Standing up to our fear: the interaction of human balance and emotion

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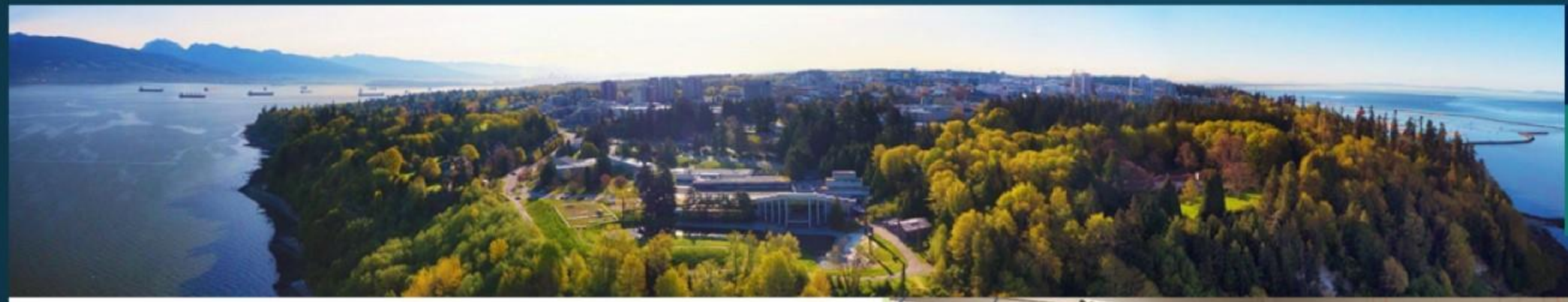
Disclosure

I have no relevant financial or non-financial relationships to disclose in relation to this presentation



UBC
School of Kinesiology

LAND ACKNOWLEDGMENT

We humbly and gratefully acknowledge to live and work on the traditional, ancestral, and unceded territory of the

xʷməθkʷəy̓əm (Musqueam), Sḵwx̱wú7mesh (Squamish), and səlilwətaɬ (Tsleil-Waututh) peoples

Why study fear of falling?

High level of fear of falling reported in older adults:

- 50% of those who have previously had a fall
- >30% of those that have not fallen

Fear of falling with balance disorders

Higher occurrence of fear of falling in individuals with:

- Vestibular loss (Yardley et al. 1996)
- Parkinson's disease (Adkin et al. 2003)
- Stroke (Watanable 2005)
- Multiple Sclerosis (Noritke Matsuda et al. 2012)
- Spinal cord injury (Singh et al. 2021)

High co-morbidity observed between anxiety and:

- dizziness and vertigo
- vestibular-balance disorders

(Furman & Jacob, 2001; Balaban & Jacob, 2001; Staab et al. 2013)

Factors associated with Fear of Falling

- Advanced aging and frailty
- Prior falls
- Anxiety / Depression
- Medication use
  - hyper-tensives, anti-depressants, sleep medications
- Other medical conditions
  - Balance and gait disorders
  - Poor functional status / visual problems

Rivasi et al. (2020)

Impacts of fear of falling in older adults

- Fear of falling is associated with:
  - Decreased balance confidence
  - Restricted activity
  - Social isolation and Depression
  - Decreased quality of life
  - Poor balance control
  - Increased fall risk (up to 50%)

(Cumming et al. 2000)

Differences in balance control between fearful/anxious groups

Altered balance control in fearful vs. non-fearful older adults

Maki et al. (1991, 1994); Baloh et al. (1994); Hughes et al. (1996); Myers et al. (1996); Okada et al. (2001); Binda et al. 2013; Uemera et a. 2012

Altered balance control in fearful vs. non-fearful individuals with PD

Franchignoni et al. (2005); Mak et al. (2012); Bryant et al. (2014); Adkin et al. (2003)

Balance control differences in individuals with:

- High Trait Anxiety
- Acrophobia & Panic disorder

(Redfern et al. 2007; Boffino et al. 2009; Jacob et al. 2009; Hainaut et al. 2011)

<u>Limitation of dichotomous studies:</u>

- Direction of relationship, unclear

How does fear, anxiety and arousal influence balance control?

Modified from Brummel-Smith, 1989

Manipulate threat of the environment to examine how fear influences balance

Save the Kitty - cityscape

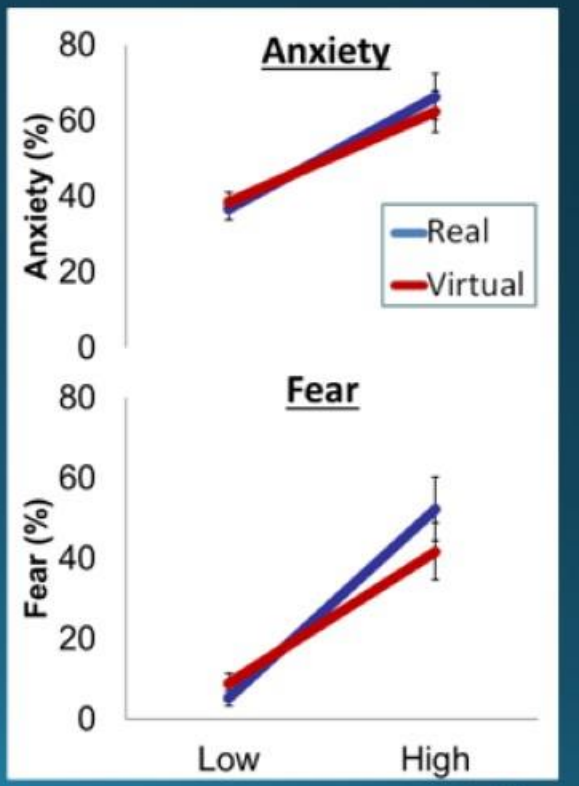
https://www.youtube.com/watch?v=bTXLDrSiBNg

Study the effects of anxiety and fear on balance

Research Paradigm:

Subjects stand on elevated surface heights (range 0 – 3.2 m)

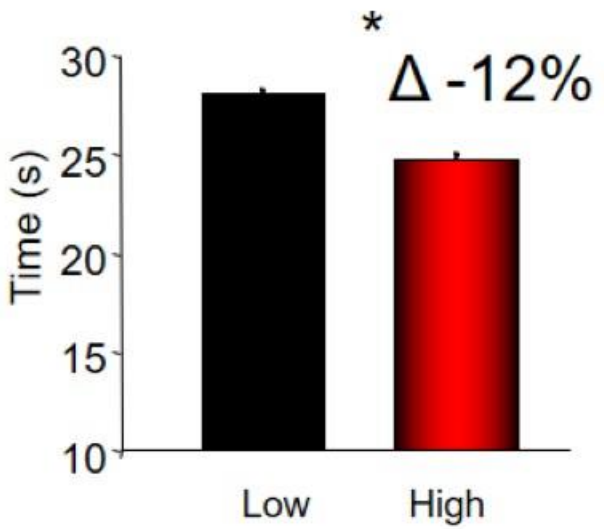
Examine how anxiety influences balance and gait in healthy adults



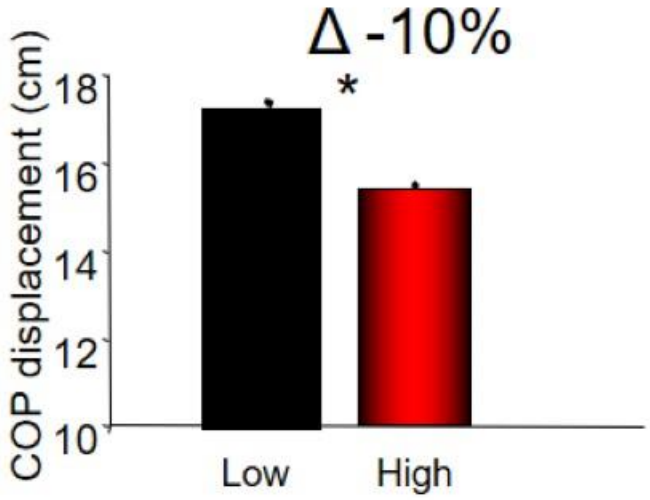
Cleworth et al. 2012

Does fear influence clinical balance measures?

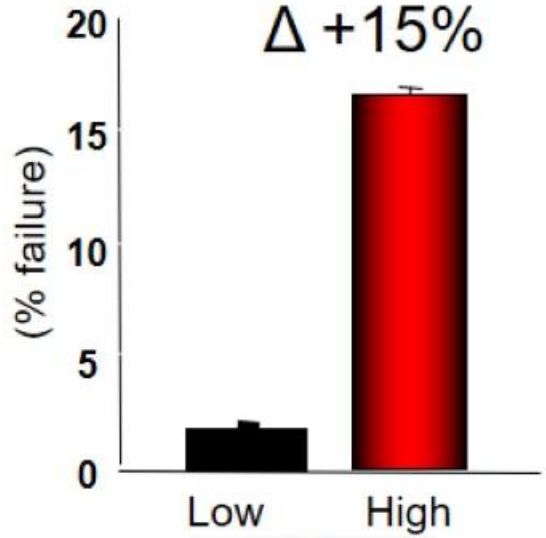
One-Leg Stance Time



Maximum Reach



Rise to toes



Hauck et al. 2008

Adkin et al. 2002

Posturography

Objective measures of static or dynamic balance performance

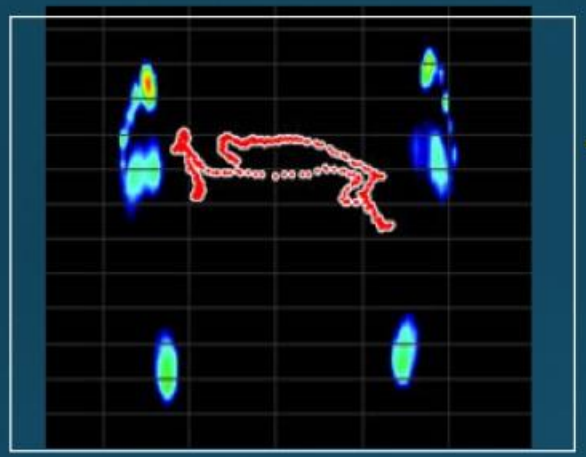
Static balance:

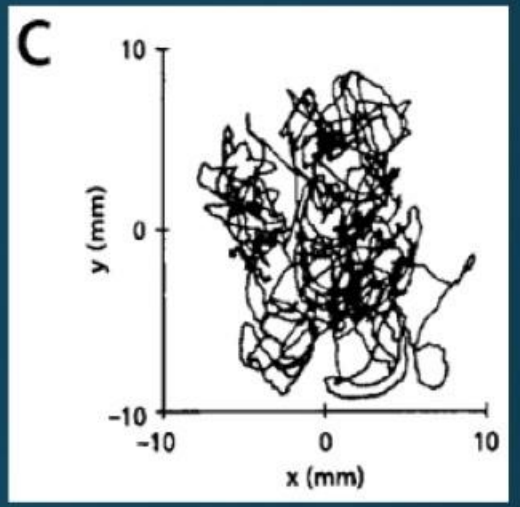
Continuous sway during quiet standing

Dynamic balance:

React to unexpected balance disturbance

Static Posturography

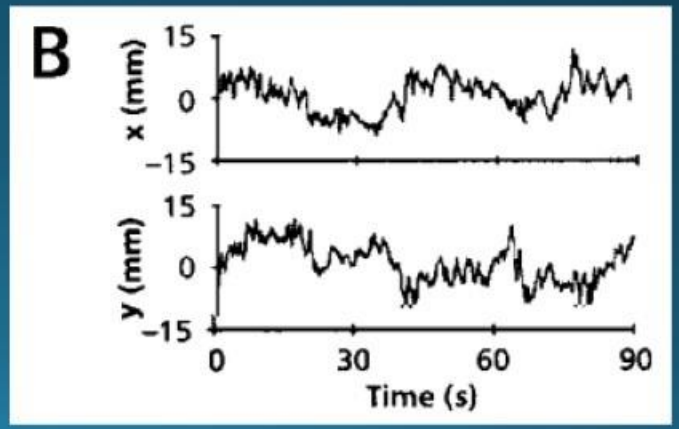




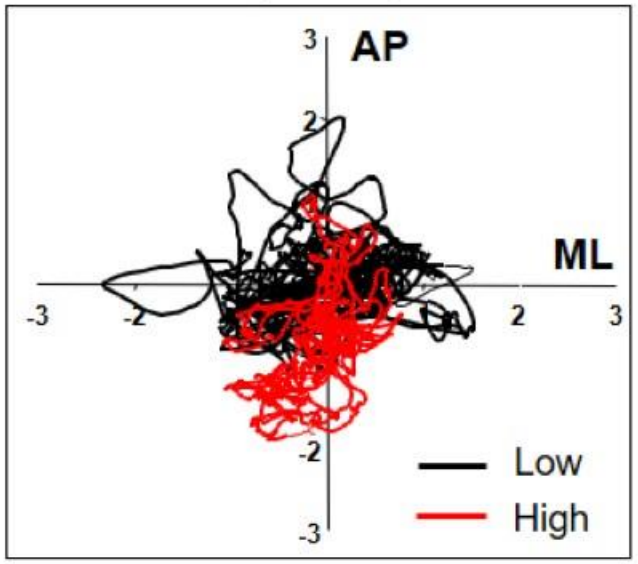
Amplitude

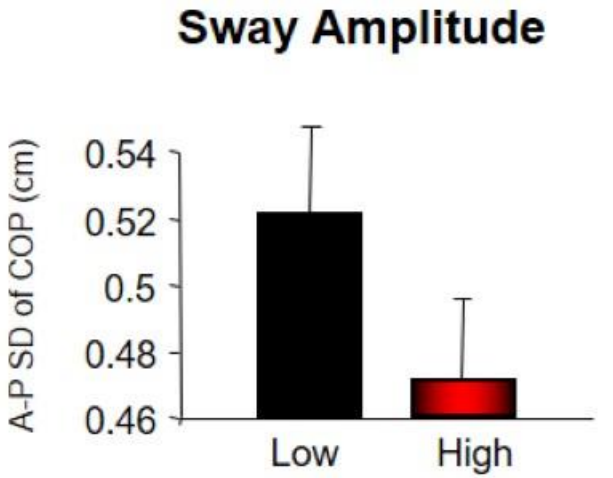
Mean Position

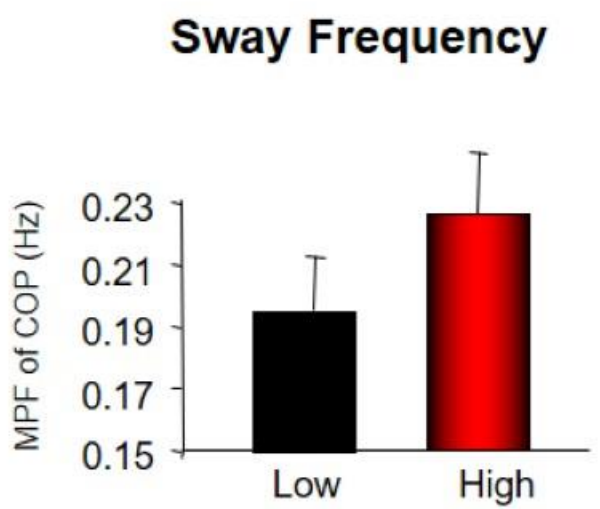
Frequency (speed)

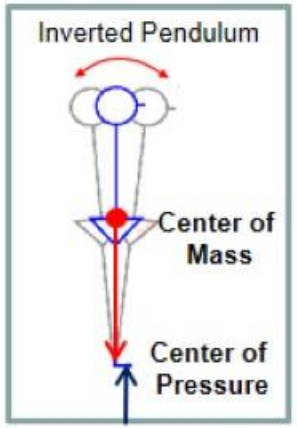


Threat influences static balance control









Carpenter et al. 2001

Threat influences static balance control

Study	Group	Max. Ht.	Duration	AP COP MPOS	AP COP MPF	AP COP RMS
Carpenter et al. (1999)	28 YA	0.81 m	120 s	Backward Lean	increase	Decrease
Adkin et al. (2000)	62 YA	1.6 m	120 s	Backward Lean	Increase	Decrease
Carpenter et al. (2001)	8 YA	0.81 m	120 s	Backward Lean	Increase*	Decrease*
Carpenter et al. (2006)	14 YA	1.6 m	120 s	Backward Lean	Increase	Decrease
Hauck et al. (2008)	31 YA	1.4 m	120 s	Backward Lean	Increase	Decrease
Davis et al. (2009)	26 YA	3.2 m	60 s	Backward Lean	Increase	Decrease
Huffman et al. (2009)	48 YA	3.2 m	60 s	Backward Lean	Increase	No Change
Cleworth et al. (2012)	18 YA	3.2 m	120 s	Backward Lean	Increase	Decrease
Zaback et al. (2015)	82 YA	3.2 m	60 s	Backward Lean	Increase	Decrease
Cleworth et al. (2016)	20 YA	3.2 m	60 s	Backward Lean	Increase	Decrease
Zaback et al. (2019)	68 YA	3.2 m	120 s	Backward Lean	Increase	Decrease
Zaback et al. (2021)	37 YA	3.2 m	90 s	Backward Lean	Increase	Decrease

Modified from Adkin and Carpenter 2018

** few exceptions in other studies:
- most often differ in amplitude changes
- likely due to rails, distance/orientation to edge, inclusion of acrophobics

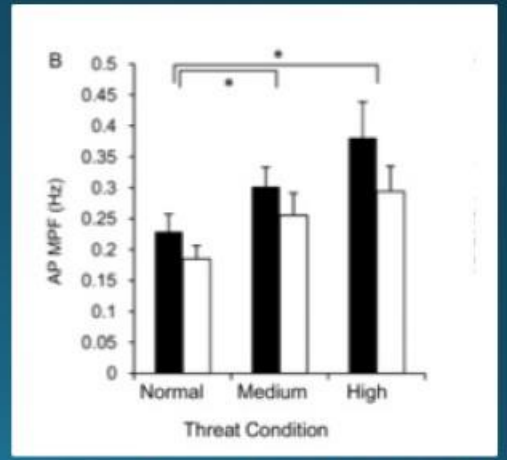
Threat influences static balance control in older adults

Aging studies at low and high heights	Group	Max. Ht.	Duration	AP COP MPOS	AP COP MPF / Vel	COP Amplitude
Carpenter et al. (2006)	13 Older Adults	1.6 m	120 s	Back Lean	Increased	Decrease
Brown et al. (2006)	15 Older Adults	1.4 m	15 s	Back Lean	Increased	Decreased
Laufer et al. (2006)	60 Older Adults	0.85 m	60 s	n.a.	Increased	No change
Pasman et al. (2011)	14 Older Adults	1.6 m	120 s	Back Lean	Increased	No Change
Sturnieks et al. (2016)	36 Older Adults (non-anxious)	0.65 m	30 s	n.a	Increased	Decreased
Ellmers et al. (2022)	44 Older Adults	0.60 m	60 s	n.a.	Increased	No change

Threat-related balance changes also observed in:

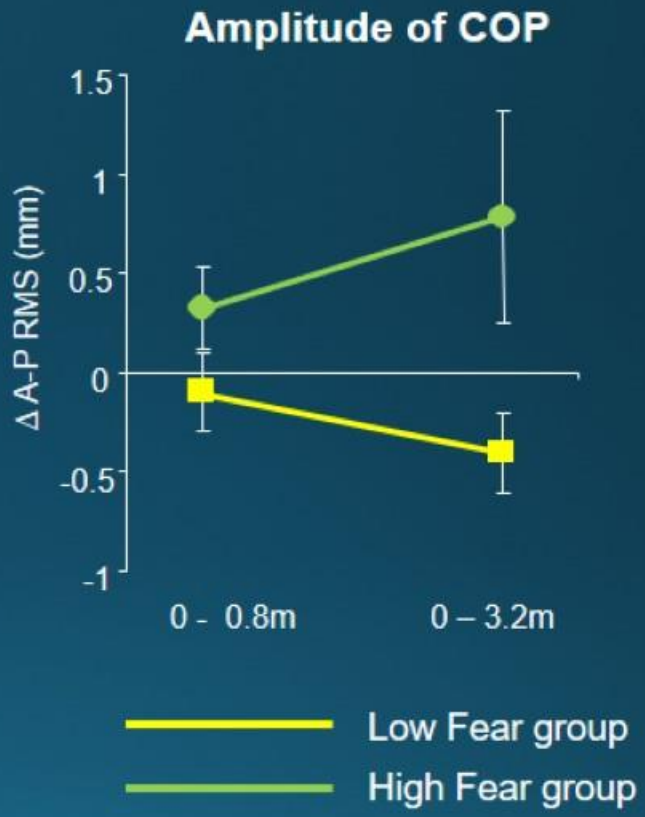
Parkinson's Disease (Pasman et al. 2011; Ehgoetz Martens et al. 2017)

Vestibular Loss (Cleworth et al. 2020; Young et al. 2012)



Pasman et al. 2011

Changes in static balance dependent on level of fear of falling



Davis et al. 2009 - Gait Posture

Measuring Dynamic Balance

- *Postural Reactions*

  Balance responses that occur in reaction to an expected or unexpected disturbance

Dynamic Posturography

Translation (slide)

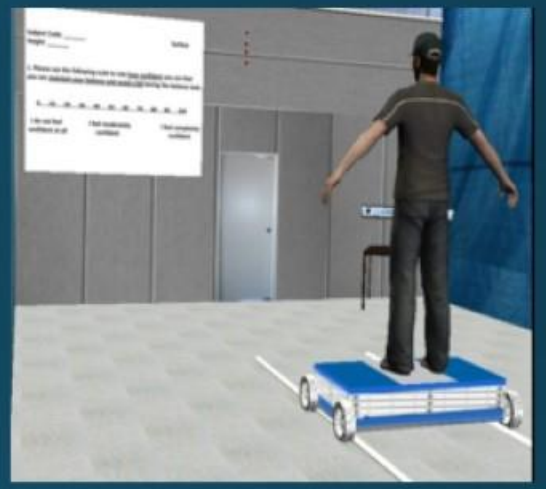
Rotation (tilt)

Changes in Dynamic Balance

Real Heights

Carpenter et al. (2004)

Virtual Heights



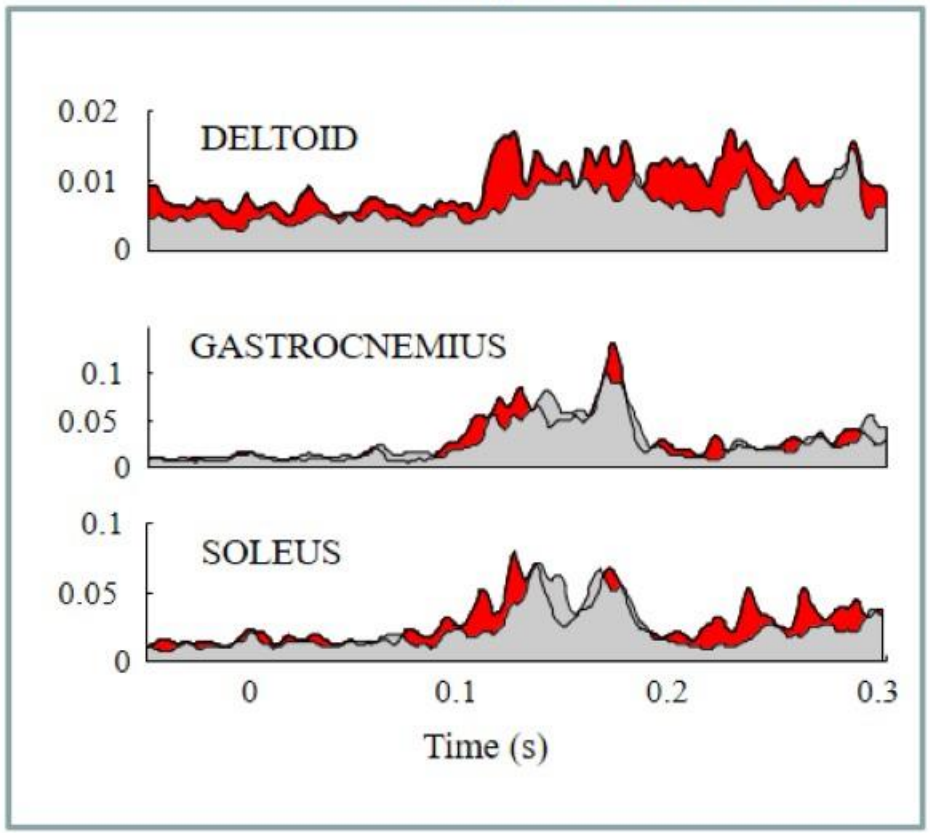
LOW

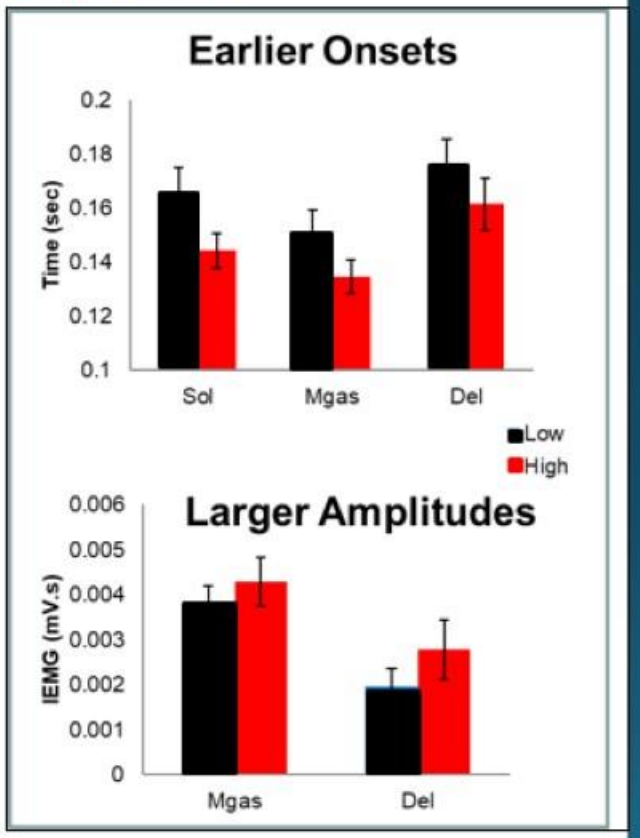
HIGH

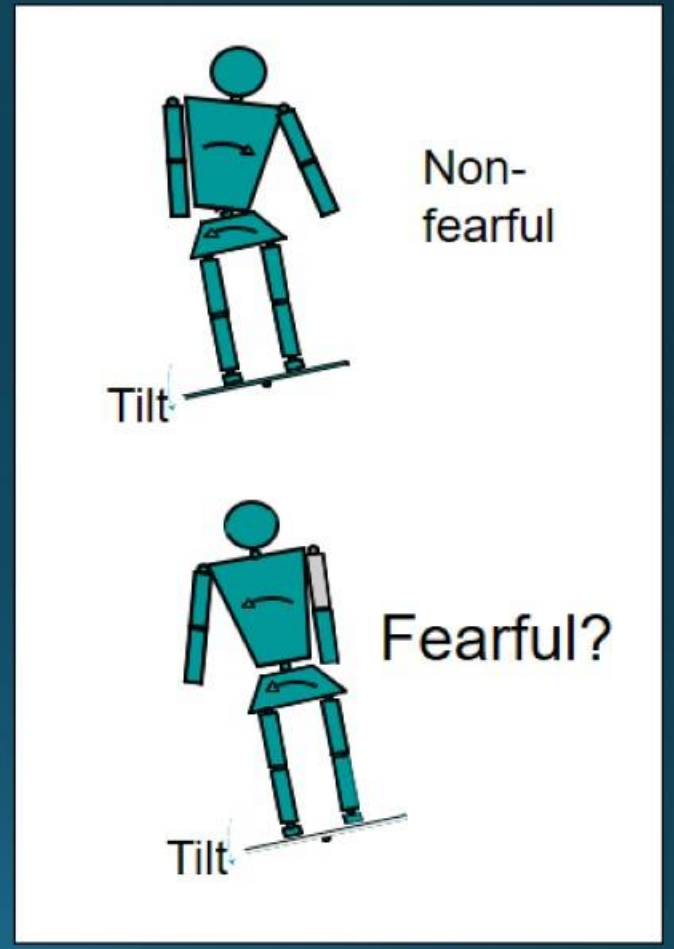
Cleworth et al. 2016

Changes in Dynamic Balance

Larger and earlier muscle responses

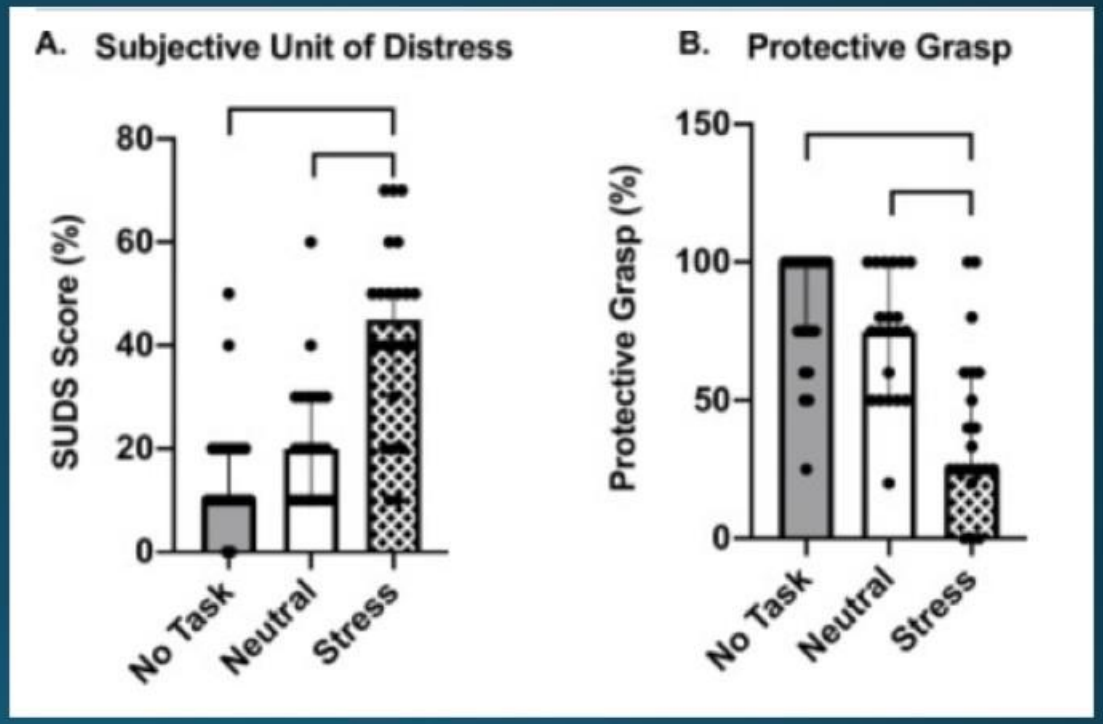






Cleworth et al. 2016

How anxiety affects grasping responses



Akinlosotu et al. 2021

Potential Mechanisms

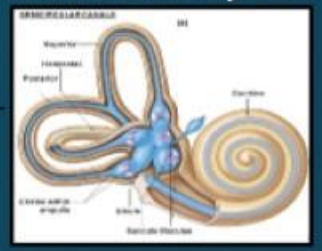
- Mechanisms currently unknown but likely involve:
  - Neural changes in sensori-motor control that affects postural reflexes
  - Changes in attentional focus
  - Changes in perceived stability

Anxiety effects on sensory-balance reflexes

Vision

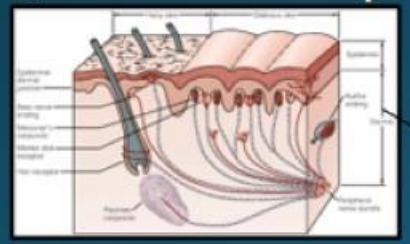
Increased visual-balance reflexes
Increased useful field of view

Vestibular System



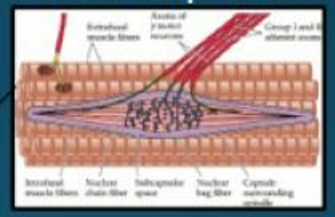
Increased coupling and gain of:
Vestibulo-spinal/ocular reflexes
- VEMPS
- vHIT
- OKN
- GVS

Skin/Cutaneous Receptors



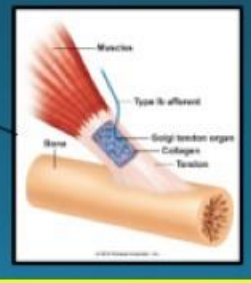
Increased cutaneous reflexes
- during gait

Muscle Spindles



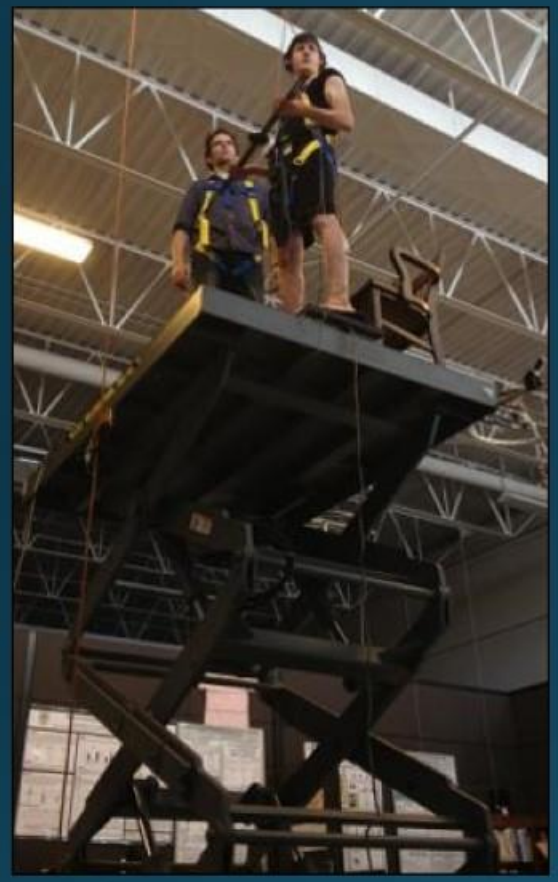
Increased stretch reflexes
- Tendon tap
- Rapid ankle rotations

Golgi Tendon Organs

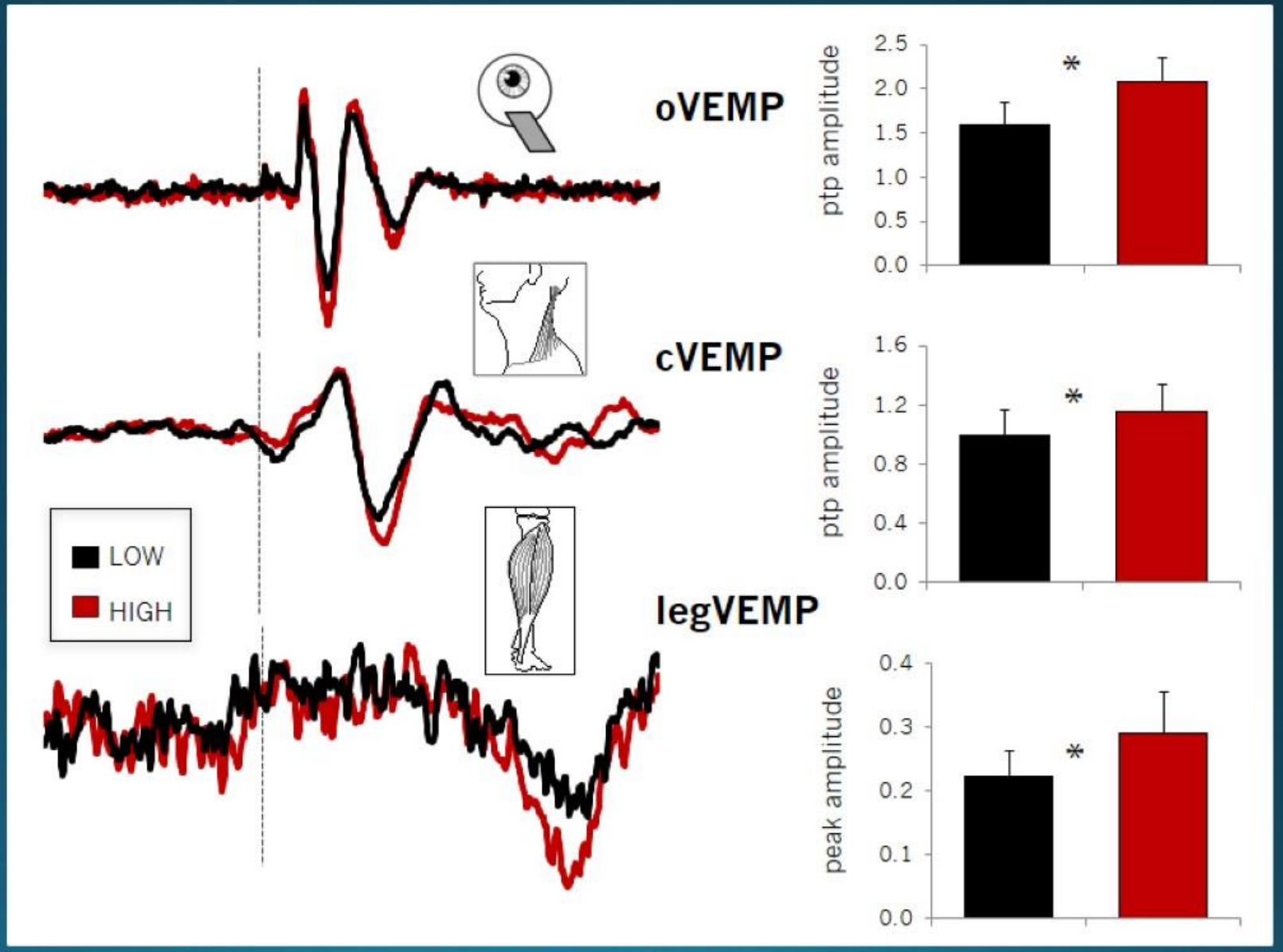


Reduced Ib inhibition
- electrical stimulation

VEMP amplitude increased with threat

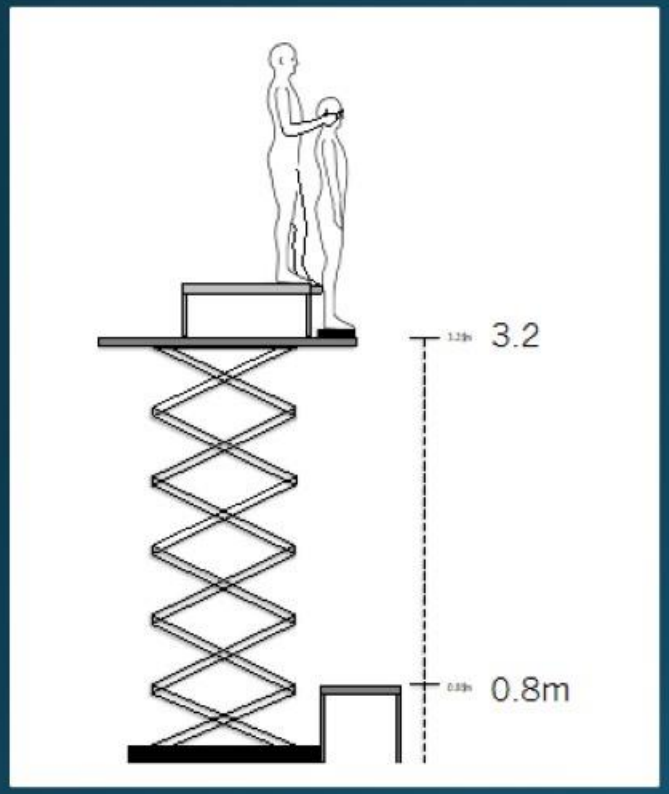


- 25 healthy young adults
- VEMPS Rt ear (125 dB SL)
- 4ms duration and 500 Hz
- Right ear (125 dB SL)
- 256 pulses per condition

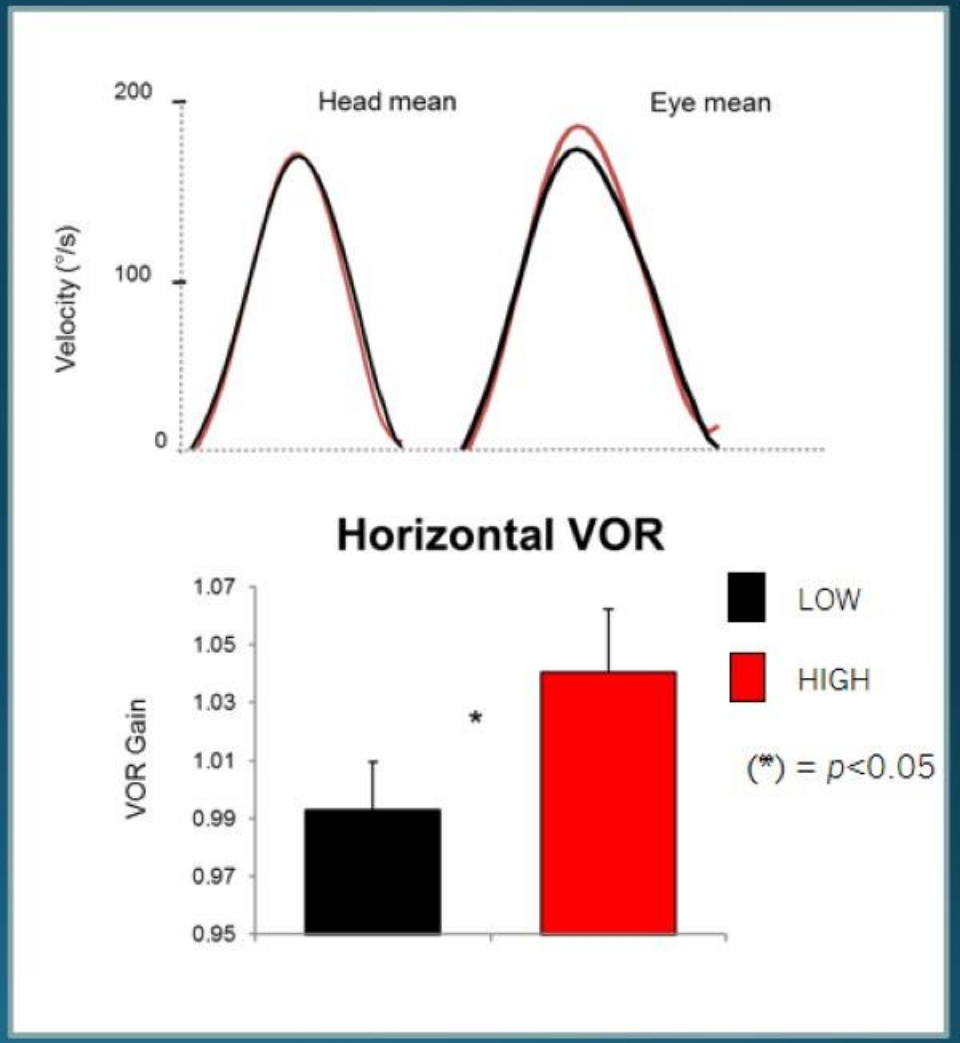


Naranjo et al. 2016 J Neurophys

VOR Reflex Gain increased with threat

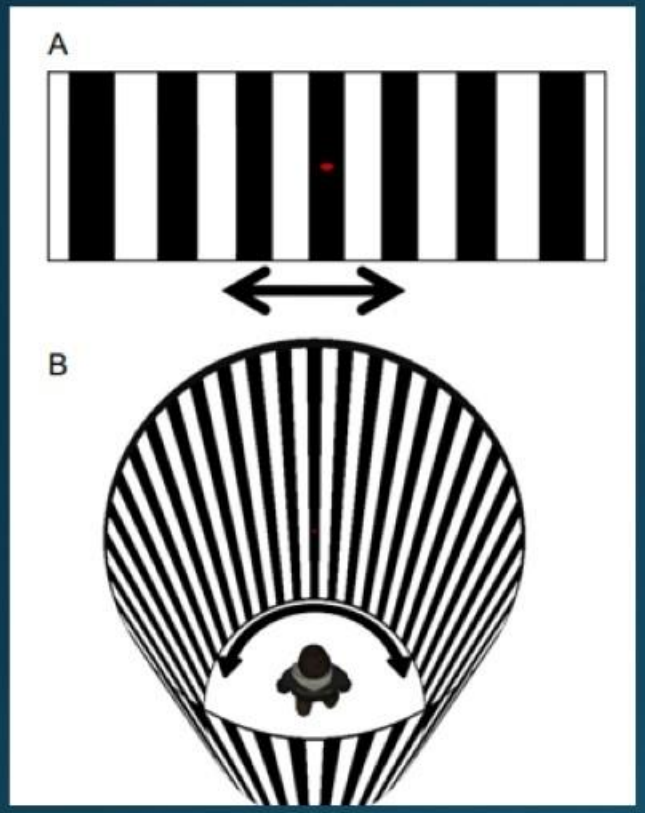


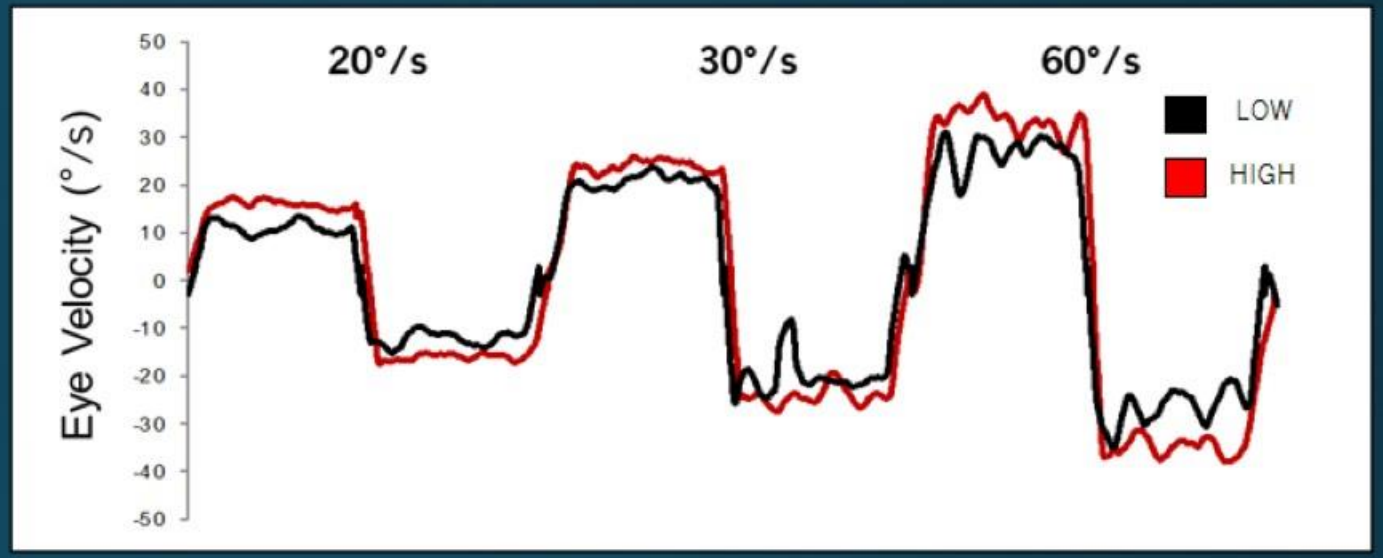
- 19 healthy young adults)
- 20 Horizontal & vertical head thrusts (vHIT) at (~150°/s) at low and high heights
- Recorded eye and head velocities using a commercial vHIT system (ICS Impulse)
- Calculated functional VOR gains



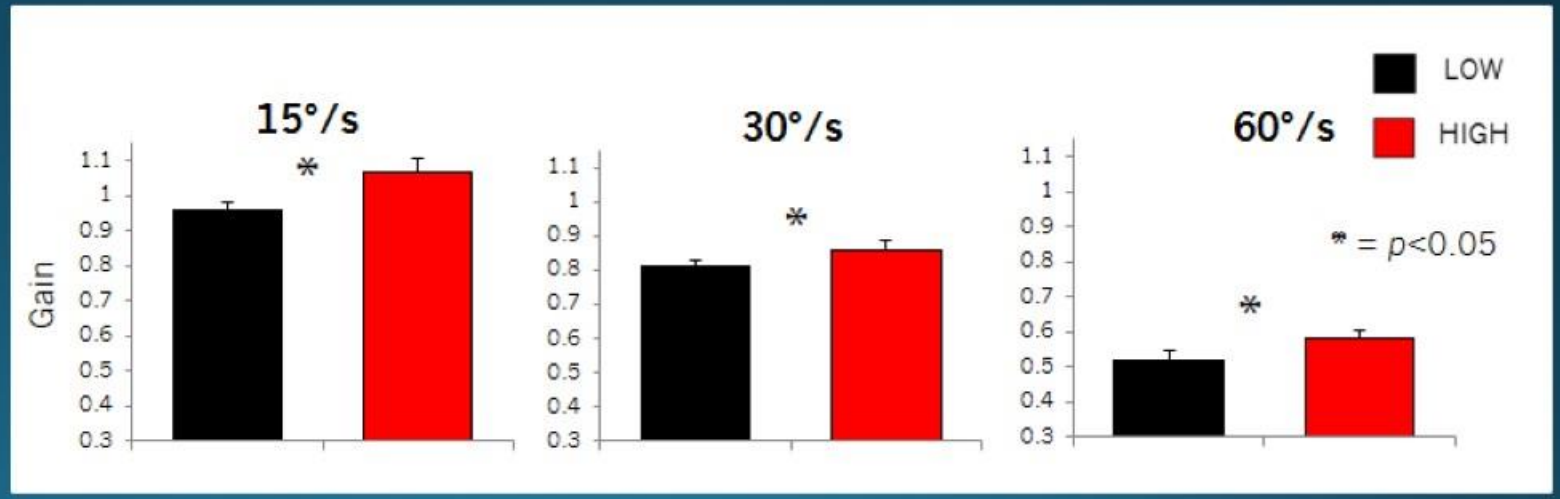
Naranjo et al. *J Neurophysiology (2016)*

OKN gain increased with Threat



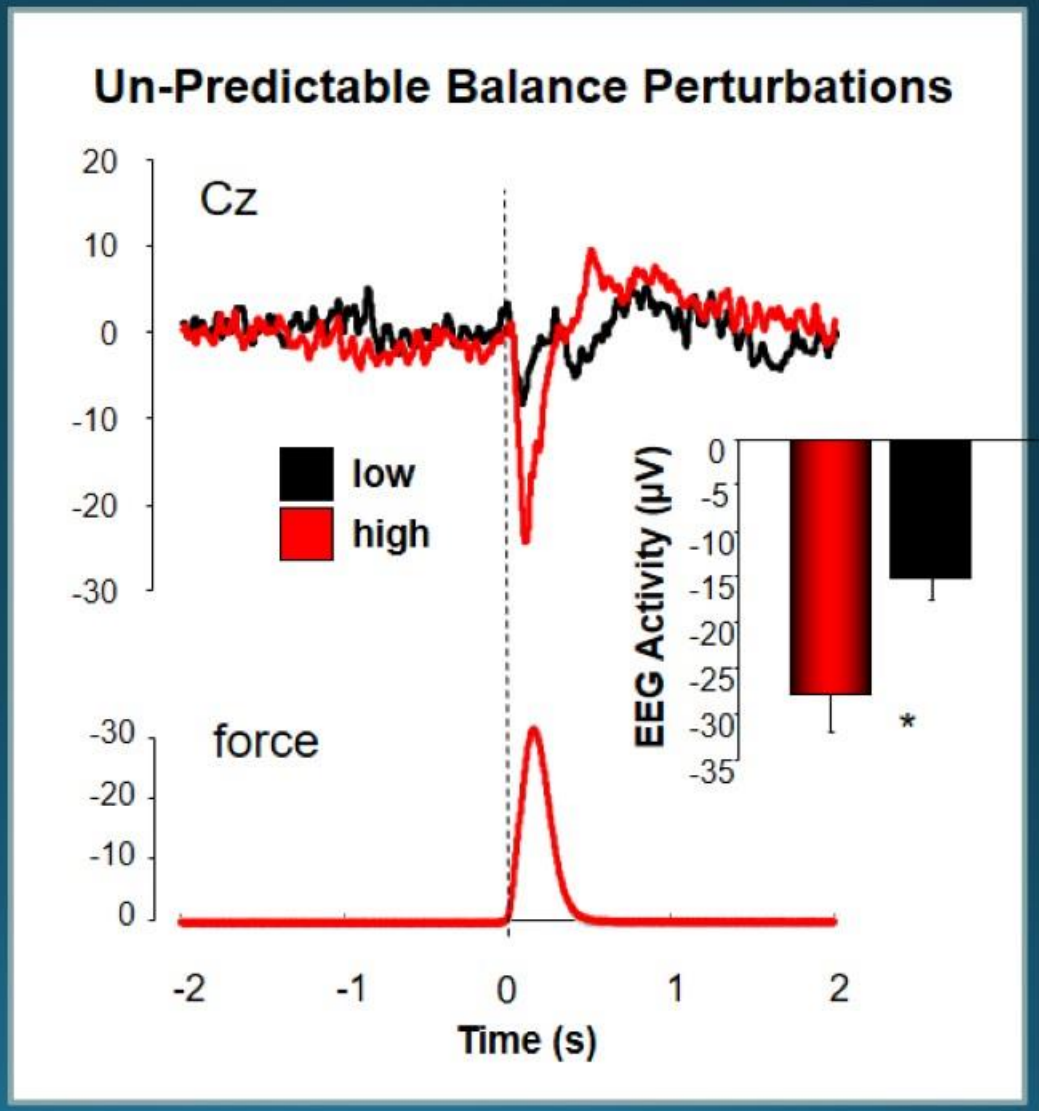


- 20 young healthy adults
- OKN - horizontal moving vertical lines (1m radius)
- 3 velocities (15, 30, 60/s), randomly presented
- 20 s per direction and height (low and high)
- Recorded using EOG



Naranjo et al. 2017– Neurosci

Threat influences sensory-motor processing



Adkin et al. 2008 – Neurosci Lett

Potential Mechanisms

- Mechanisms currently unknown but likely involve:
  - Neural changes in sensori-motor control that affects postural reflexes
  - Changes in attentional focus
  - Changes in perceived stability

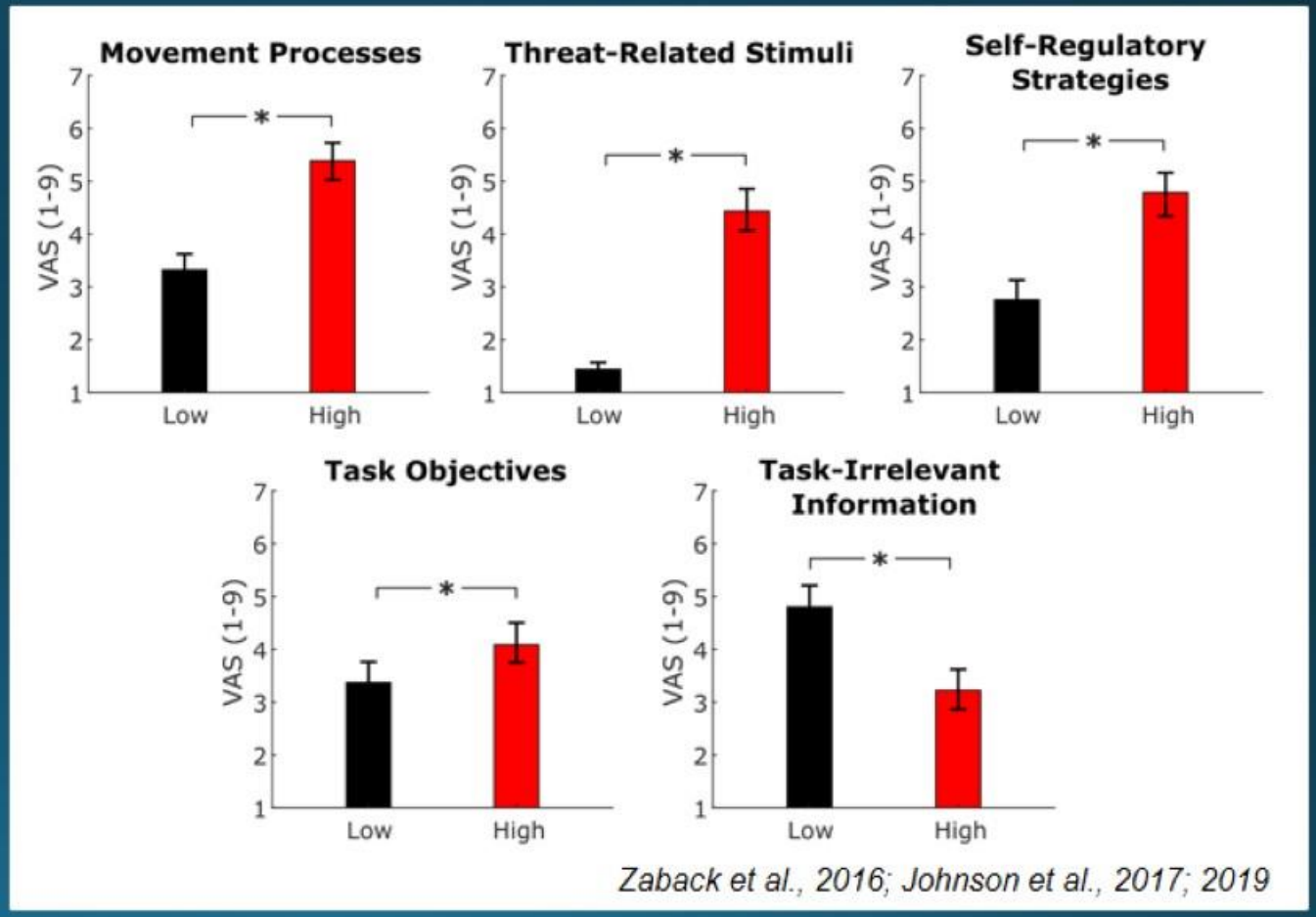
Broad changes in attention focus with threat

When threatened (height/perturbation), young adults direct more attention:

- Toward:
  - movement processes *
  - threat-related stimuli #
  - self-regulatory strategies #
  - task objectives #
- Away from:
  - task-irrelevant information

* May interfere with automatic balance control

May compete with attentional resources needed for balance control

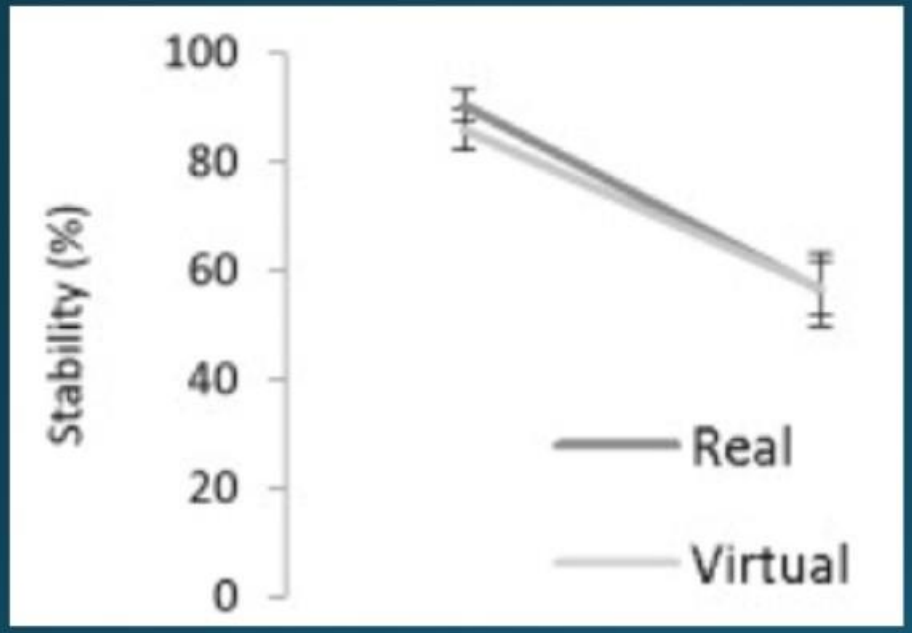


Zaback et al., 2016; Johnson et al., 2017; 2019

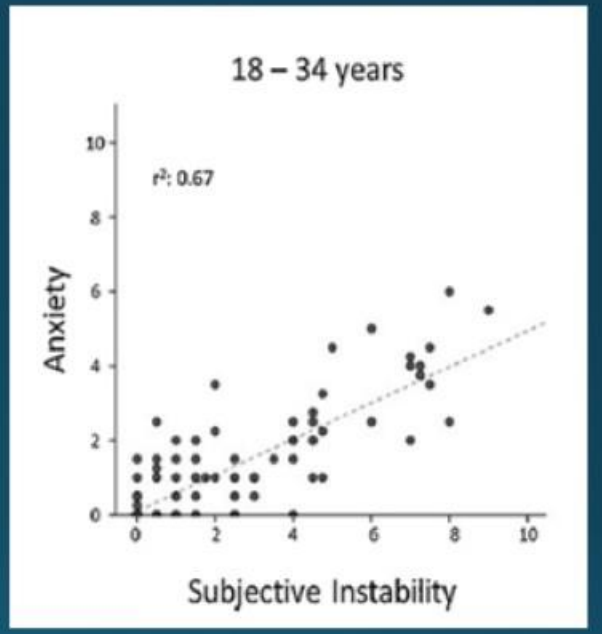
Potential Mechanisms

- Mechanisms currently unknown but likely involve:
  - Neural changes in sensori-motor control that affects postural reflexes
  - Changes in attentional focus
  - Changes in perceived stability

Threat influences perceived postural stability

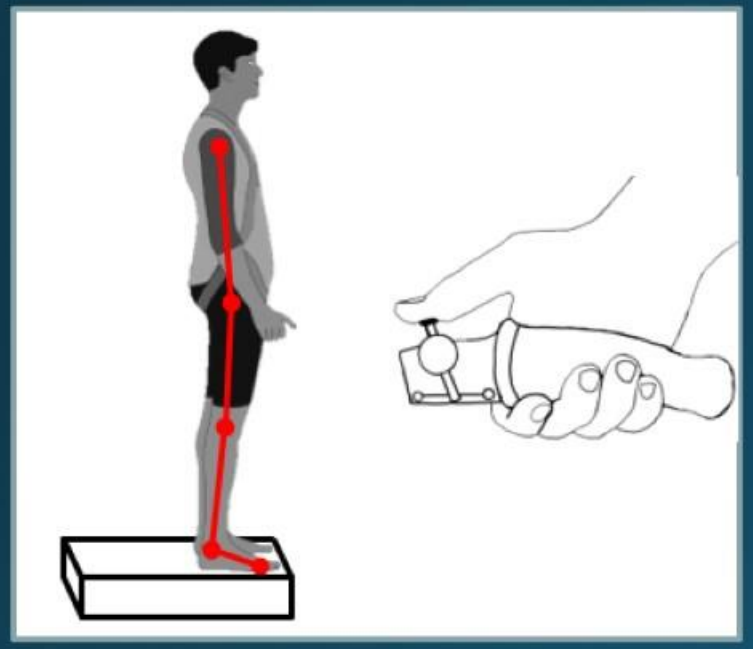


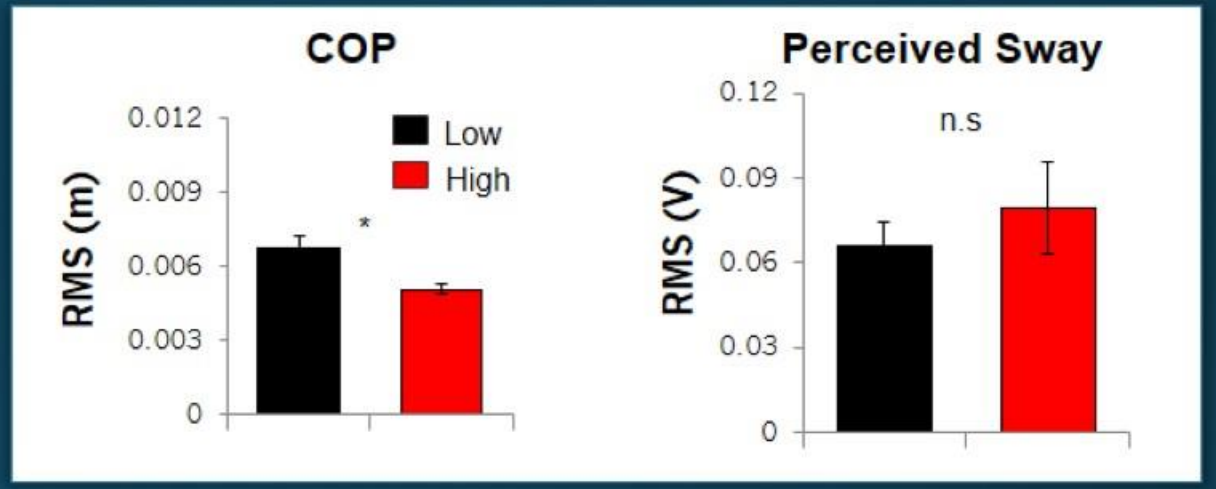
Cleworth et al. 2012



Castro et al. 2019

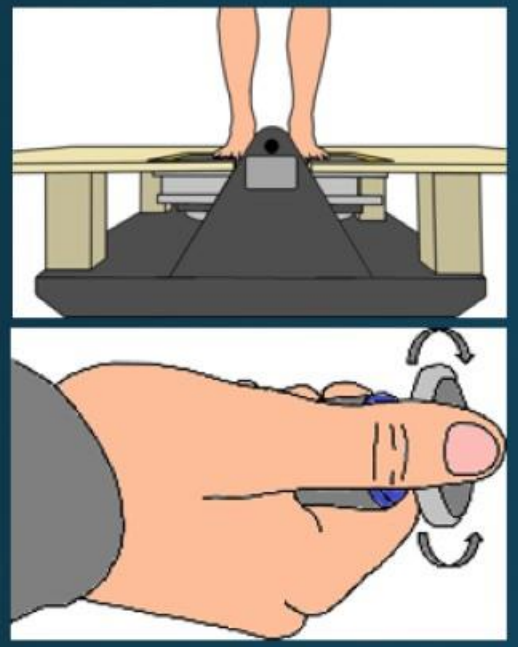
Threat influences perception of spontaneous postural sway

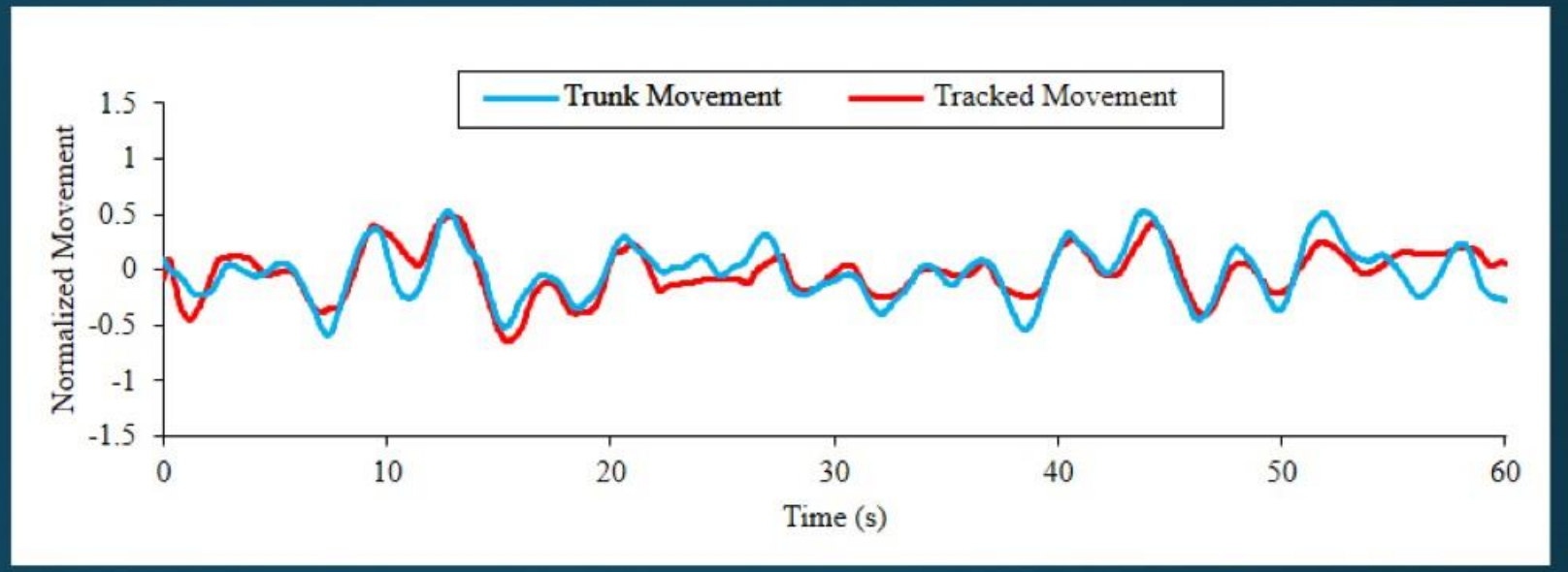


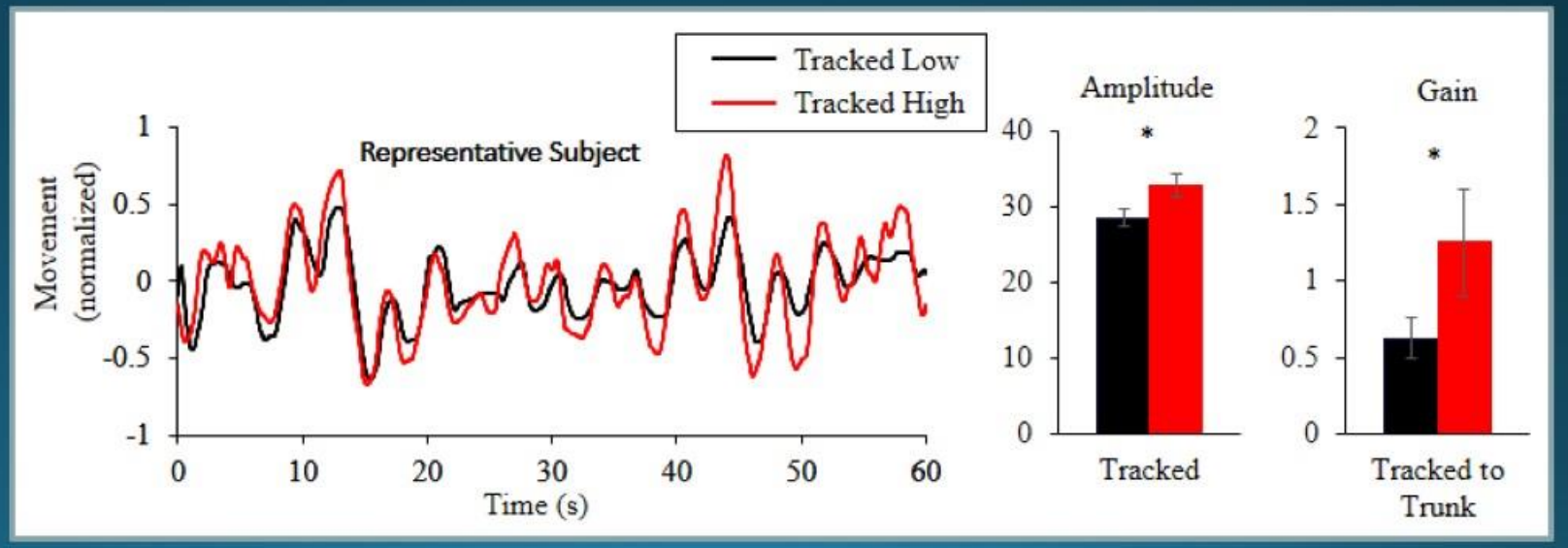


Cleworth & Carpenter, 2016

Threat influences perception of induced postural sway

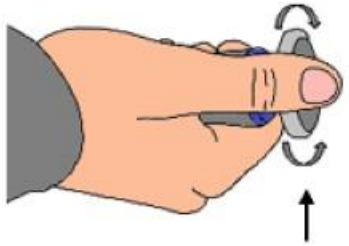




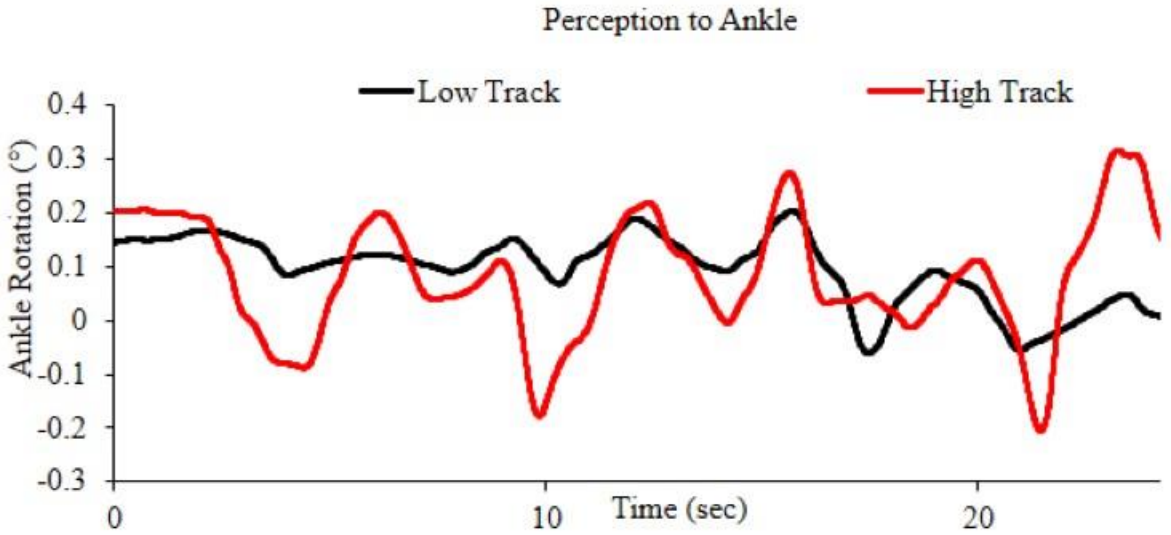


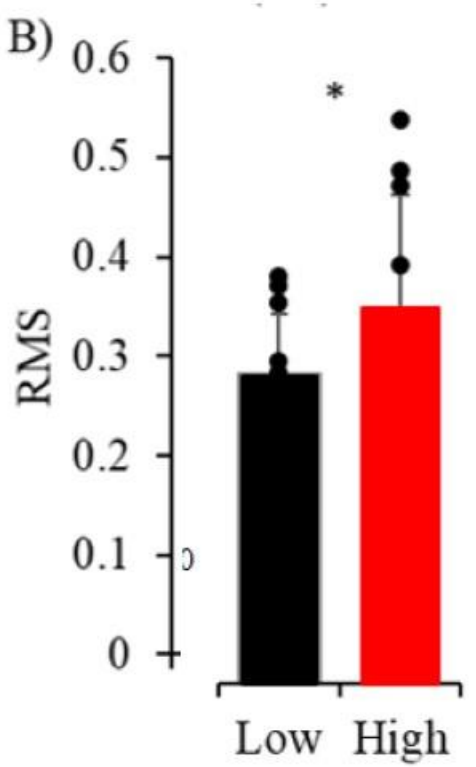
Cleworth et al. 2019

Threat influences perception of independent ankle motion



Rotary Encoder

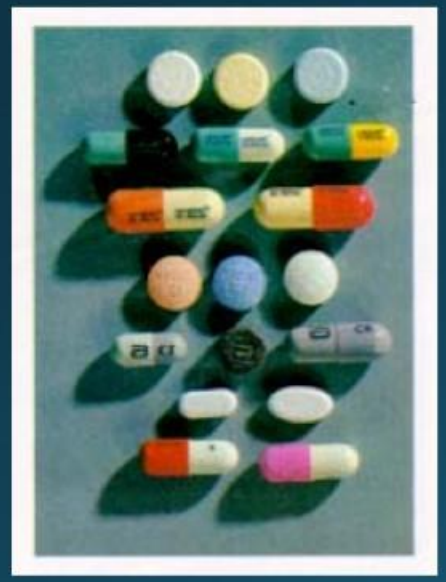




Cleworth et al. 2023 Front Neurosci

Potential interventions for fear of falling and its effect on balance

Medication



Fall protection

Physical activity

Cognitive–Behavioural Therapy

Received: 13 March 2019 | Revised: 10 June 2019 | Accepted: 2 July 2019
DOI: 10.1111/jan.14150

REVIEW PAPER

JAN WILEY

Effectiveness of cognitive behaviour therapy-based multicomponent interventions on fear of falling among community-dwelling older adults: A systematic review and meta-analysis

Claris Hui Min Chua BSN (Hons), RN | Ying Jiang MScN, RN, RMN | Der Shin Lim BSc | Vivien Xi Wu PhD, RN | Wenru Wang PhD, RN

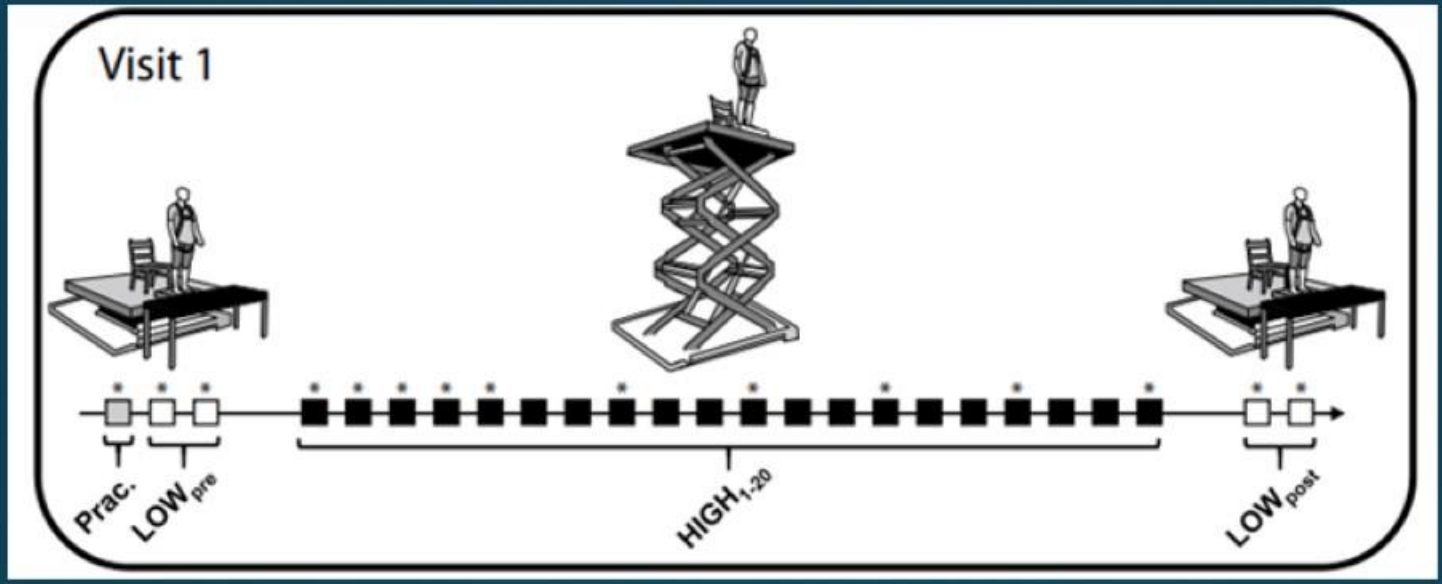
15 RCTs including a cognitive behaviour therapy (CBT) based intervention in older adults with FoF (ie. Motivational interviewing, small groups, supervised exposure, face-to-face counselling)

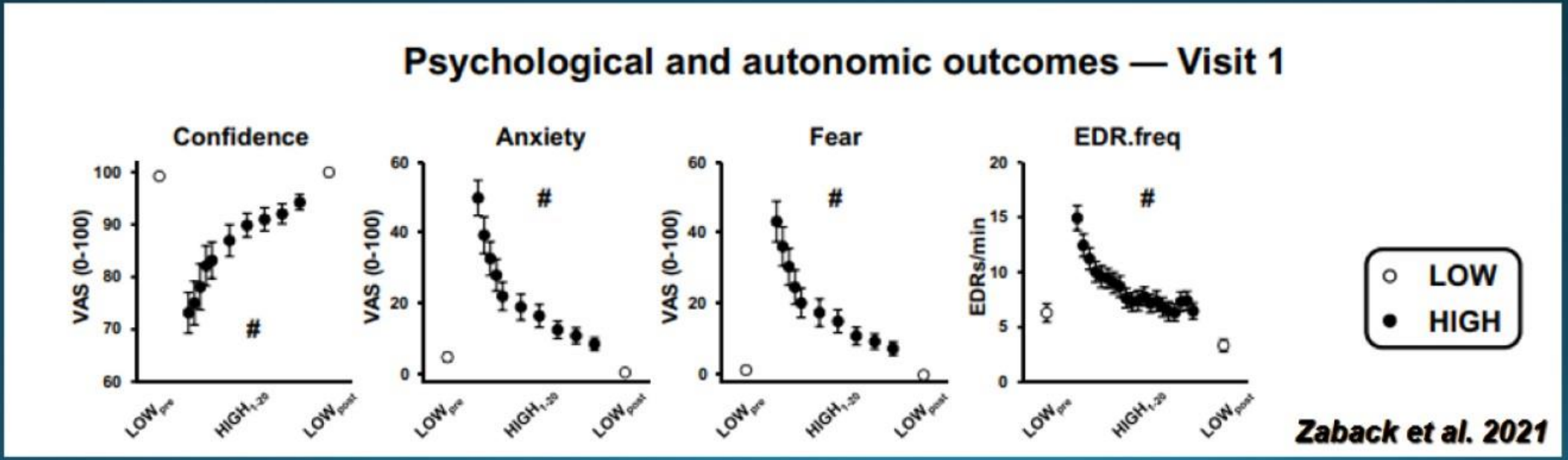
Greater effects on Fear of Falling for interventions including:

CBT + Exercise (compared to only exercise/no exercise) *
CBT alone (compared to no CBT) *

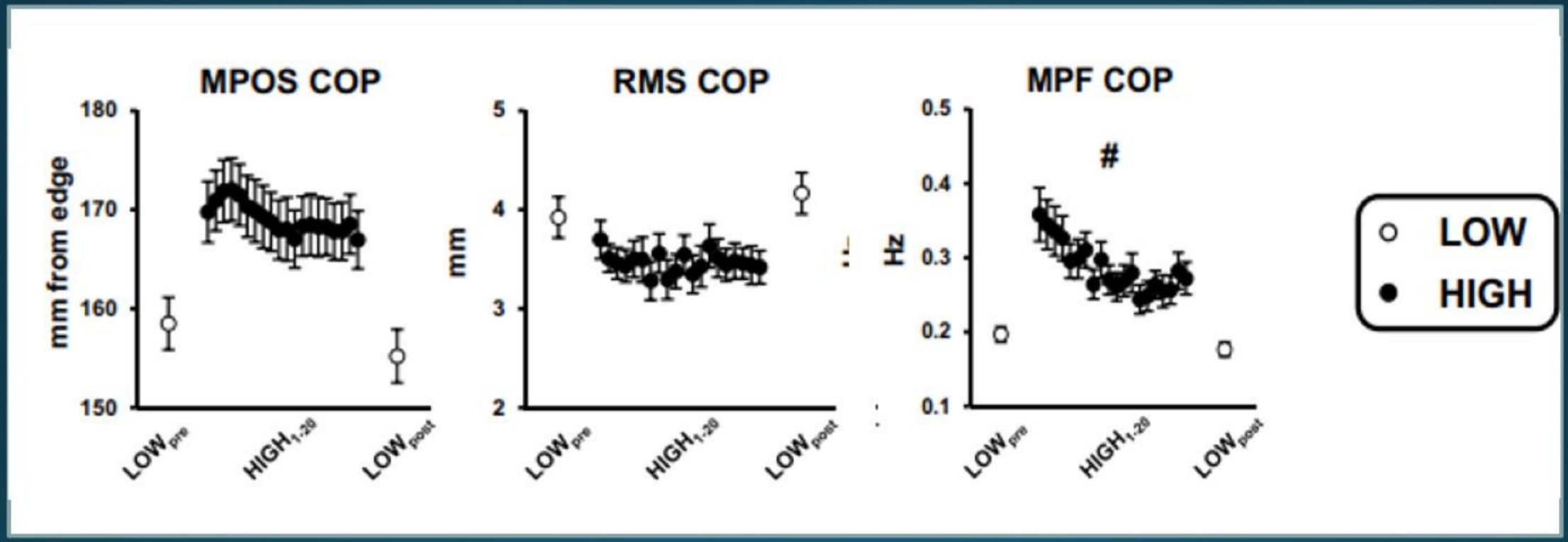
* Reduced Fear of Falling observed immediately, 6 months and >6 months post-intervention

Adaptation to repeated threat exposure





Changes in standing balance control following repeated exposure to height related threat



Zaback et al. 2021

Finding the balance between Fearful vs Fearless

Too much fear:

- maladaptive balance behaviours
- activity avoidance

No fear:

- over-estimating capacities
- lack of protective strategies

(Delbaere et al. 2006).

Implications for Clinical Assessment

Psychological factors may mask or mimic clinical symptoms

Physiological problem?

Other non-physiological factors?

Challenge to separate psychological and physiological mechanisms

Postural deficits in anxious conditions	Postural deficits in Parkinson's disease
Increased velocity/frequency of sway, stiffness and co-contraction	Increased velocity/frequency of sway, stiffness and co-contraction
Smaller anticipatory postural adjustments and voluntary movements	Smaller anticipatory postural adjustments and voluntary movement
Increased postural responses	Increased postural responses
Earlier onset of arm responses	Earlier onset of arm responses
Slow and reduced gait speed	Slow and reduced gait speed
Freezing Behaviour	Freezing Behaviour

GUIDELINE

Age and Ageing 2022; **51:** 1–36
https://doi.org/10.1093/ageing/afac205

World guidelines for falls prevention and management for older adults: a global initiative

Strong Recommendation:

Include evaluation of "Concerns about Falling" in multi-factorial fall risk assessments

Reason:

Strong evidence that concerns about falling* is predictive of future falls

Definition:

Concerns about Falling is a "lasting feeling of dread and apprehension about situations that are believed to threaten or challenge balance" *

**closely related to notion of "Fear of Falling (FoF) which is more commonly referred to in the literature. Concerns about falling recommended as it may carry less stigma, being considered as 'less intense and emotional' than FoF, and to avoid being inappropriately linked to psychiatric conditions*

White-coat effects on balance

2 Age Groups

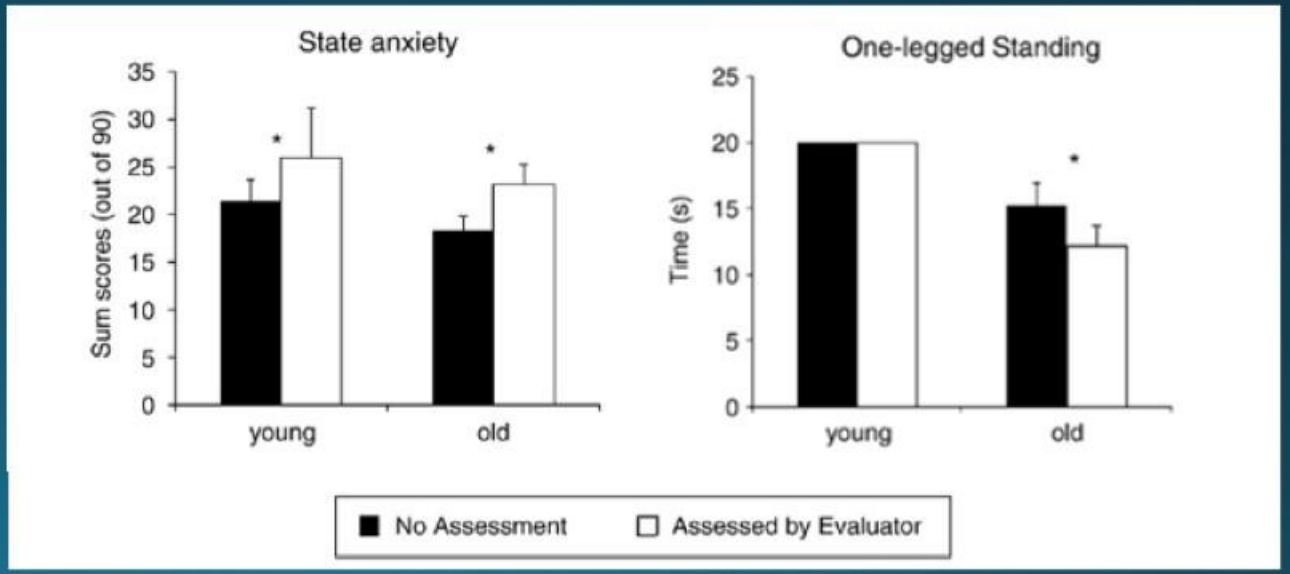
Young Healthy Females
(n=19; mean age =22.3 yrs)

Older Healthy Females
(n=19; mean age =72.9 yrs)

2 Conditions

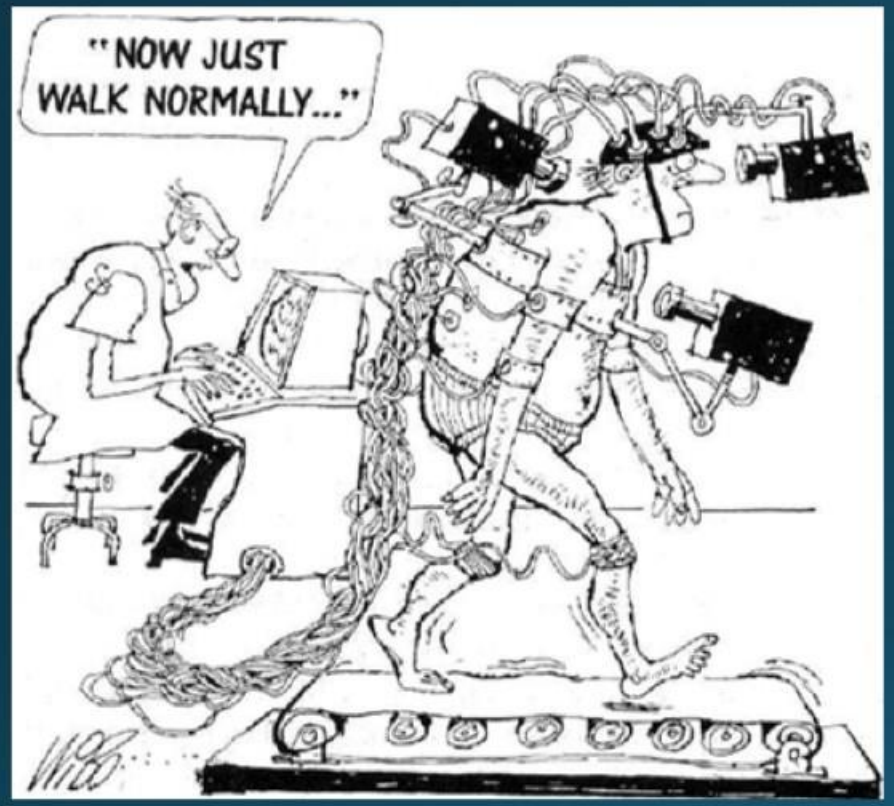
Evaluator present

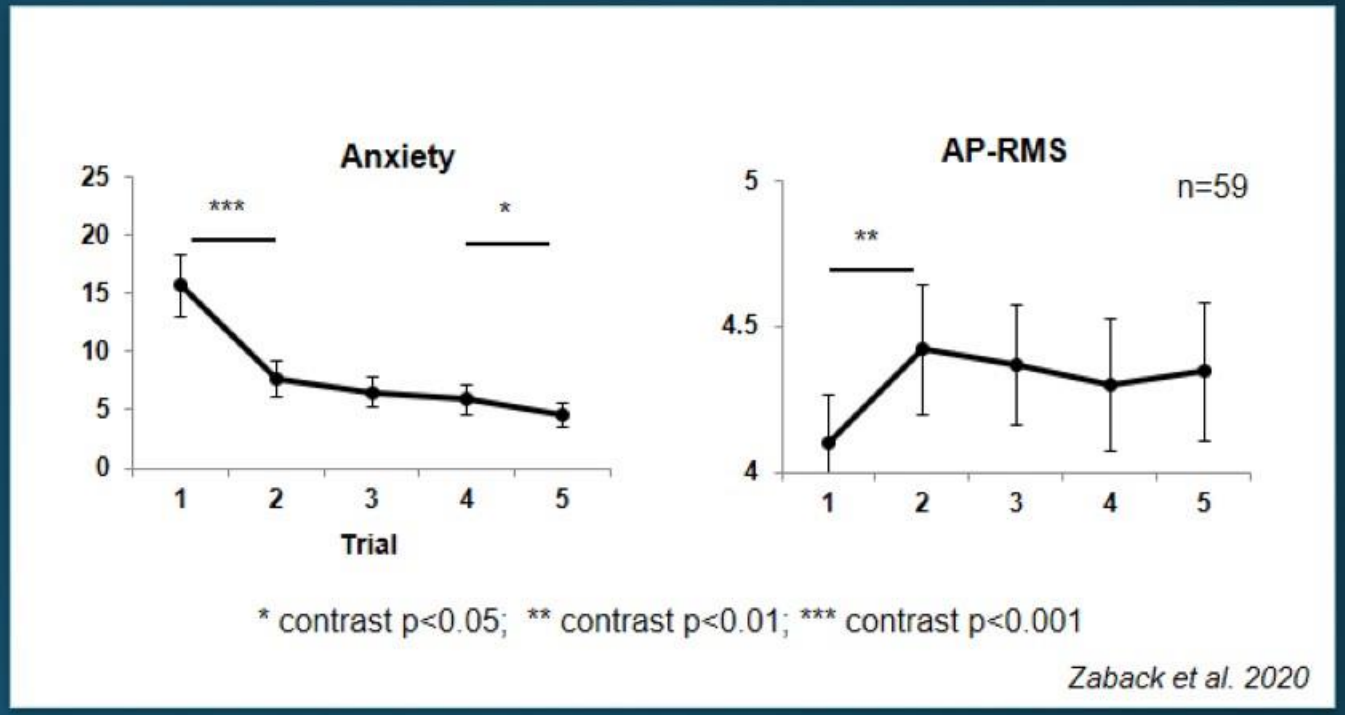
Evaluator not present



Geh et al. 2011

First trial effects

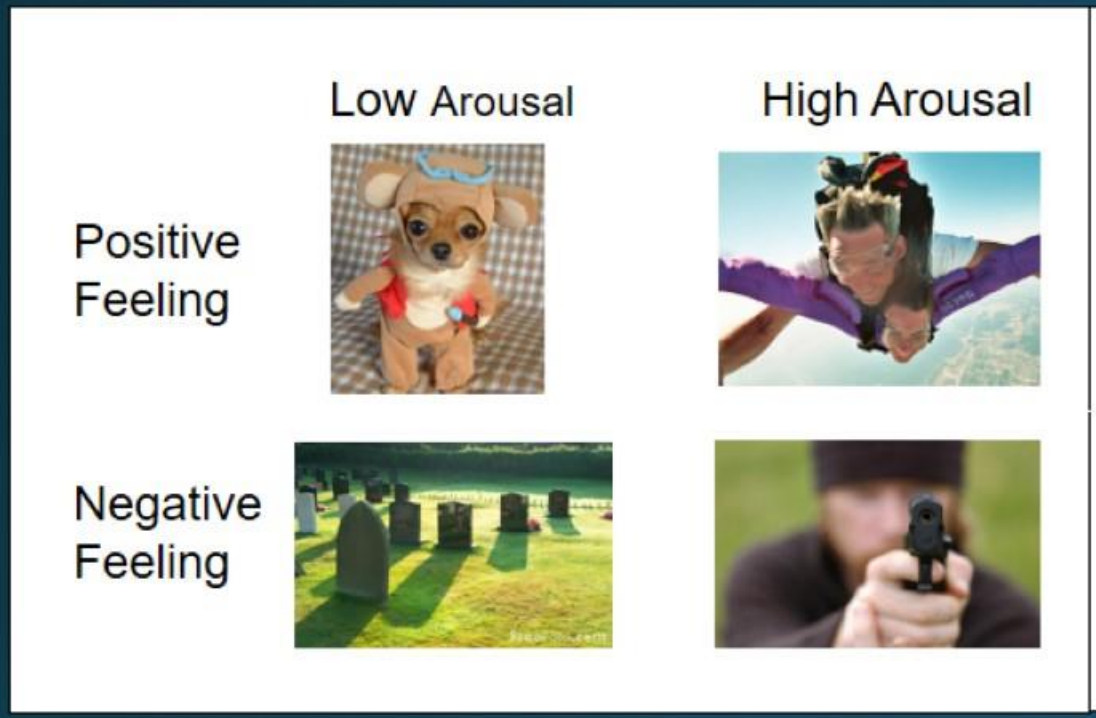


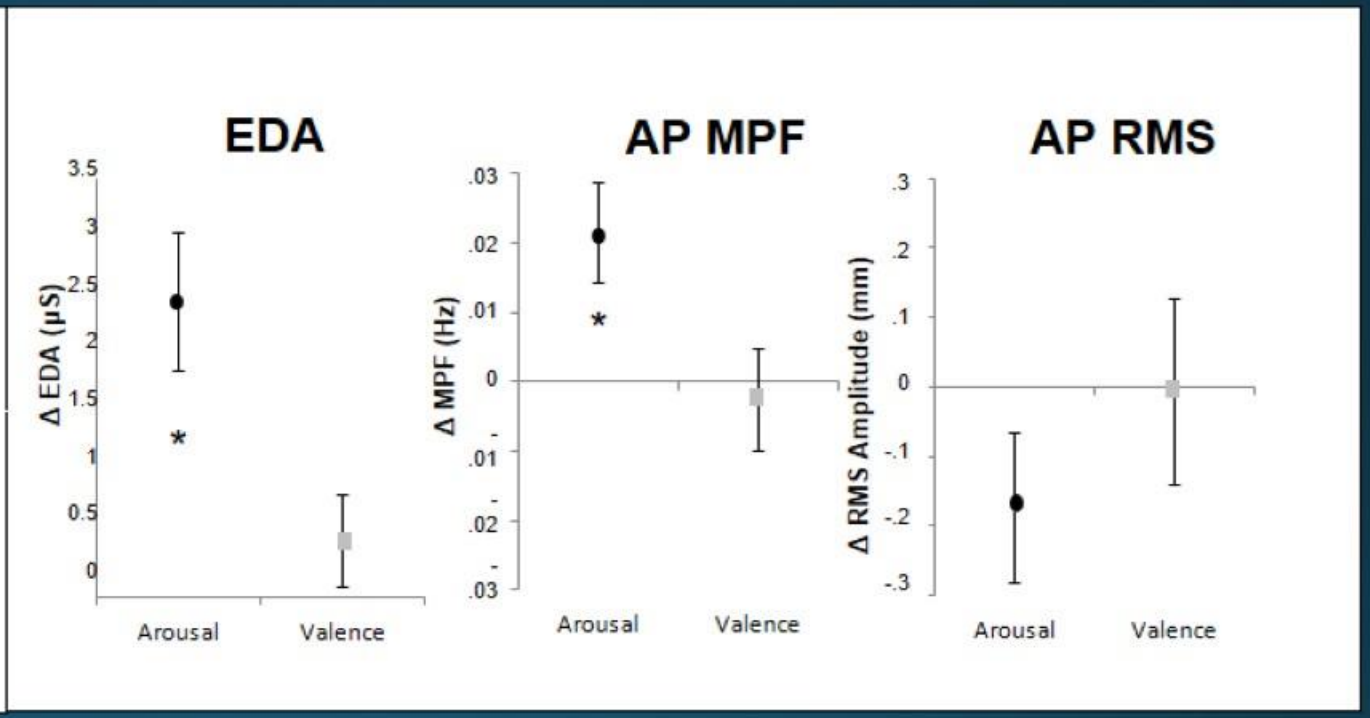


Arousal decreases as trials are repeated

Maki & Whitelaw (1993)

Not only negative emotions influence postural control





Horslen et al. 2011

Conclusions

- Emotions such as anxiety and fear can have significant impact on both static and dynamic balance control in both young healthy adults and those with balance deficits
- Some changes (ie. mean position and amplitude) are context dependent and may be protective/beneficial
- Others (ie. co-contraction & high frequency sway) vary more closely with fear/anxiety/arousal and may reflect more systemic changes that are potentially mal-adaptive
- The effect of threat influences both the actual performance of the balance task as well as perceptions of ongoing balance changes
- The underlying mechanisms are likely a combination of threat-related neurophysiological changes, as well as changes in perception and attentional focus
- We must account for potential threat-related changes in balance in both research, clinical and occupational practices
- Continue to investigate new interventions that can improve balance and underlying emotional factors that may contribute to falls

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