 15 young adults (25.9 ± 8 years old, 7M/8F).
- Total 28 trials per subject
  - 7 different walking speeds (25% to 175% of self selected walking speed)
  - 2 different direction of balance disturbance (forward trips and backward slips)
  - 2 arm conditions (arms tied and free)



Perceived risk (PR)= Ratings provided by the subject on scale of 0 to 10 for each perturbation.

Perceived capacity (PC)= Maximum perturbation magnitude experienced during a trial on each side.

Statistical analysis

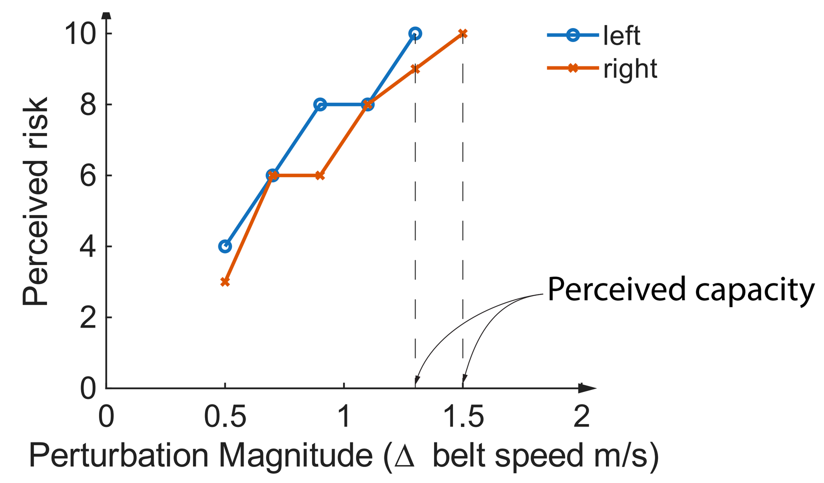
Linear mixed effects models:

1. $PR_{ij} = (\beta_0+b_{0j}) + (\beta_1+b_{1j})\, \Delta S_{ij} + (\beta_2+b_{2j})\, S_{ij} + (\beta_3+b_{3j})\, Dir_{ij} + (\beta_4+b_{4j})\, Arm_{ij} + \varepsilon_{ij}$
2. $PC_{kj} = (\beta_0+b_{0j}) + \beta_1 S_{kj} + \beta_2 Dir_{kj} + \beta_3 Arm_{kj} + \varepsilon_{kj}$

i : Pertrubation
k: Trial
j : Subject

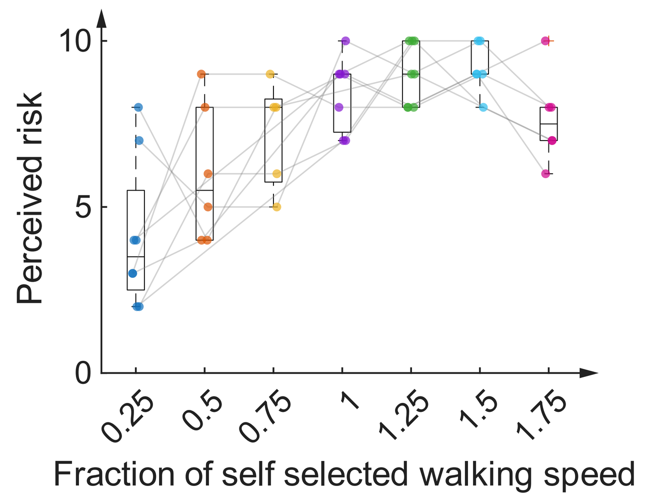
Results

1. Example of how perceived risk scales with perturbation magnitude during a trial

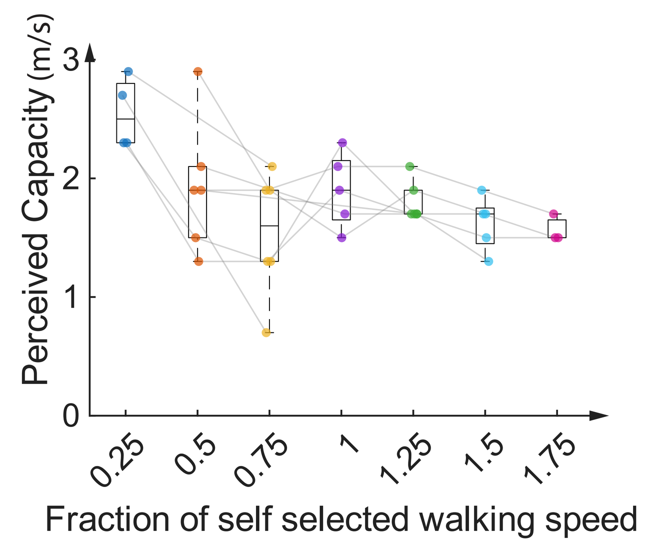


2. Example of how perceived risk and capacity changes with walking speed, perturbation direction and arm constraint for a subject

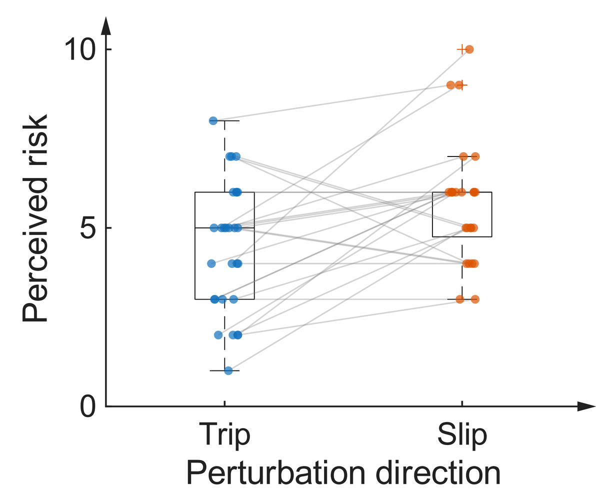
Perceived risk increases with walking speed



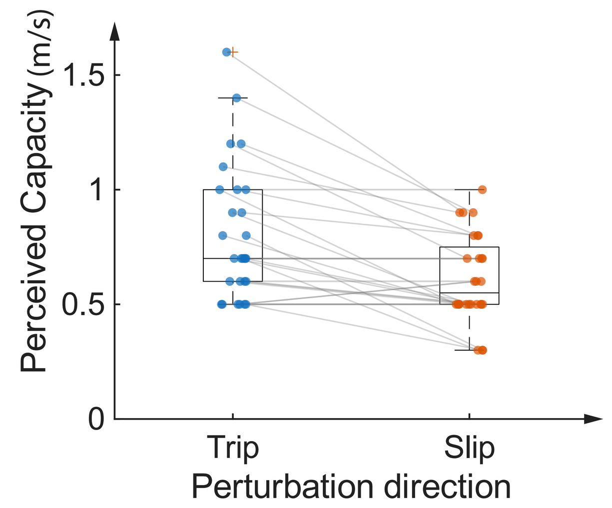
Perceived capacity decreases with walking speed



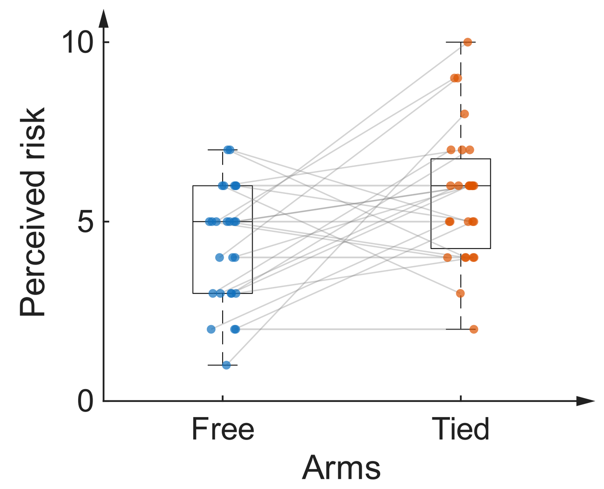
Perceived risk is higher for slips



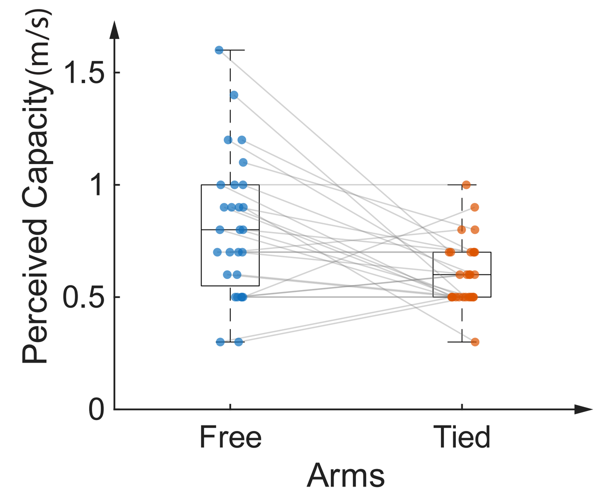
Perceived capacity is higher for trips



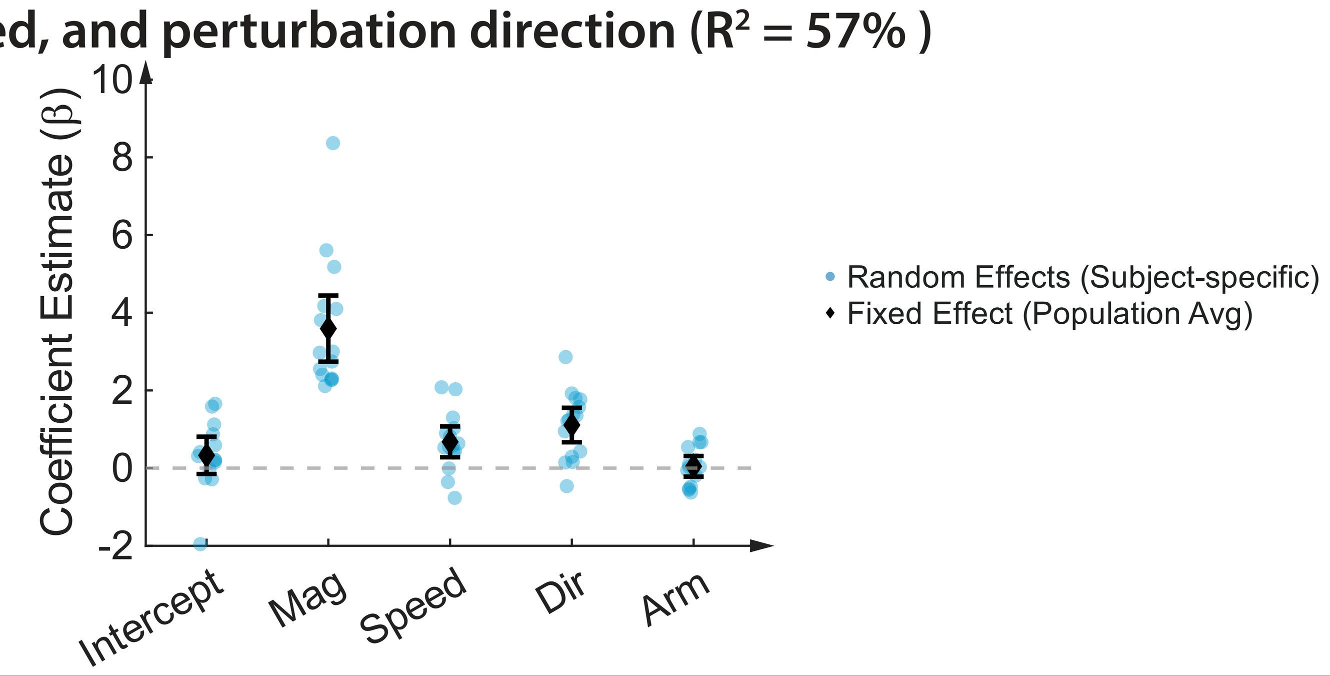
Perceived risk is higher for arms tied



Perceived capacity is higher for arms free



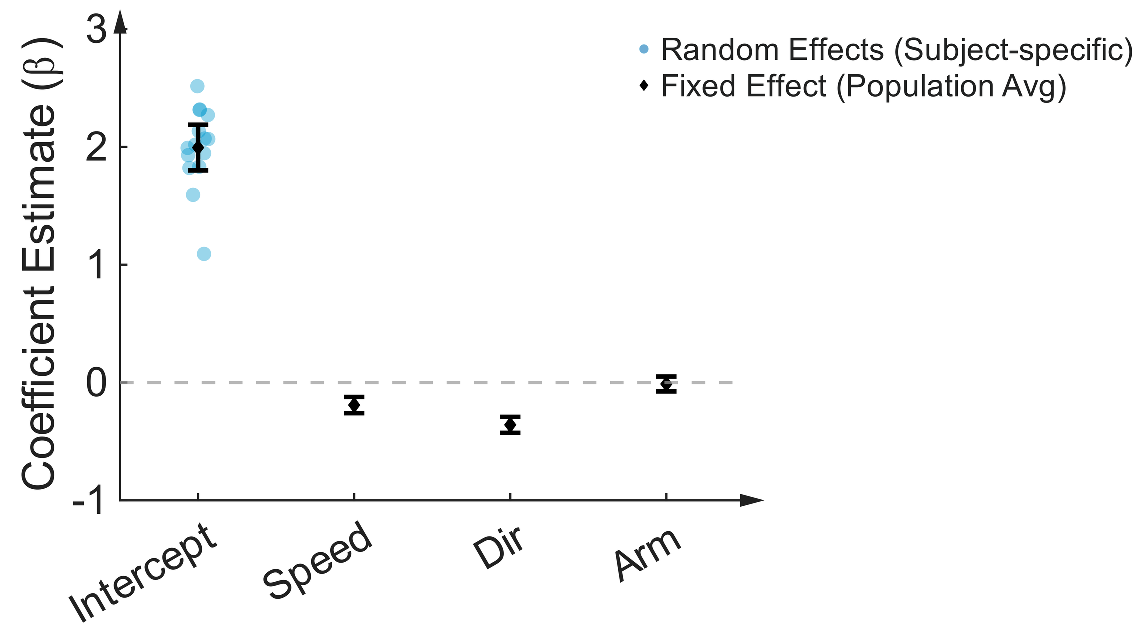
3. Perceived risk varied with perturbation magnitude, walking speed, and perturbation direction (R^2 = 57%)



Perceived risk for young adults:

- Increases by 3.6 points for unit increase in perturbation magnitude ($p<0.05$).
- Increases by 0.7 points for unit increase in walking speed ($p<0.05$).
- Higher for slips by 1.1 points compared to trips ($p<0.05$).
- No significant overall effect of arm constraint ($\beta \sim 0$, $p>0.05$), but diverse subject specific effect.

4. Perceived capacity varied with walking speed and perturbation direction (R^2 =55 %)



Perceived capacity for young adults:

- Decreases by 0.19 m/s for unit increase in walking speed ($p<0.05$).
- Higher for trips by 0.36 m/s compared to slips ($p<0.05$).
- No significant effect of arm constraint ($\beta \sim 0$, $p>0.05$).

Conclusions & Future Directions

Speed Effects: Faster walking elevates perceived risk and lowers perceived capacity compared to slower speeds.

Perturbation Direction: Backward slips elevate perceived risk and lower perceived capacity compared to forward trips.

Arm constraint: Perceived risk and capacity varied significantly across subjects; the lack of a main overall effect highlights distinct individual differences in whether constrained or free arms are perceived as the riskier state.

Proposed Mechanism: Changes in perceived risk and capacity likely occur due to differences in th extent of physical disturbance relative to nominal movement caused by the perturbations.

Future Directions: We aim to correlate biomechanical measures of the physical disturbance with perceived risk and capacity to isolate the drivers of these differences.

Clinical Relevance: This paradigm can be useful to quantify perceived risk and capacity changes due to aging, disease, and injury to better understand behavioral decisions.

References

[1] Xing et al. (2023), Front Public Health. [2] Batchelor et al. (2012), Int J Stroke. [3] Vizcarra et al. (2025), medRxiv (Preprint). [4] Cameron et al. (2013), Mult Scler Int. [5] Jain et al. (2024), Front Aging Neurosci . [6] Feldman and Chaudhury (2008), Can J Occup Ther 75(2). [7] Connell and Wolf (1997), Arch Phys Med Rehabil.

Acknowledgements

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