Reactive Balance Training for Falls Prevention From Laboratory to Practice

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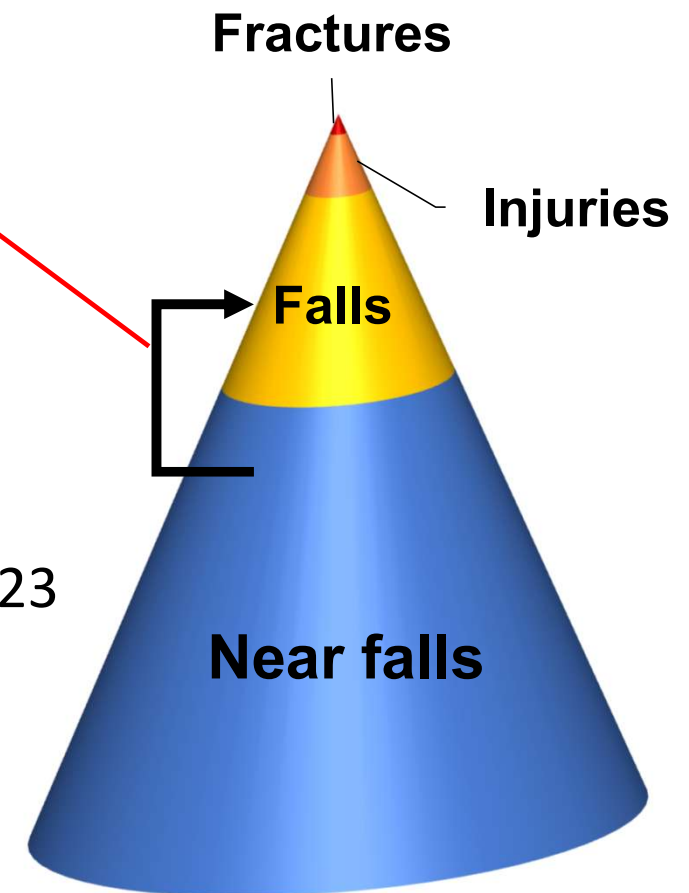# Falls in Community-Dwelling Older People

Reactive balance

✓Sensation to detect a postural threat
✓Postural reactions, muscle strength

Falls in Australia

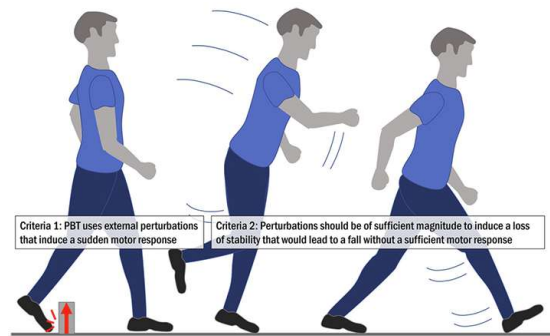✓>132,000 fall-related hospitalisations in 2022–23
✓33% by trips, slips and stumbles

(Australian Institute of Health and Welfare, 2024)

Fractures

Injuries

Falls

Near falls

(Berry et al., 2008; Nagai et al., 2016;
Teno et al., 1990; Okubo et al., 2016)

Reactive Balance Training

Involves **repeated, externally applied mechanical perturbations** designed to trigger **rapid, automatic reactions** to **regain** postural stability.

Criteria 1: PBT uses external perturbations that induce a sudden motor response   Criteria 2: Perturbations should be of sufficient magnitude to induce a loss of stability that would lead to a fall without a sufficient motor response

Key criteria

✓ **External perturbations** must be used to trigger a sudden, involuntary motor response (not self-initiated).

✓ The perturbation must be of **sufficient magnitude to cause a loss of stability**—one that would likely lead to a fall without a rapid motor reaction or use of safety equipment.

McCrum, Okubo et al., Front. Sports Act. Living, 2022

Types of Reactive Balance Training

Pre-Perturbation Activity

- Standing
  - Upright
  - leaning
- Walking
  - Self-paced
  - Pre-set speed
- Sit-to-stand

McCrum, Okubo et al., Front. Sports Act. Living, 2022

Laboratory-based Training

SafeTrip
Stepping to avoid falls due to trips and slips

SafeTrip Study

Participants
✓ Healthy community-dwelling older people (n = 111)

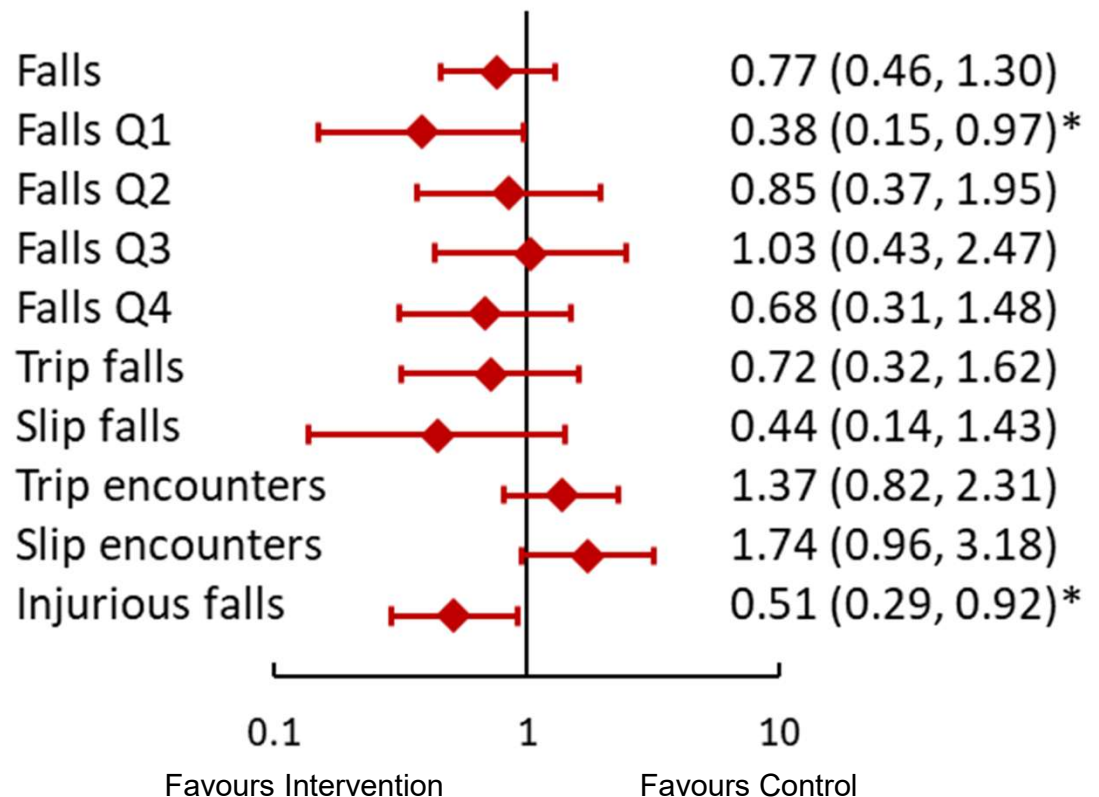## Randomised
✓ Control group (n = 57)
✓ Intervention group (n = 54)

Intervention
✓ 3 training sessions using trips and slips
✓ 3-monthly re-training sessions

Falls monitoring
✓ Weekly SMS for one year

ITT Rate ratios (95% CIs)

Falls	0.77 (0.46, 1.30)
Falls Q1	0.38 (0.15, 0.97)*
Falls Q2	0.85 (0.37, 1.95)
Falls Q3	1.03 (0.43, 2.47)
Falls Q4	0.68 (0.31, 1.48)
Trip falls	0.72 (0.32, 1.62)
Slip falls	0.44 (0.14, 1.43)
Trip encounters	1.37 (0.82, 2.31)
Slip encounters	1.74 (0.96, 3.18)
Injurious falls	0.51 (0.29, 0.92)*

0.1   1   10

Favours Intervention   Favours Control

Okubo, Phu et al., In preparation

Adaptation, Retention and Reactivation
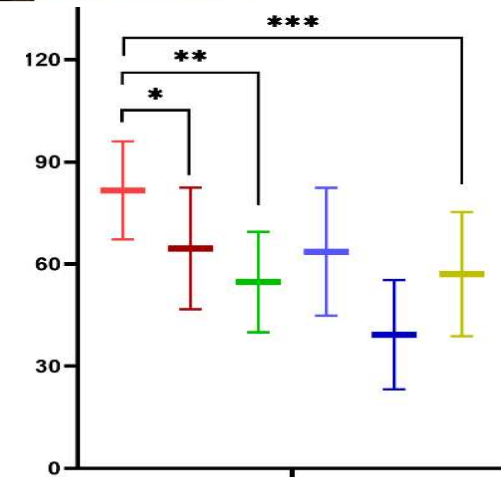

Training 1 (week 1) Pre
Training 1 (week 1) Post
Training 3 (week 3) Post
Re-training (month 3) Pre
Re-training (month 3) Post
Follow-up (month 12)
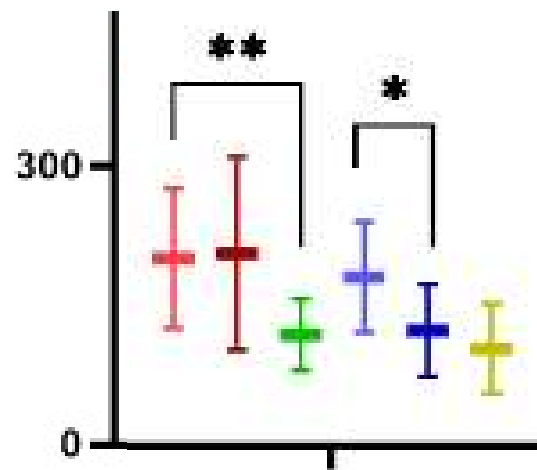
Co-Contraction around Ankle
(Tibialis anterior vs Gastronomies tripped foot)

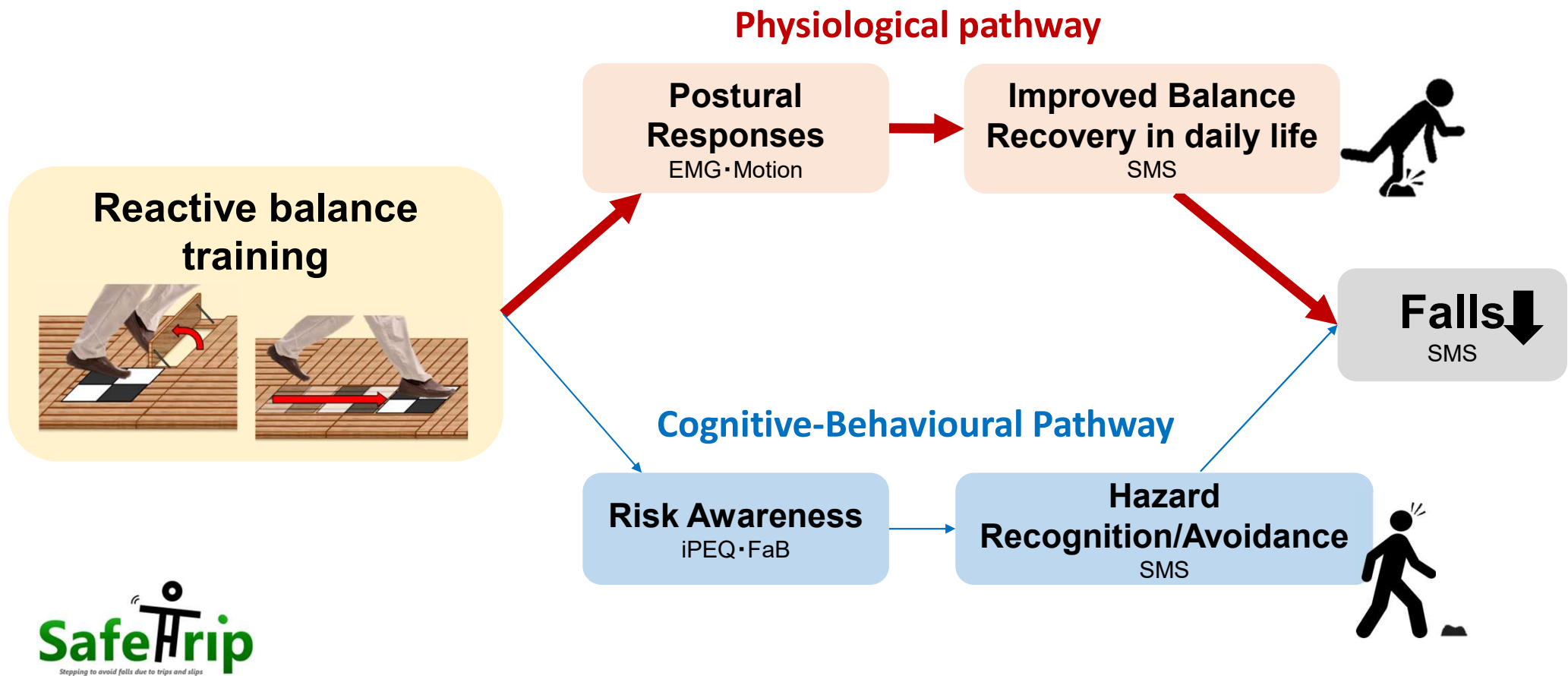P<0.05, ** P<0.01, ***P<0.001

Harness Loading (%body weight)

Phu, Doctoral Thesis, Manuscript in preparation

Mechanisms of reactive balance training

Physiological pathway

Postural Responses
EMG·Motion

Improved Balance Recovery in daily life
SMS

Falls⬇
SMS

Reactive balance training

Cognitive-Behavioural Pathway

Risk Awareness
iPEQ·FaB

Hazard Recognition/Avoidance
SMS

SafeTrip
Stepping to avoid falls due to trips and slips

ReacStep program

45 min, 1 d/wk, 6 weeks, an Exercise Physiologist

Tether-Release Reactive Step Training (30 min)
- Forward, Backward, Sideways
- Cognitive challenge (simulating everyday tasks)

Volitional Slip Training (10 min)
- 20/40/60cm slip targets

Home-based Strength Training | 2 d/wk, 8 weeks
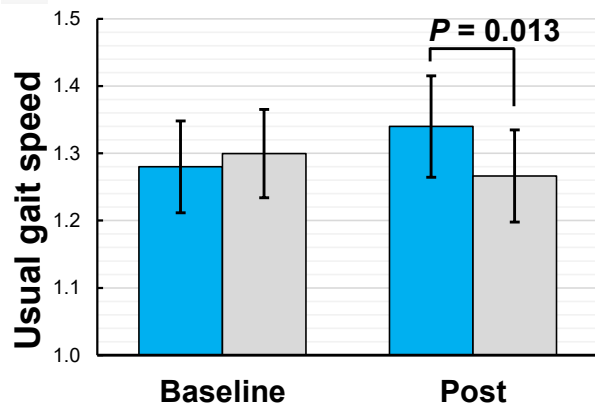- Squat, Hip flexion, Hip extension, Hip abduction

Banded
Hip Flexion
Left Leg - Set 2

ReacStep

Okubo et al., In preparation

Balance Skills & Physical improvements
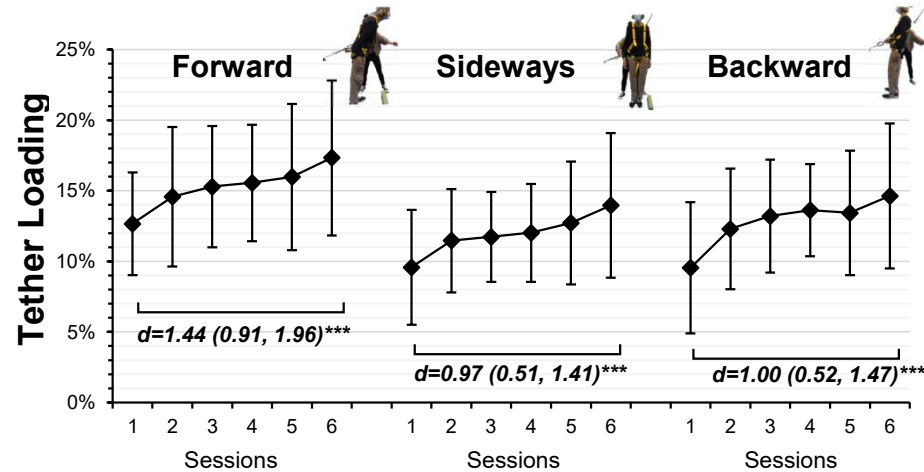
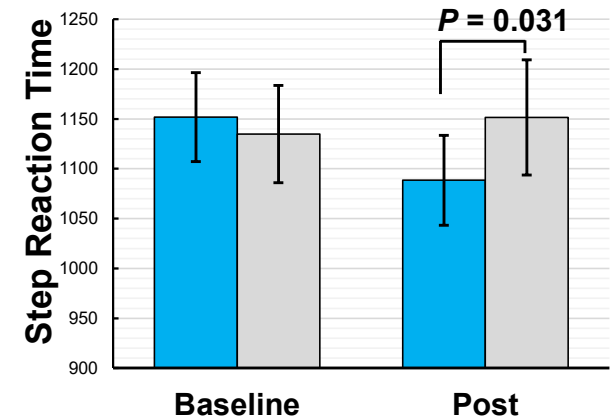**SeacStep**

Forward — Sideways — Backward

Tether Loading (%): 25% 20% 15% 10% 5% 0%

Sessions: 1 2 3 4 5 6

Forward: $d=1.44\ (0.91, 1.96)$***

Sideways: $d=0.97\ (0.51, 1.41)$***

Backward: $d=1.00\ (0.52, 1.47)$***

Usual gait speed — Intervention / Control — $P = 0.013$ — Baseline / Post

Maximum Step Length — Intervention / Control — $P = 0.001$ — Baseline / Post

Step Reaction Time — Intervention / Control — $P = 0.031$ — Baseline / Post
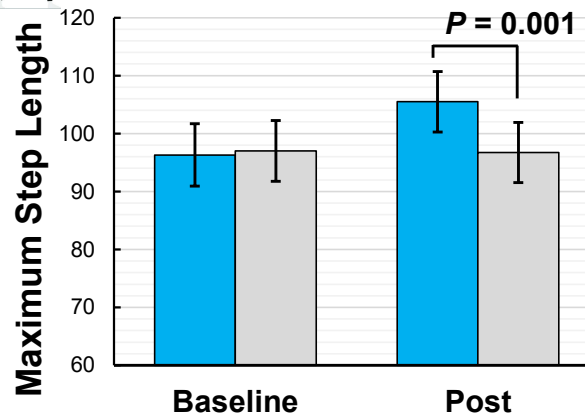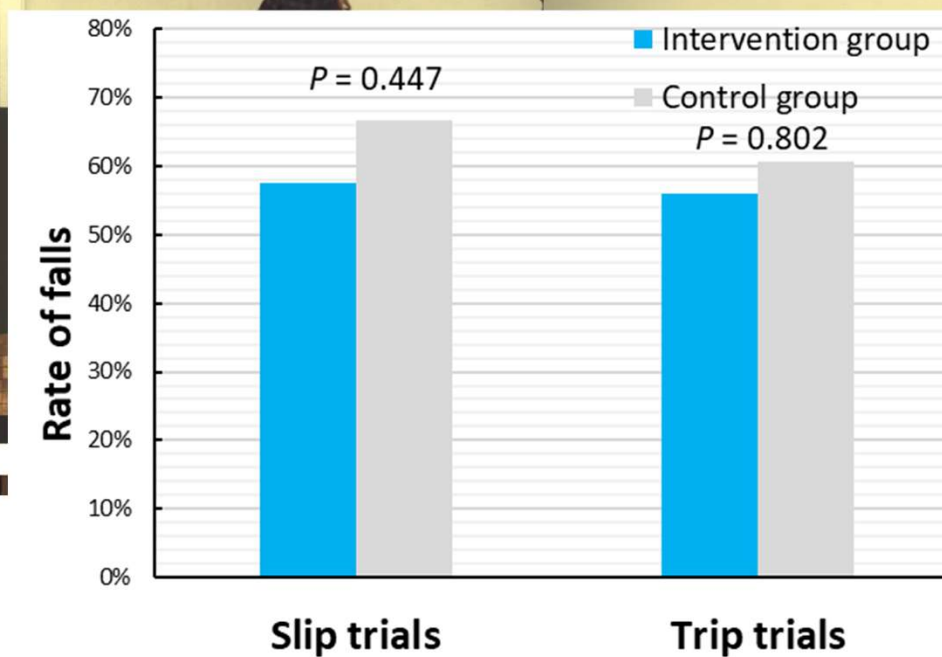
Optimal Reactive Balance Training Methods?
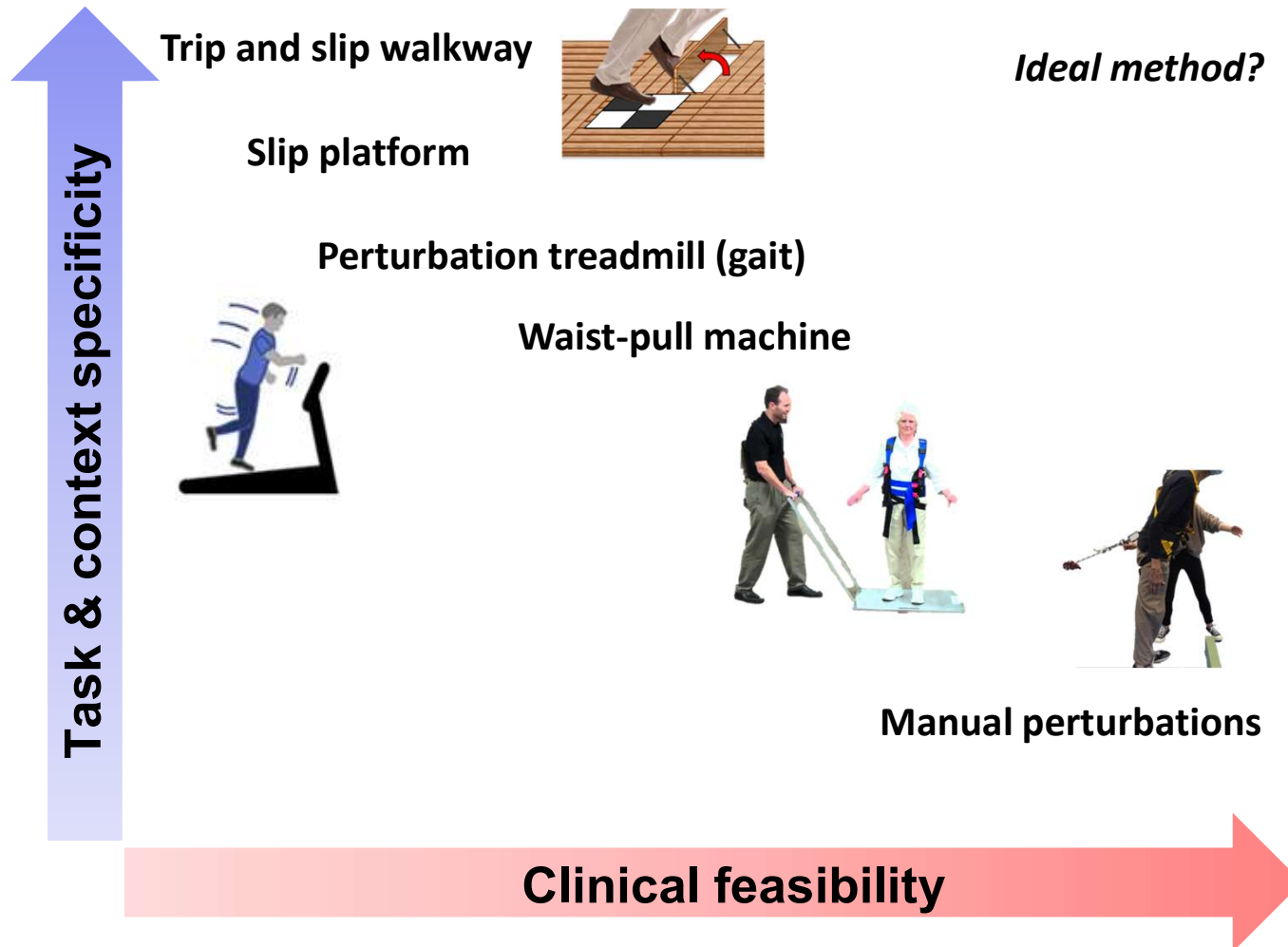
Take-Home Messages

➢ Reactive balance training (RBT) targets postural responses to real-life perturbations such as slips and trips.

➢ RBT can be delivered in low doses and has been shown to reduce falls and fall-related injuries in older adults.

➢ Motor adaptations gained through training may diminish after ~3 months, but can be re-activated with booster sessions.

➢ RBT can be implemented using low-cost methods, but should be designed to promote real-world transfer and fall prevention.

➢ Further research is needed to support the translation of RBT into widespread clinical practice.

Acknowledgements