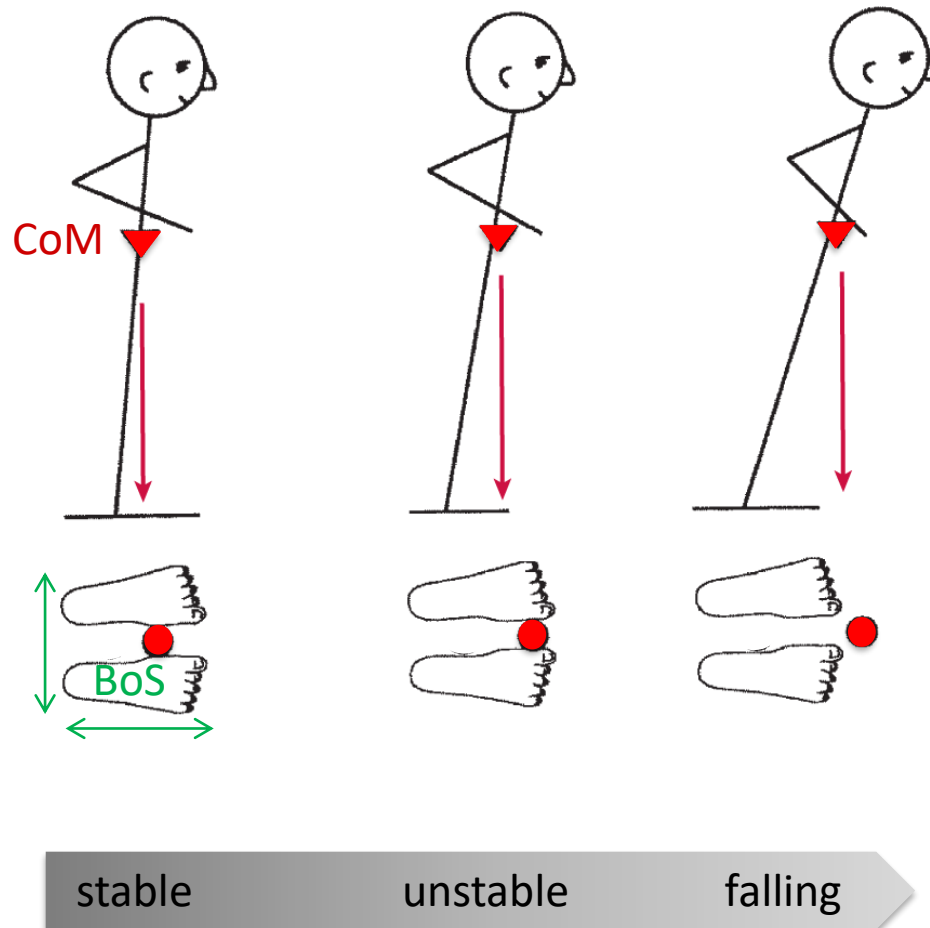


# Training voluntary and reactive stepping for fall prevention

Daina Sturnieks



# Balance Control



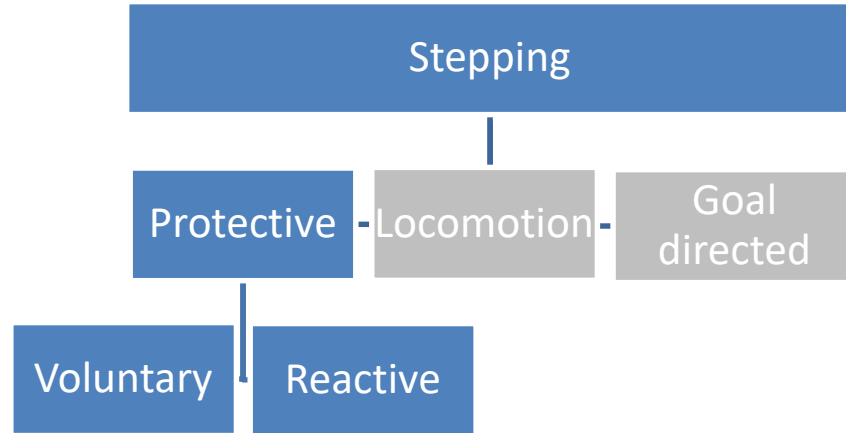
Standing balance requires controlling the centre of mass (CoM) of the body so that it remains over the feet, often called the base of support (BoS).

COM motion towards the edge of the BOS causes instability

-Feet-in-place responses

-Stepping - to increase the BoS.

# Protective Stepping



Lord et al. (1993) Aust J Pub Health;17:240-5



**Trips & Slips = 60%**

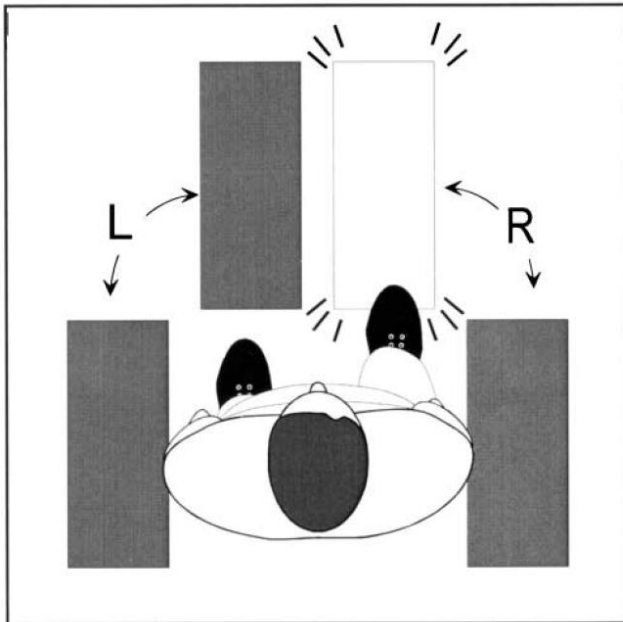
Berg et al. (1997) Age Ageing;26:261-8.

Stepping is often the critical (final) option by which to maintain balance and avoid a fall.

Inappropriate step responses are significantly more prevalent in older people.

# Voluntary Stepping

# Choice Stepping Reaction Time



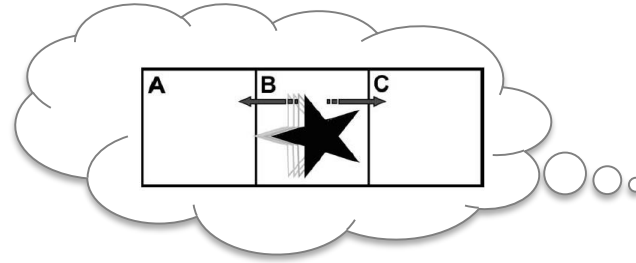
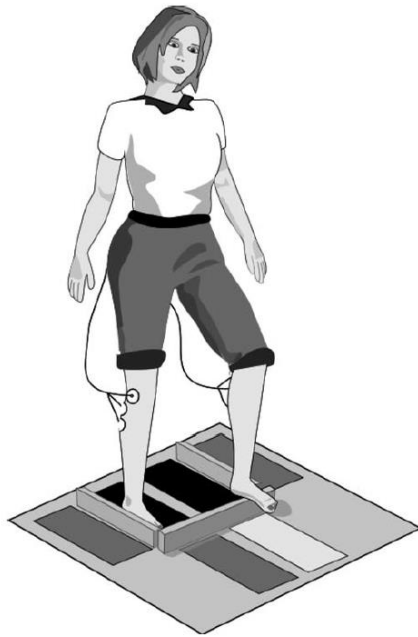
	Fallers		Nonfallers	
	Mean	(SD)	Mean	(SD)
Stepping choice reaction time, ms	1322	(331)**	1168	(203)

Table 4. Predictor Variables of CSRT and Their Beta Weights

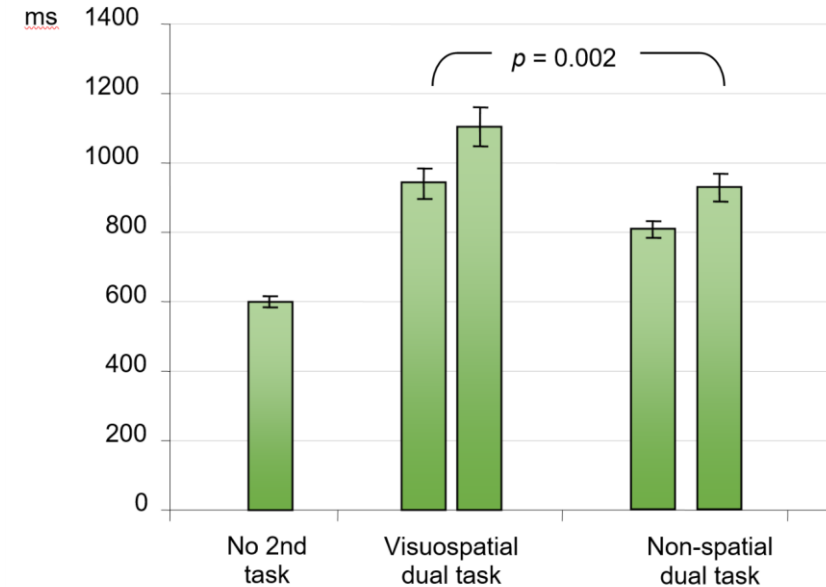
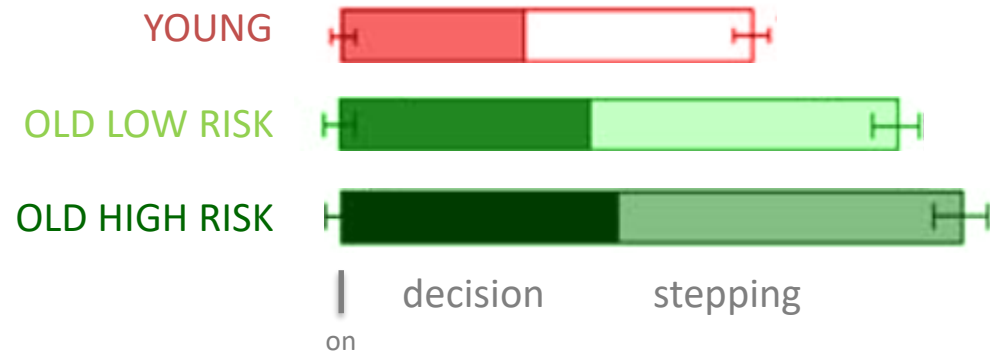
Predictor Variables	Beta Weights	$r^2$
Trails B score	0.12	.450**
Quadriceps strength	0.33	
Simple reaction time	0.20	
Sway: eyes closed on foam	0.14	
Maximal balance range	-0.25	.454
Age		



# Choice Stepping Reaction Time



75...68...61...  
54...47...

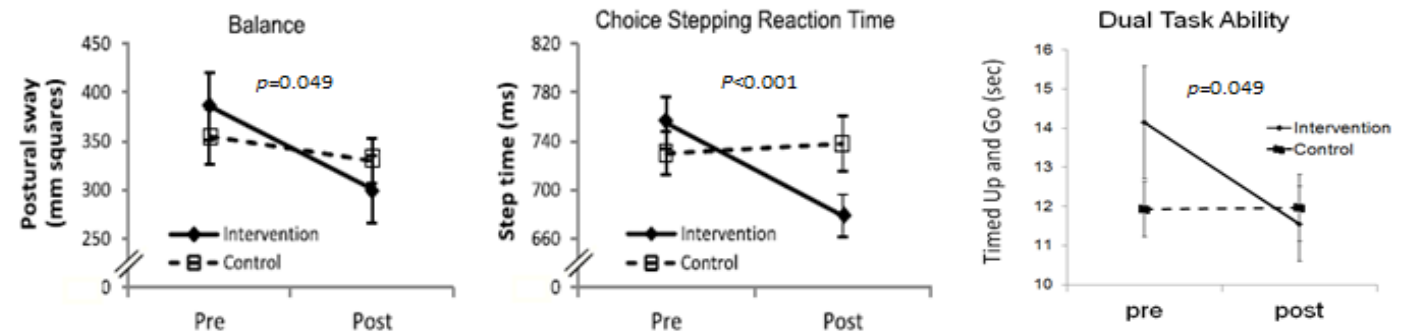


Sturnieks et al. J Gerontol, 2008

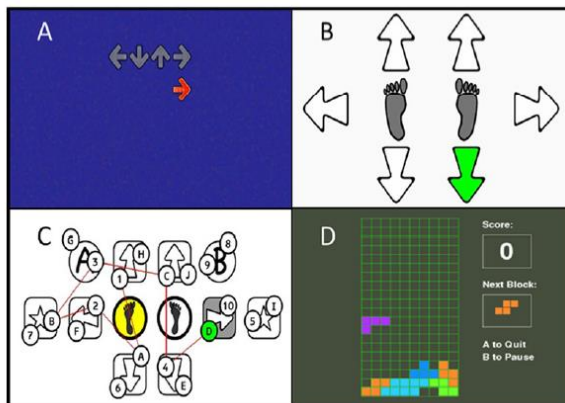
# Step training pilot trials



n=37, independent units of retirement village, 1hr/week, 8 weeks



Schoene et al. Plos One, 2013



n=90, community dwelling, 1+hr/week, 16 weeks.

Compared to control, the intervention group improved in measures of processing speed, visuo-spatial ability and concern about falling.

Schoene et al. Plos One, 2015

# smart step

step+cognitive training: standing stepping + brain exercises

balance challenging

accurate stepping

fast responses

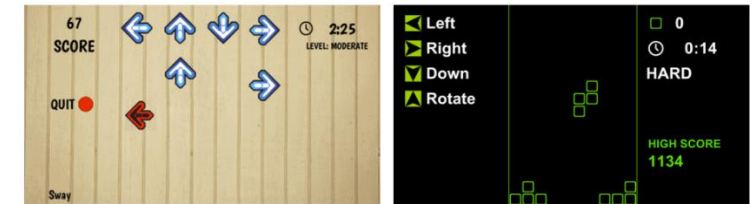


response inhibition

selective attention

visuospatial processing

set shifting



Cognitive training :  
seated brain  
exercises



response inhibition

selective attention

visuospatial processing

set shifting

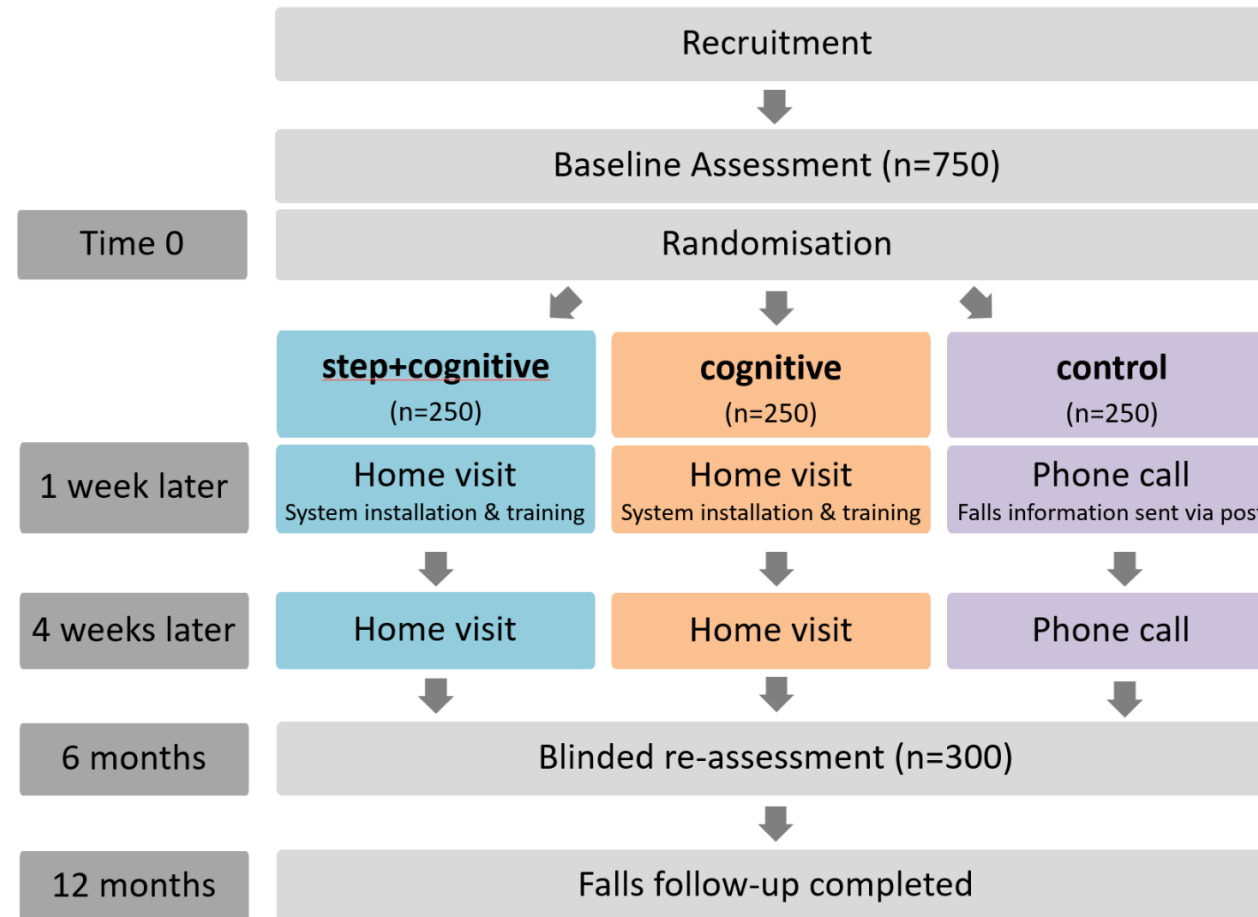


# smart step

**AIM:** to determine the effects of **cognitive** and **step+cognitive** training, compared with a no-intervention control group, on preventing falls in older people.

- i. compare effect sizes of **step+/-cognitive** training on reducing falls
- ii. examine the effects of **step+cognitive** and **cognitive** training on:
  - a) physical function (i.e. balance, gait, mobility)
  - b) cognitive function
  - c) neural plasticity (i.e. changes in brain structure and function)
- iii. calculate the cost effectiveness of delivering the interventions

# smart step



# smart step

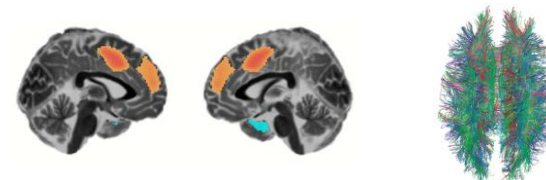
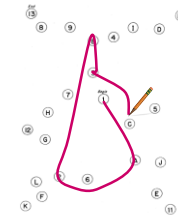
## Primary outcome

- Prospective fall events over 12 months



## Secondary outcomes

- Balance
- Stepping performance and speed
- Gait and mobility
- Cognitive functions
- Neuroplasticity (n=105)



# smart+step

 Logged In as **d.sturnieks@neura.edu.au**

Non-Compliant Participants: 96

[Edit profile](#) | [Logout](#)

 Show 50 entries

 Study Name: Motor Cognitive

 Search: 

Participant ID	Recruit ID	Device ID	Study	Last Active	Last Week (min)	Last Fortnight (min)	Last Month (min)	Compliant Weeks	
473	WBY-1561	508	Motor Cognitive	13-Nov-2018 08:52	99 minutes, 54 seconds	205 minutes, 30 seconds	567 minutes, 42 seconds	7 / 7	Show
436	ADP-1000	470	Motor Cognitive	16-Nov-2018 13:32	99 minutes, 44 seconds	193 minutes, 54 seconds	346 minutes, 4 seconds	12 / 14	Show
539	TON-1000	575	Motor Cognitive	17-Nov-2018 15:31	99 minutes, 2 seconds	163 minutes, 23 seconds		1 / 2	Show
348	WBY-1000	378	Motor Cognitive	15-Nov-2018 18:39	99 minutes, 17 seconds	247 minutes, 27 seconds	562 minutes, 12 seconds	25 / 28	Show
532	CHS-1573	568	Motor Cognitive	16-Nov-2018 09:41	98 minutes, 9 seconds	231 minutes, 33 seconds		2 / 3	Show
260	ROS-1000	278	Motor Cognitive	16-Nov-2018 19:01	97 minutes, 56 seconds	219 minutes, 19 seconds	332 minutes, 53 seconds	28 / 39	Show
178	WGS-1000	190	Motor Cognitive	16-Nov-2018 19:19	96 minutes, 32 seconds	220 minutes, 23 seconds	542 minutes, 11 seconds	38 / 45	Show
201	BLM-1000	213	Motor Cognitive	17-Nov-2018 13:04	96 minutes, 11 seconds	305 minutes, 15 seconds	710 minutes, 52 seconds	43 / 43	Show
216	CHS-1000	232	Motor Cognitive	17-Nov-2018 07:58	95 minutes, 40 seconds	225 minutes, 18 seconds	556 minutes, 8 seconds	39 / 41	Show
173	YBN-1000	185	Motor Cognitive	14-Nov-2018 16:14	59 minutes, 10 seconds	59 minutes, 10 seconds	102 minutes, 33 seconds	7 / 45	Show
316	YBN-1000	340	Motor Cognitive	17-Nov-2018 19:40	58 minutes, 45 seconds	101 minutes, 9 seconds	372 minutes, 51 seconds	18 / 32	Show

Showing 1 to 50 of 353 entries (filtered from 547 total entries)

 Previous 1 2 3 4 5 ... 8 Next

# Step training in people with MS

- Falls are a significant problem in people with multiple sclerosis (MS): one in two people.
- Fallers having an average fall rate of 1.9 falls/month.
- Study of 200 community-dwelling participants with MS with 6-months of falls follow-up
  - Impaired balance control is the most important risk factor.
  - Other risk factors include poor stepping reaction time, impaired cognitive function.

Effects of a home-based step training programme on balance, stepping, cognition and functional performance in people with multiple sclerosis - a randomized controlled trial

Hoang, Phu; Schoene, Daniel; Gandevia, Simon; Smith, Stuart; Lord, Stephen R.

*Multiple Sclerosis Journal*; London Vol. 22, Iss. 1, (Jan 2016): 94-103. DOI:10.1177/1352458515579442

# Step training in people with MS

**AIM:** to investigate whether 6-months of step mat training can improve balance, cognition and risk of falling over 12 months in 500 people with MS.

Additional outcomes:

MS severity, mood, fatigue, sleep, gait, mobility, physical activity, sensorimotor function

[www.neura.edu.au/clinical-trial/step-training-ms/](http://www.neura.edu.au/clinical-trial/step-training-ms/)

ACTRN12616001053415



# Step training

## THE LANCET

Volume 388, Issue 10050, 17–23 September 2016, Pages 1170–1182

THE LANCET



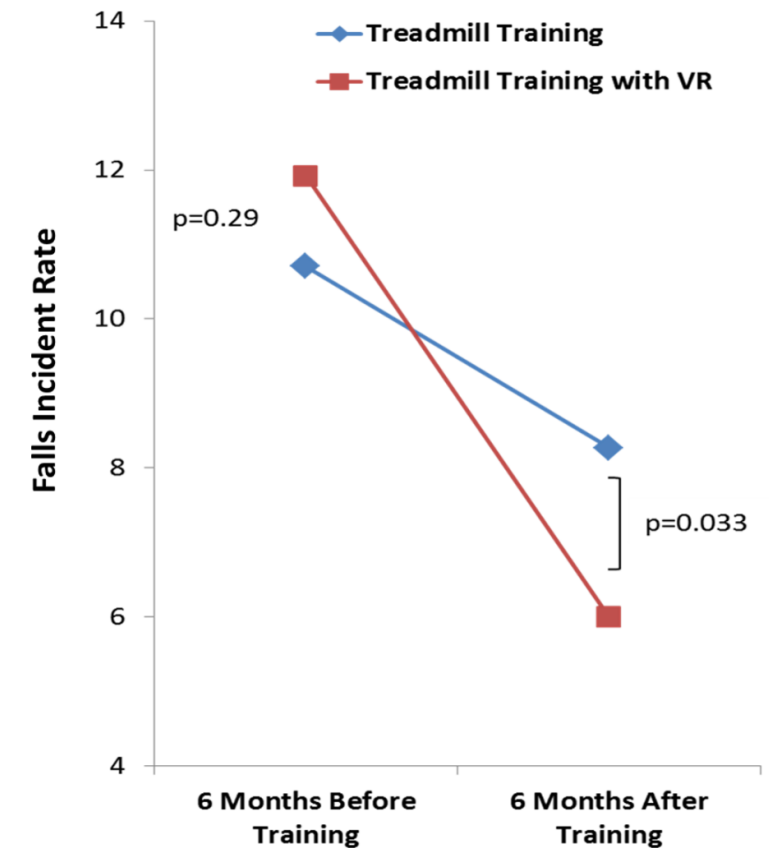
### Articles

### Addition of a non-immersive virtual reality component to treadmill training to reduce fall risk in older adults (V-TIME): a randomised controlled trial

Dr Anat Mirelman PhD <sup>a, b</sup>, Prof Lynn Rochester PhD <sup>e</sup>, Inbal Maidan PhD <sup>a</sup>, Silvia Del Din PhD <sup>e</sup>, Lisa Alcock PhD <sup>e</sup>, Freek Nieuwhof MS <sup>f, g, h</sup>, Prof Marcel Olde Rikkert MD <sup>f, g</sup>, Prof Bastiaan R Bloem MD <sup>h</sup>, Elisa Pelosin PhD <sup>i</sup>, Laura Avanzino MD <sup>i, j</sup>, Prof Giovanni Abbruzzese MD <sup>i</sup>, Kim Dockx MS <sup>k</sup>, Esther Bekkers MS <sup>k</sup>, Prof Nir Giladi MD <sup>a, b, d</sup>, Prof Alice Nieuwboer PhD <sup>k</sup>, Prof Jeffrey M Hausdorff PhD <sup>a, c, d</sup>



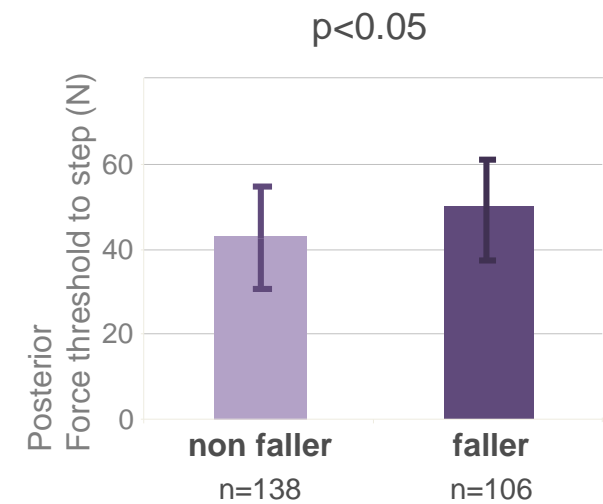
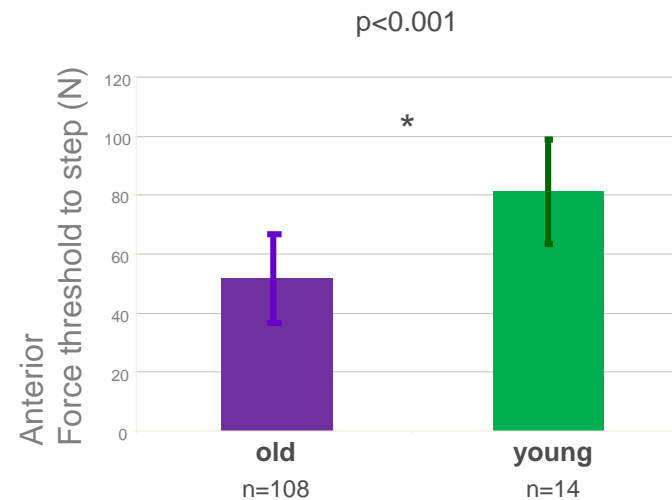
N=302



# Reactive Stepping



# Perturbation responses



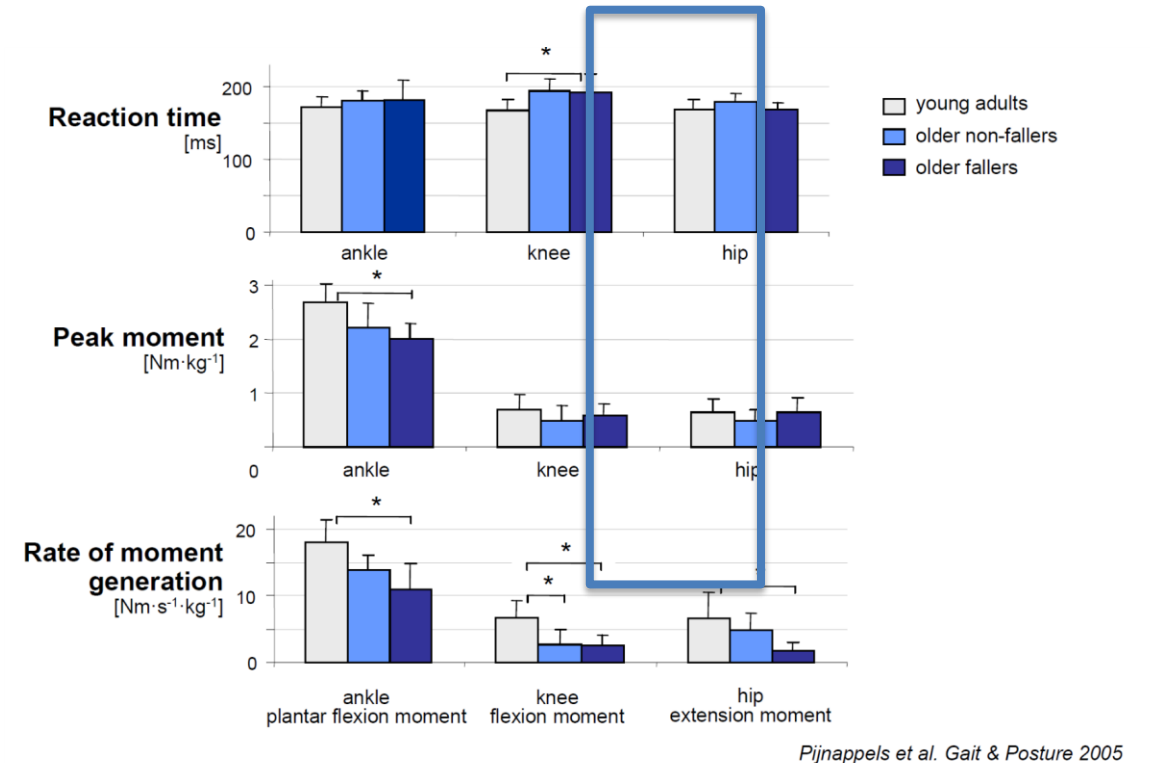
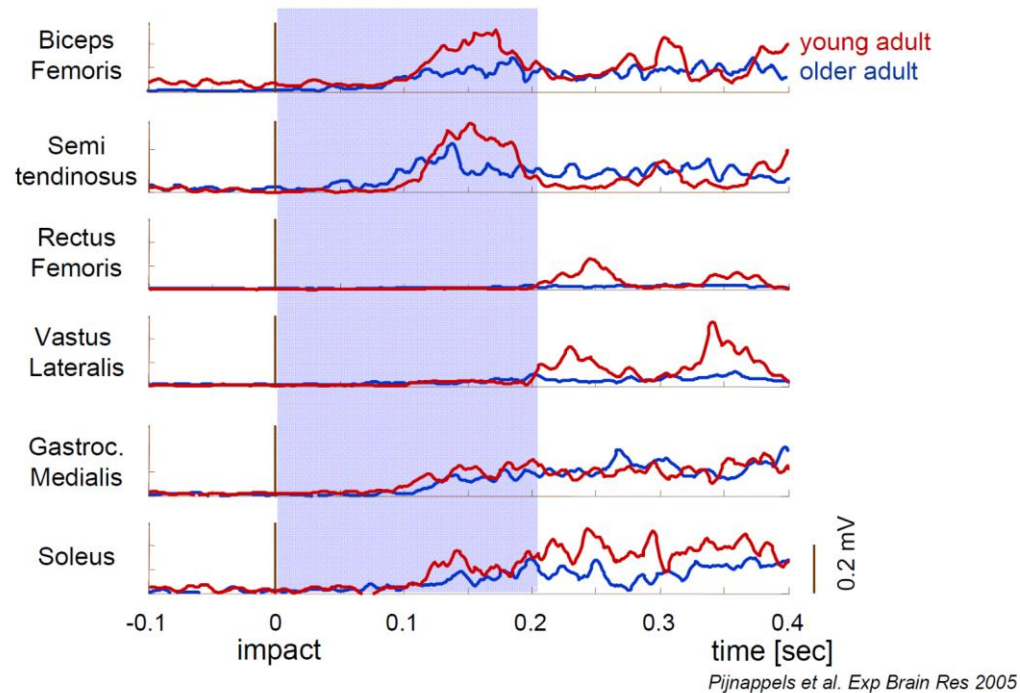
Sturnieks et al. Plos One, 2013



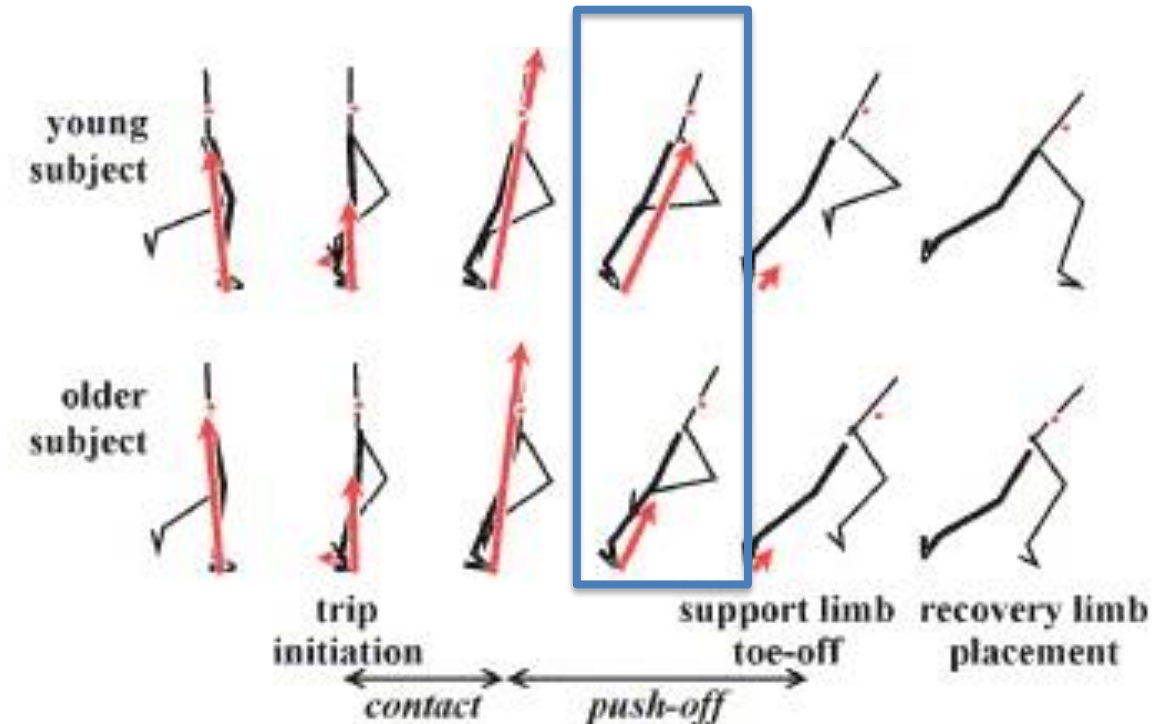
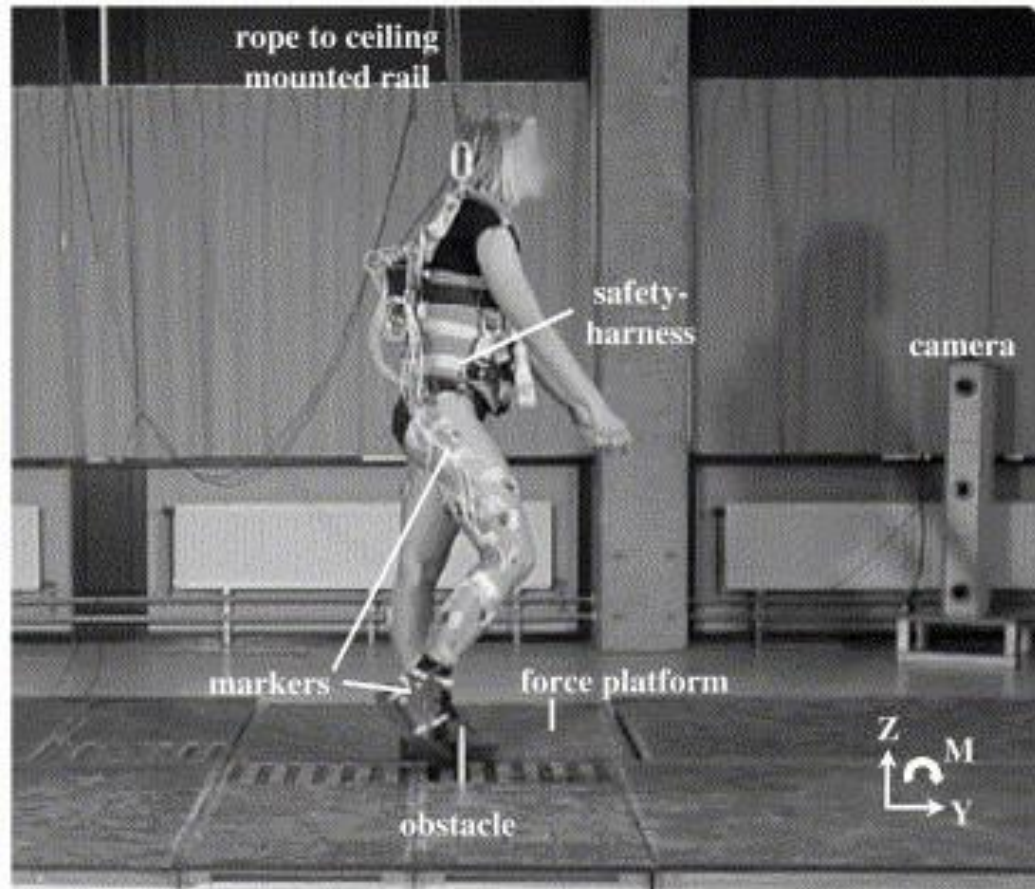
Knee extension strength ( $\beta=0.330$ )  
 Body weight ( $\beta=-0.459$ )  
 ML sway ( $\beta=-0.208$ )  
 Ankle strength ( $\beta=0.207$ )  
 24.8%

Sturnieks et al. Gait Posture, 2012

# Quantifying Trip Responses



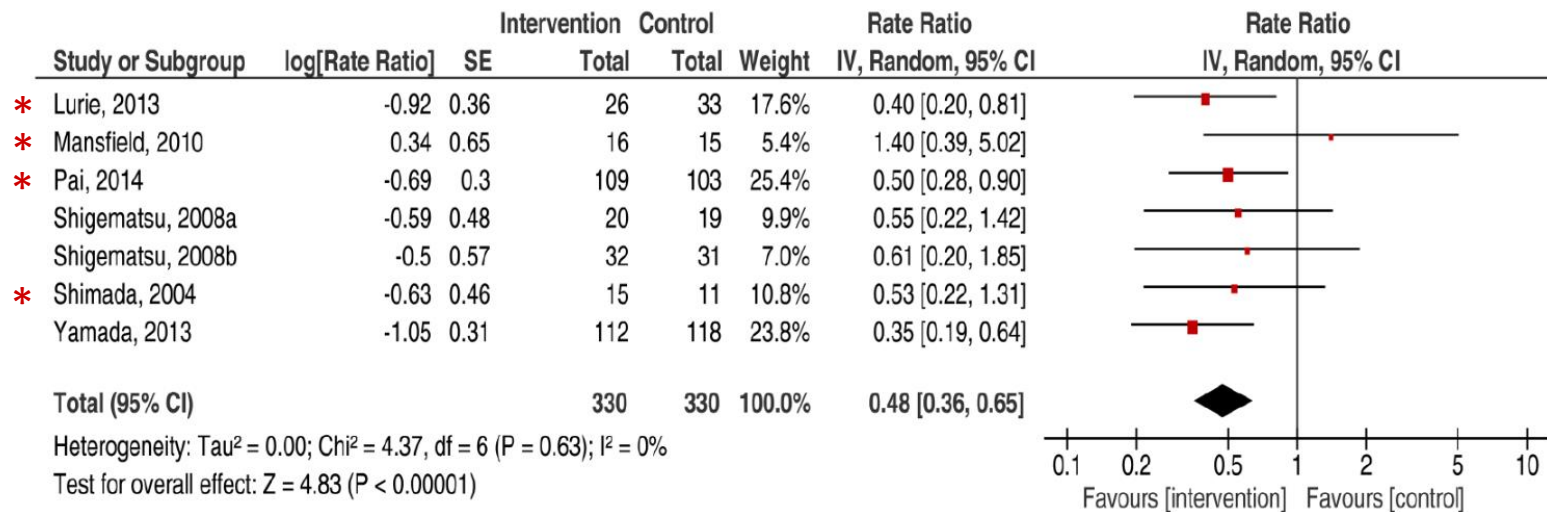
# Quantifying Trip Responses



Pijnappels et al. Gait & Posture 2005

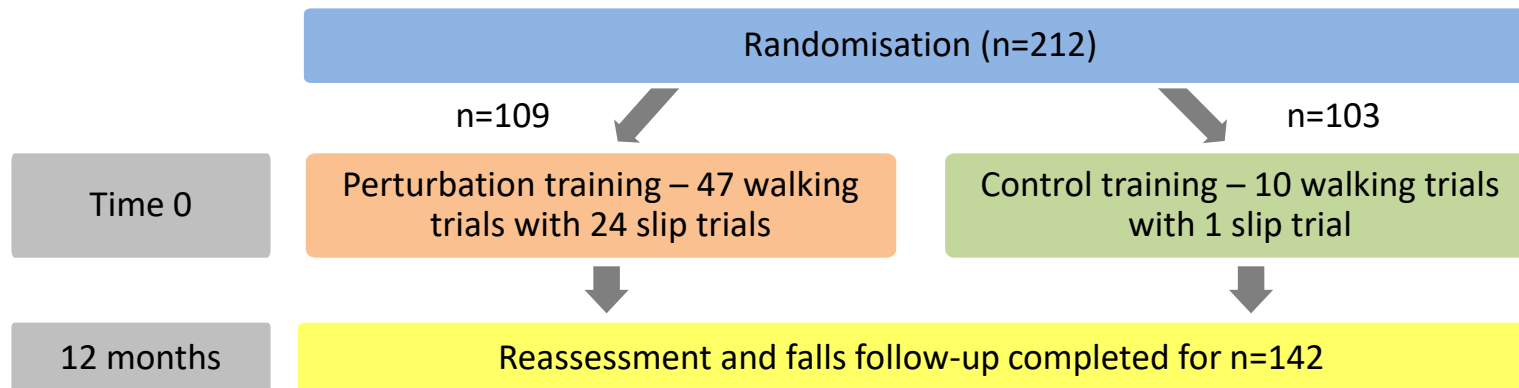
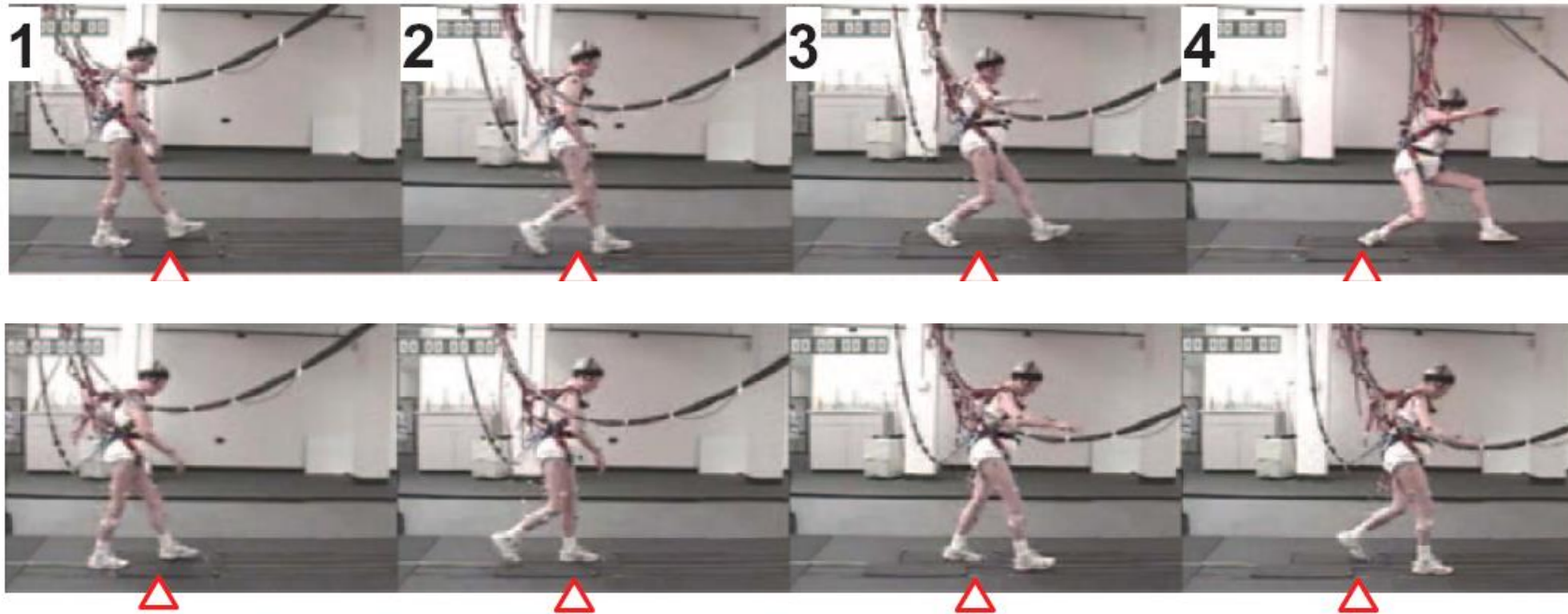
# Perturbation Training

- Task-specific perturbation training - practicing the motor skill of avoiding a fall during conditions that mimic an actual fall
- Within a single session of repeated exposure to perturbations (slips, trips, platforms/treadmills) laboratory-induced falls can be significantly reduced among older adults.





# Perturbation Training RCT



# Slip Training RCT

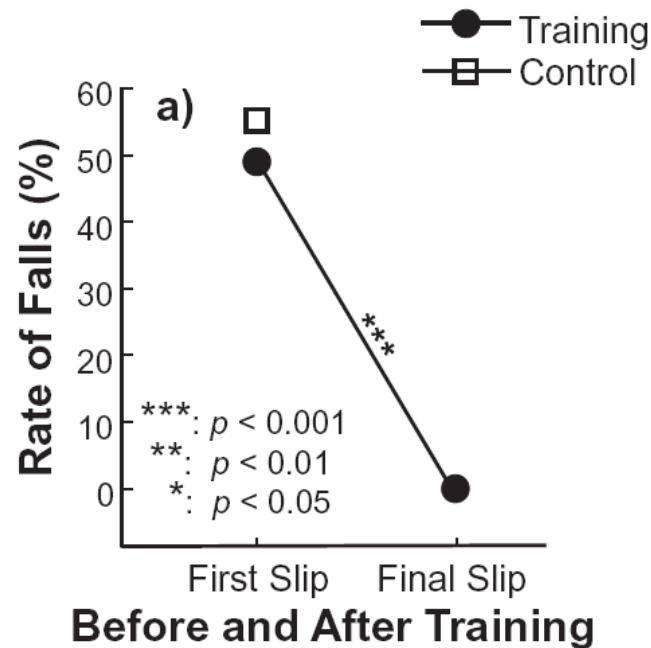
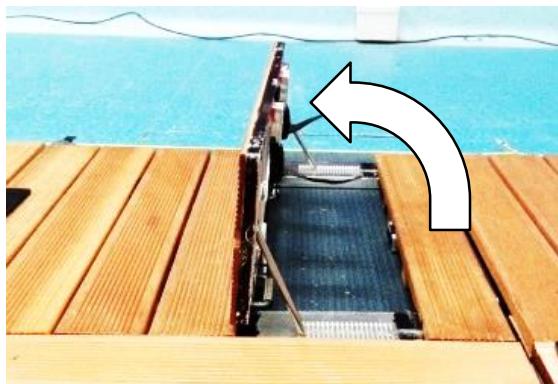
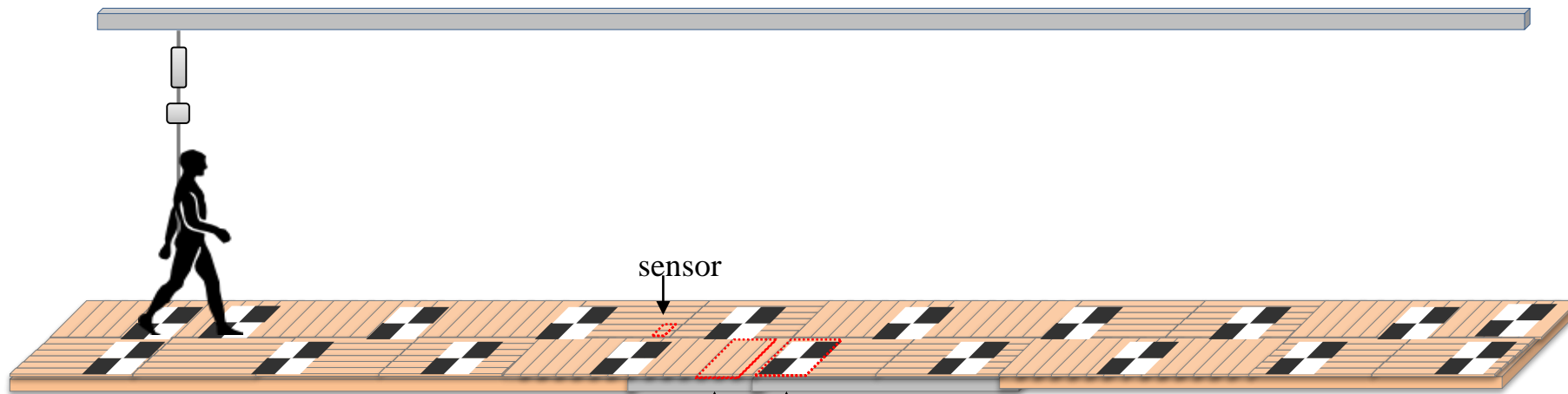


Table 4. Prospective Falls During 12-Month Follow-up Period by Experimental Groups

Baseline	Training (N = 67)		Control (N = 75)		p Value
	Faller/Total	%	Faller/Total	%	
History of Falls					
Yes	6/23	26.1	16/29	55.2	.0350
No	4/44	9.1	8/46	17.4	.2469
Total	10/67	14.9	24/75	32.0	.0173

Control group (single slip) were **2.3 times more likely** to fall during the 12-month follow-up period ( $p < .05$ ) than those who experienced the 24 repeated slips.

# Trip and Slip walkway



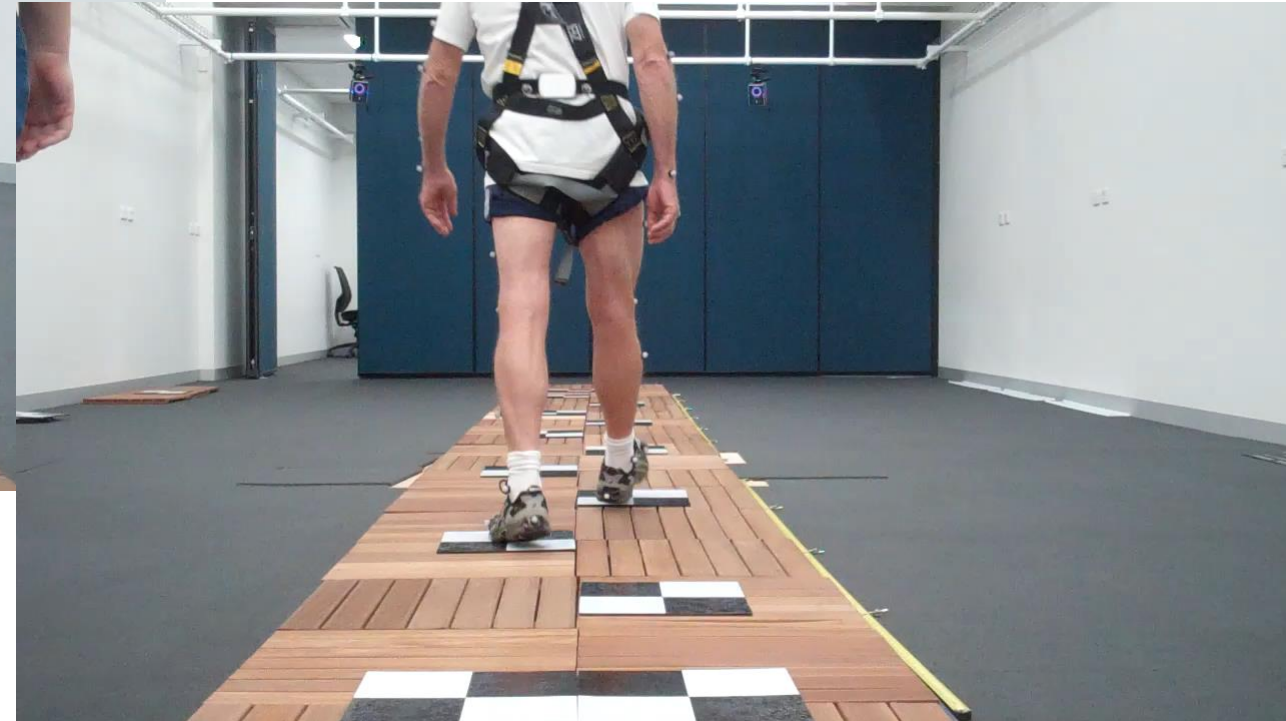
TRIP



SLIP



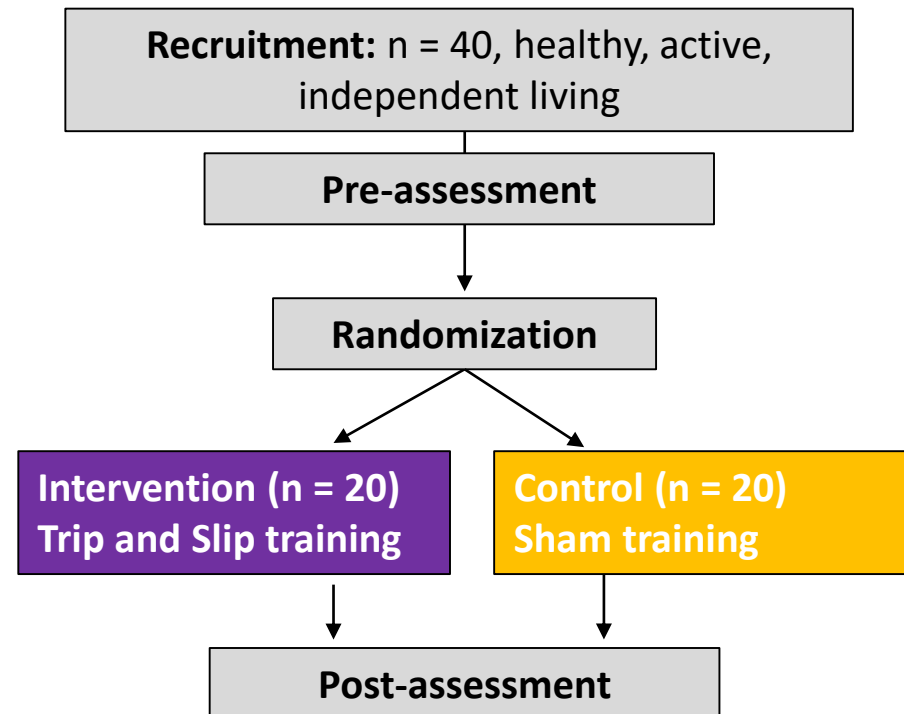
# Trip and Slip walkway



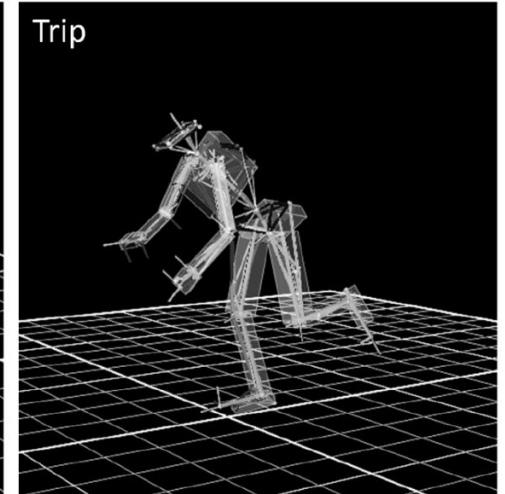
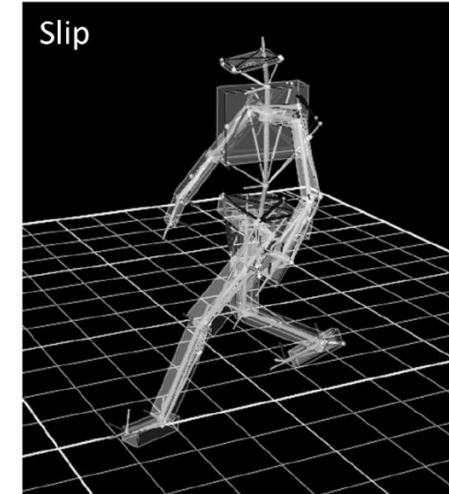
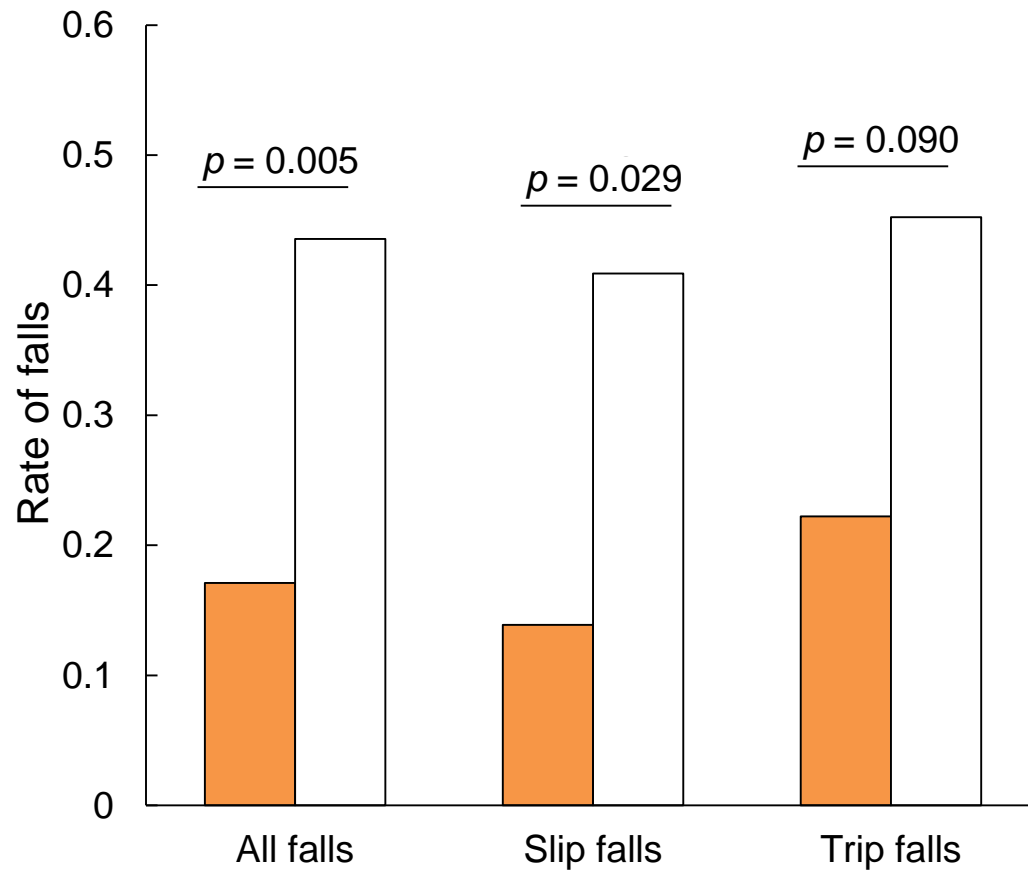


# Slip and Trip training RCT

**Aims:** To examine the effect of reactive step training (induced slips and trips) on balance recovery in older adults.



# Results | falls/slips and trip exposures



Intervention

Control

# Future applications

- Good evidence for trip and slip training for fall prevention
- Definitive trial needed
- Effectiveness in other populations
  - pilot studies in people with PD and people with MS.
- How can this be applied in the community?



# Step training conclusions

	Balance Training	Voluntary Step Training	Reactive Step Training
<b>Movement type</b>	Volitional	Volitional	Reactive
<b>Task-specificity</b>	Low - Medium	Medium	High
<b>Speed of movement</b>	Slow - Moderate	Moderate	Fast
<b>Stability range of activities</b>	Within limit of stability	Within limit of stability	Outside limit of stability
<b>Balance threat &amp; learning stimulus</b>	Low	Low	High
<b>Minimum dose</b>	High: 3+hours/wk, ongoing	High: 2+hours/wk, ongoing	Low: 1-3 hr sessions in 6mo
<b>Additional benefits</b>	Likely	Likely	Unlikely
<b>Evidence for fall prevention</b>	Established (40% reduction)	Preliminary (50% reduction)	Preliminary (50% reduction)

# NeuRA

*Discover. Conquer. Cure.*

[neura.edu.au](http://neura.edu.au)

