UNIVERSITY OF BIRMINGHAM

# Dr Mark Hollands

## Don’t put a foot wrong!

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# walking and falling

- falls occur mostly during over-ground walking on even or uneven surfaces and result from trips or slips
  - i.e. inappropriate movement of the leg and/or placement of the foot

- vision is the only sense that tells us in advance where we should or should not step

# where do we look when we walk?

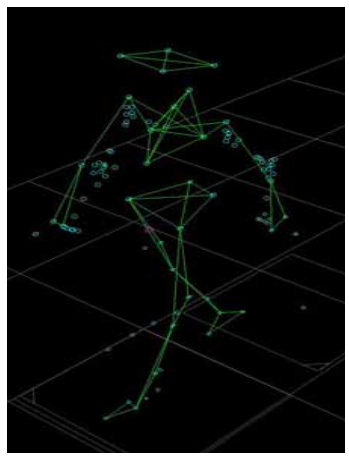
- there is a strong relationship between looking and stepping

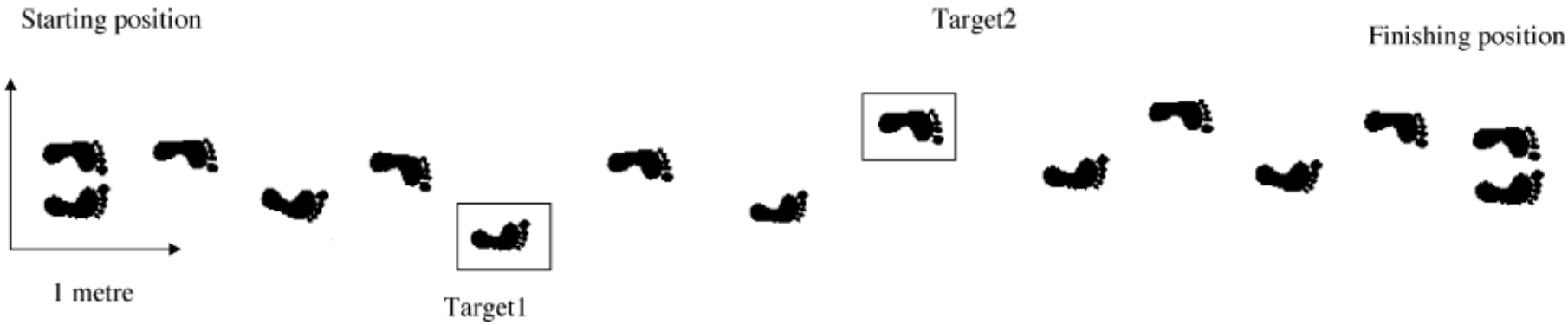
- are there age-related differences in sampling and using visual information and what are the implications for falls?

# measurements

**Gaze - high speed ASL 500 eye tracking system**

**Walking characteristics - 13 camera Vicon MX motion analysis system**






| | Young adults | | Low-risk older adults | | High-risk older adults | |
|---|---|---|---|---|---|---|
| | Target1 | Target2 | Target1 | Target2 | Target1 | Target2 |
| Interval between saccade onset and toe-off (ms) | $0.28 \pm 0.09$ | $0.56 \pm 0.33$ | $1.22 \pm 0.65^{a}$ | $1.45 \pm 0.11^{a}$ | $1.32 \pm 0.66^{a}$ | $1.72 \pm 0.75^{a,b}$ |
| Total fixation time (s) | $0.72 \pm 0.21$ | $0.91 \pm 0.40^{c}$ | $1.65 \pm 0.52^{a}$ | $1.45 \pm 0.59^{a}$ | $1.82 \pm 0.61^{a}$ | $2.11 \pm 0.78^{a,b,c}$ |
| Medio-lateral foot placement (mm) | $15.66 \pm 11.63$ | $20.04 \pm 19.28^{c}$ | $-2.09 \pm 11.64^{a}$ | $1.33 \pm 17.75^{a}$ | $-14.21 \pm 23.04^{a,b}$ | $11.72 \pm 17.55^{a,b}$ |
| Medio-lateral foot variability (mm) | $8.95 \pm 2.53$ | $9.53 \pm 2.62$ | $10.53 \pm 3.95$ | $9.16 \pm 1.42$ | $21.54 \pm 10.40^{a,b}$ | $15.84 \pm 6.35^{a,b}$ |
| Anterior–posterior foot placement (mm) | $-32.86 \pm 29.39$ | $-35.52 \pm 24.40^{c}$ | $-24.97 \pm 23.67^{a}$ | $-34.21 \pm 23.07^{c}$ | $-43.02 \pm 25.86^{a,b}$ | $-36.79 \pm 28.04^{c}$ |
| Anterior–posterior foot variability (mm) | $19.02 \pm 4.84$ | $17.62 \pm 4.39$ | $23.57 \pm 4.25$ | $18.57 \pm 4.43$ | $24.38 \pm 5.60$ | $22.20 \pm 4.20$ |
| Step length (mm) | $662.55 \pm 78.26$ | $690.39 \pm 61.82^{c}$ | $661.42 \pm 113.12$ | $596.59 \pm 157.68^{a,c}$ | $433.80 \pm 117.81^{a,b}$ | $427.97 \pm 184.53^{a,b}$ |
| Step width (mm) | $165.81 \pm 67.09$ | $178.27 \pm 43.75^{c}$ | $192.79 \pm 40.95^{a}$ | $187.47 \pm 33.68^{c}$ | $219.03 \pm 42.79^{a,b}$ | $191.61 \pm 48.40^{c}$ |
| Walking velocity (m $s^{-1}$) | $1.21 \pm 0.16^{b,c}$ | | $1.15 \pm 0.23^{a}$ | | $0.79 \pm 0.14^{a,b}$ | |

[a] Significantly ($p < 0.05$) different from young adults.
[b] Significantly different from low-risk older adults.
[c] Significantly different from Target1.

**Chapman GJ and Hollands MA (2005)** Evidence for a link between changes to gaze behaviour and risk of falling in older adults during adaptive locomotion. *Gait and Posture* 24(3):288-94

# differences between young, older adults and older adult fallers in gaze and stepping behaviour

- older adults (particularly high-risk) look at stepping targets much sooner than young adults and stay looking for much longer
- high-risk older adults show increased variability in medioloateral foot positioning

# why do older adult fallers show altered visual behaviour?

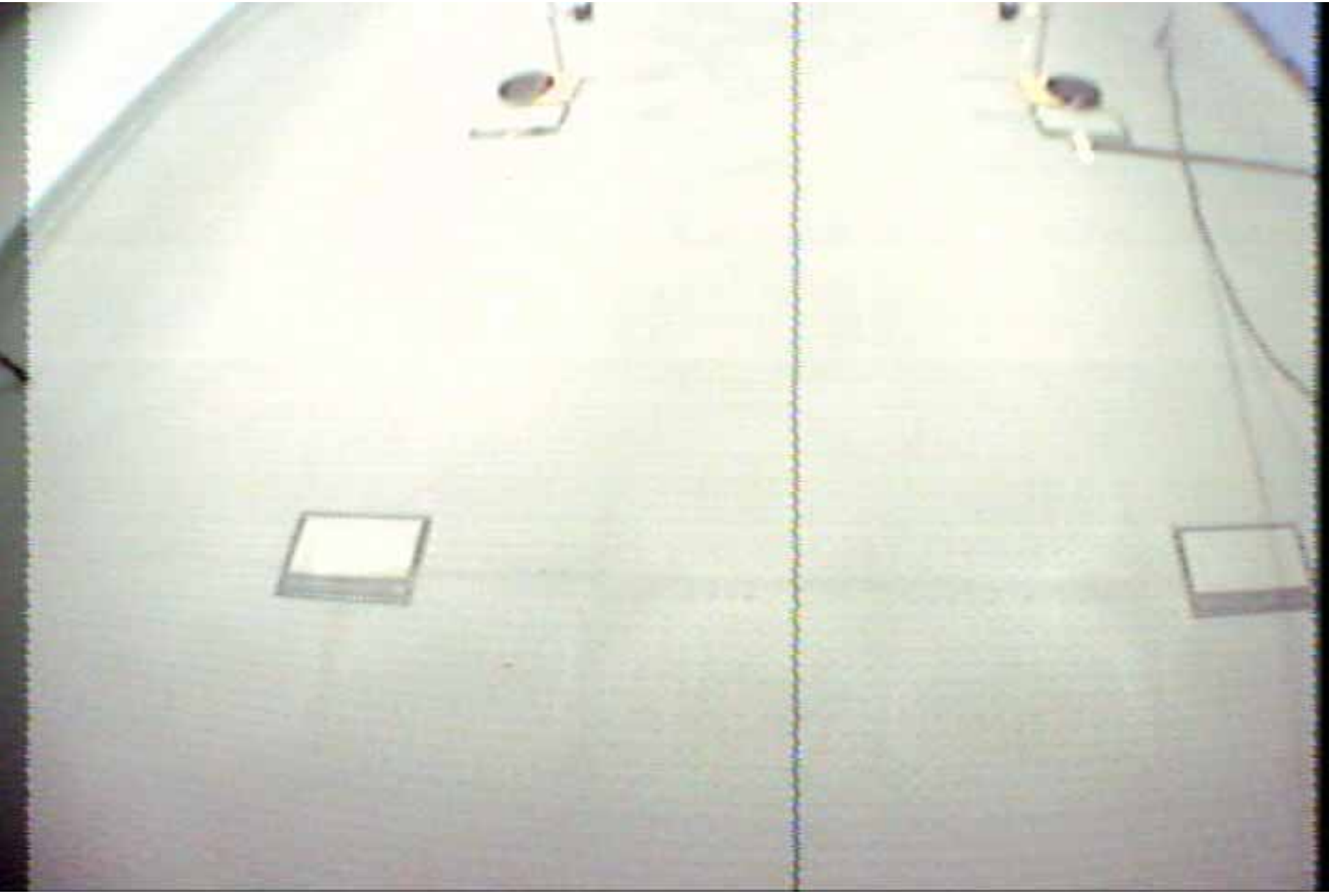
- cognitive changes?
  - anxiety/fear of falling?
  - attentional deficits?
  - changes in executive functioning?
- changes in visuomotor processing?
  - more time needed fixating target in order for CNS to process visual info and/or transform it into appropriate stepping movements?


# "The contribution of visuomotor decline to falls in older adults during adaptive locomotion"

## Aims

systematically test if high-risk older adults require more time visually fixating targets than low-risk older adults and younger adults to ensure accurate stepping

# experimental paradigm



# experimental design

- participant groups
  - young adults (10)
  - low-risk older adults (10)
  - high-risk older adults (10)
- target conditions
  - neutral (central) targets
  - wide targets
- gaze behaviour (time fixating a target prior to foot landing on (or near) it
  - 0 to 1 second
  - 1 to 2 seconds
  - 2 to 3 seconds

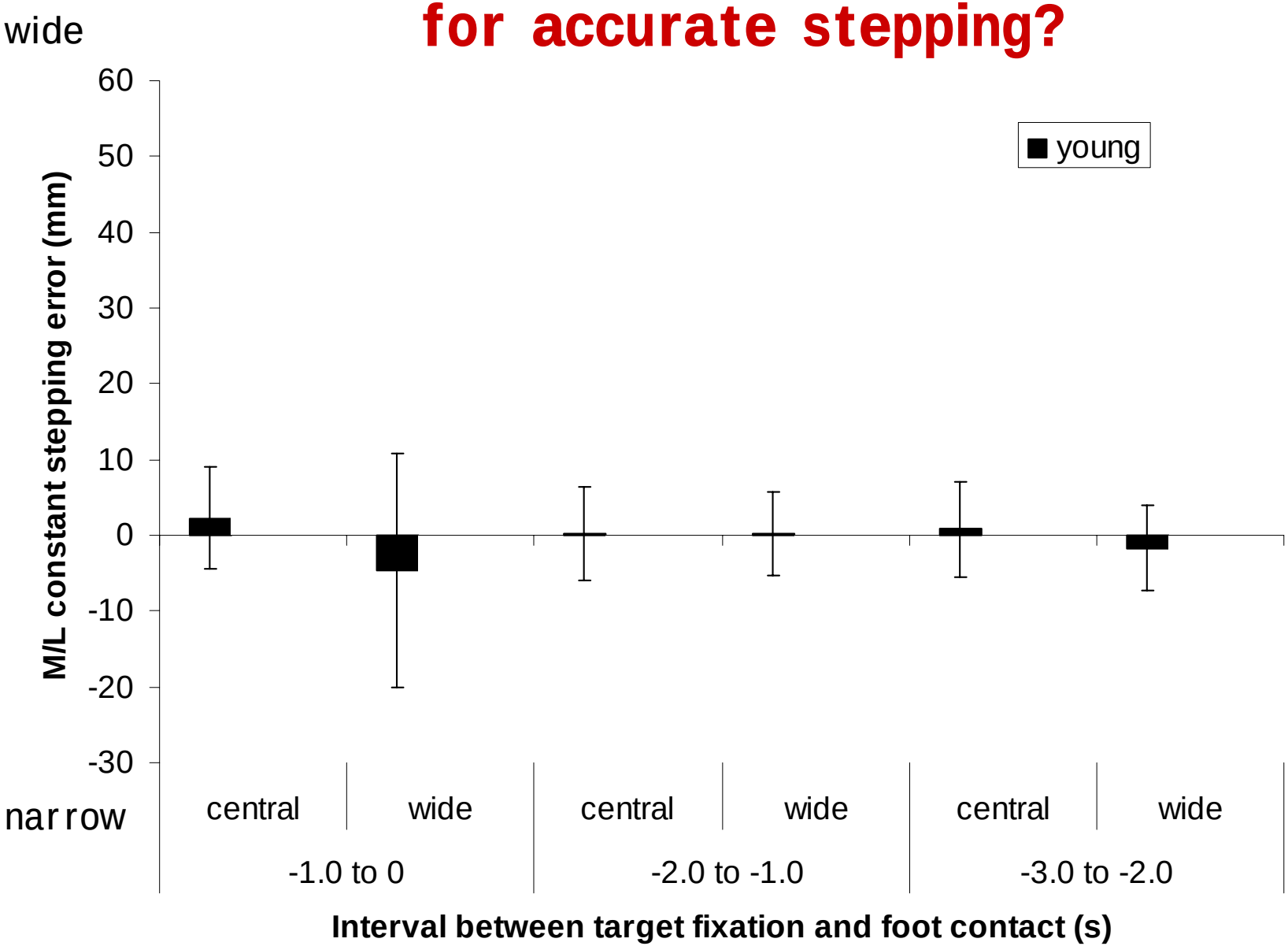
# predictions

constraining the timing of LED illumination will have a detrimental effect on older adults stepping performance

high-risk older adults will require more time fixating the LEDs in order to step as accurately as low-risk older adults and younger adults

high-risk older adults will show greater errors when stepping to wide targets

# how much time is needed looking at a target for accurate stepping?



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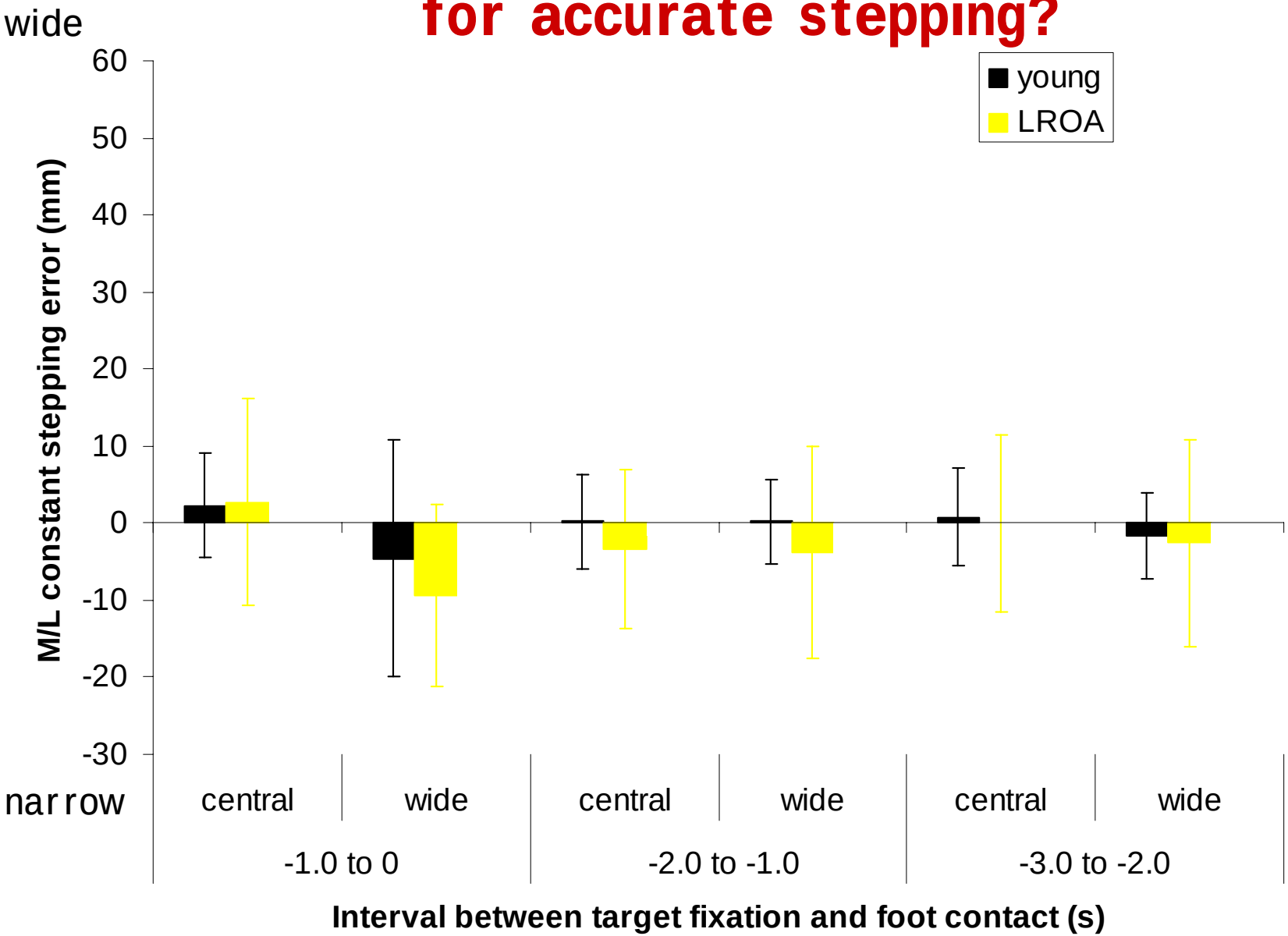

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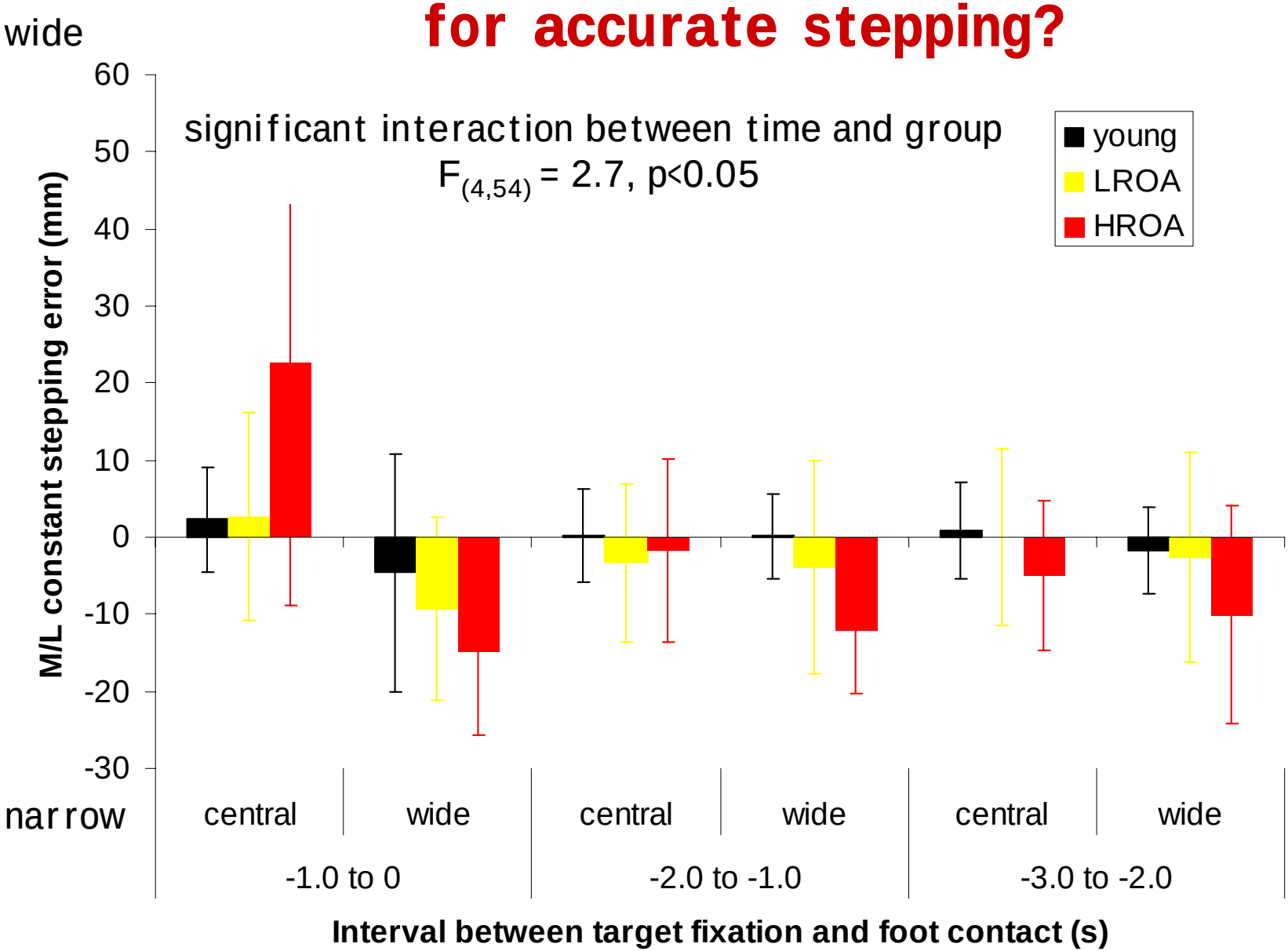
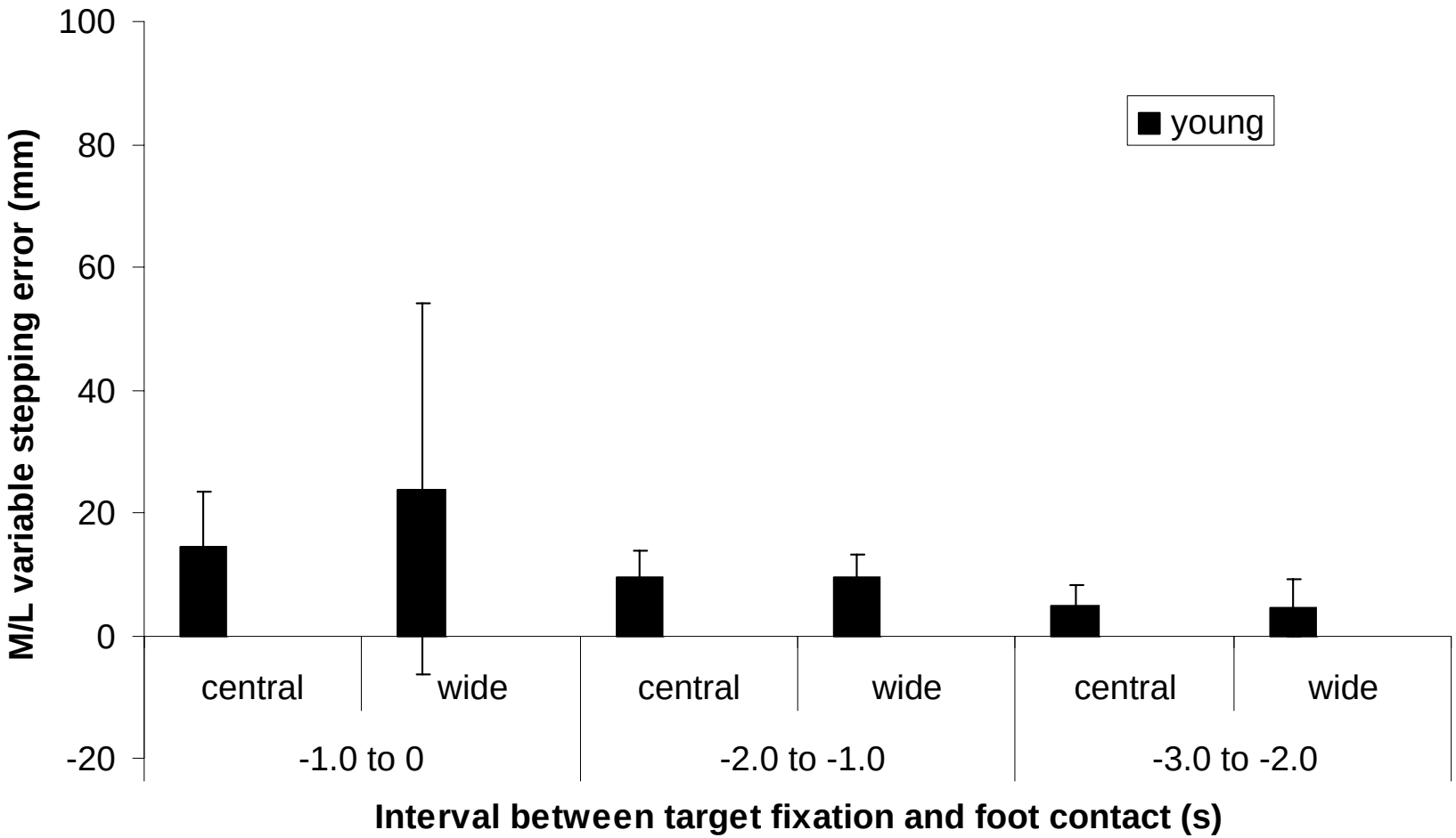


# results summary
# m/l stepping error

- high-risk older adults significantly less accurate than other groups (especially to wide targets)
- all groups show increase step width errors when receiving less than one second fixating target (especially high-risk older adults)

# how much time is needed looking at a target for consistent stepping?



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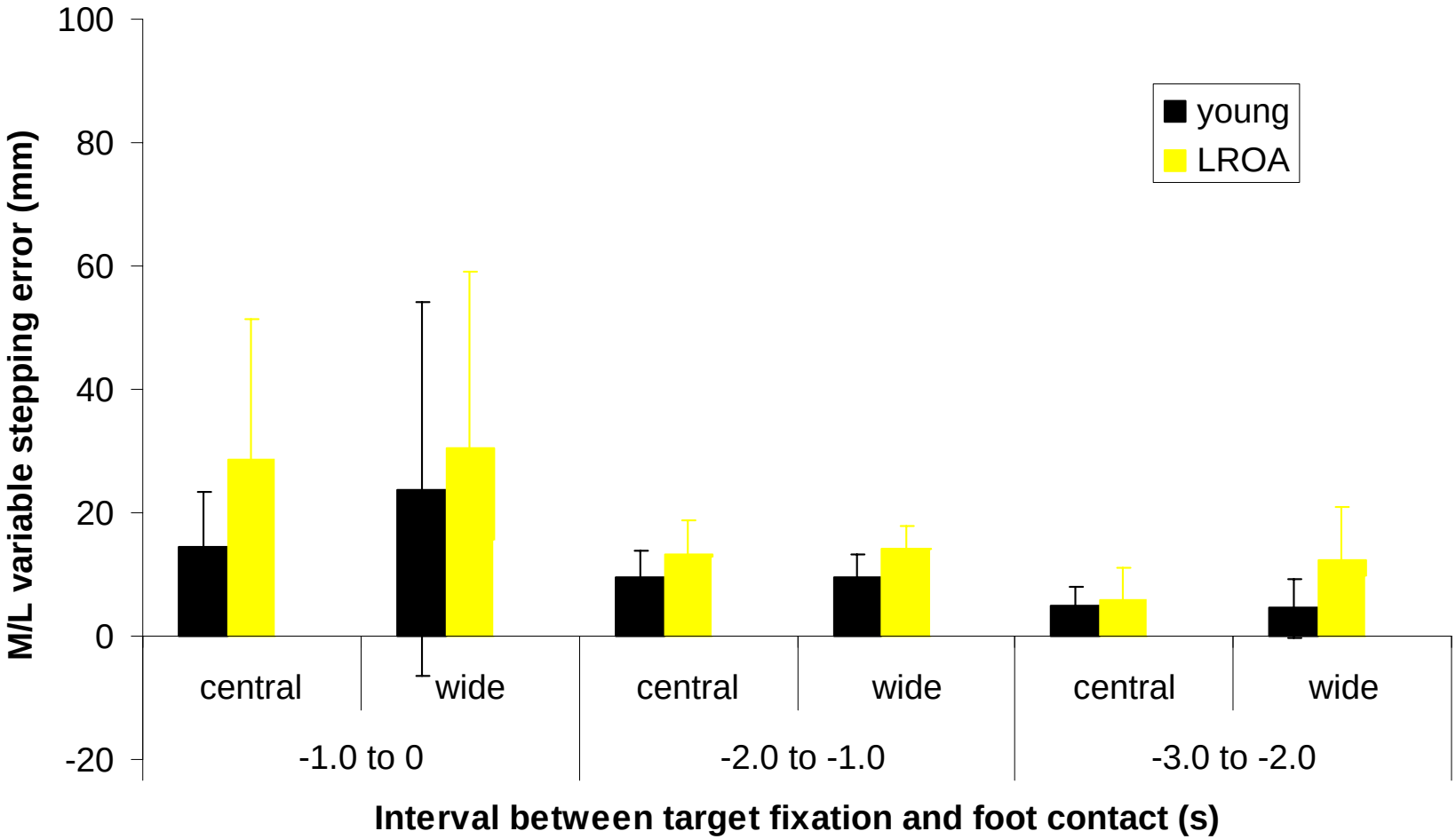

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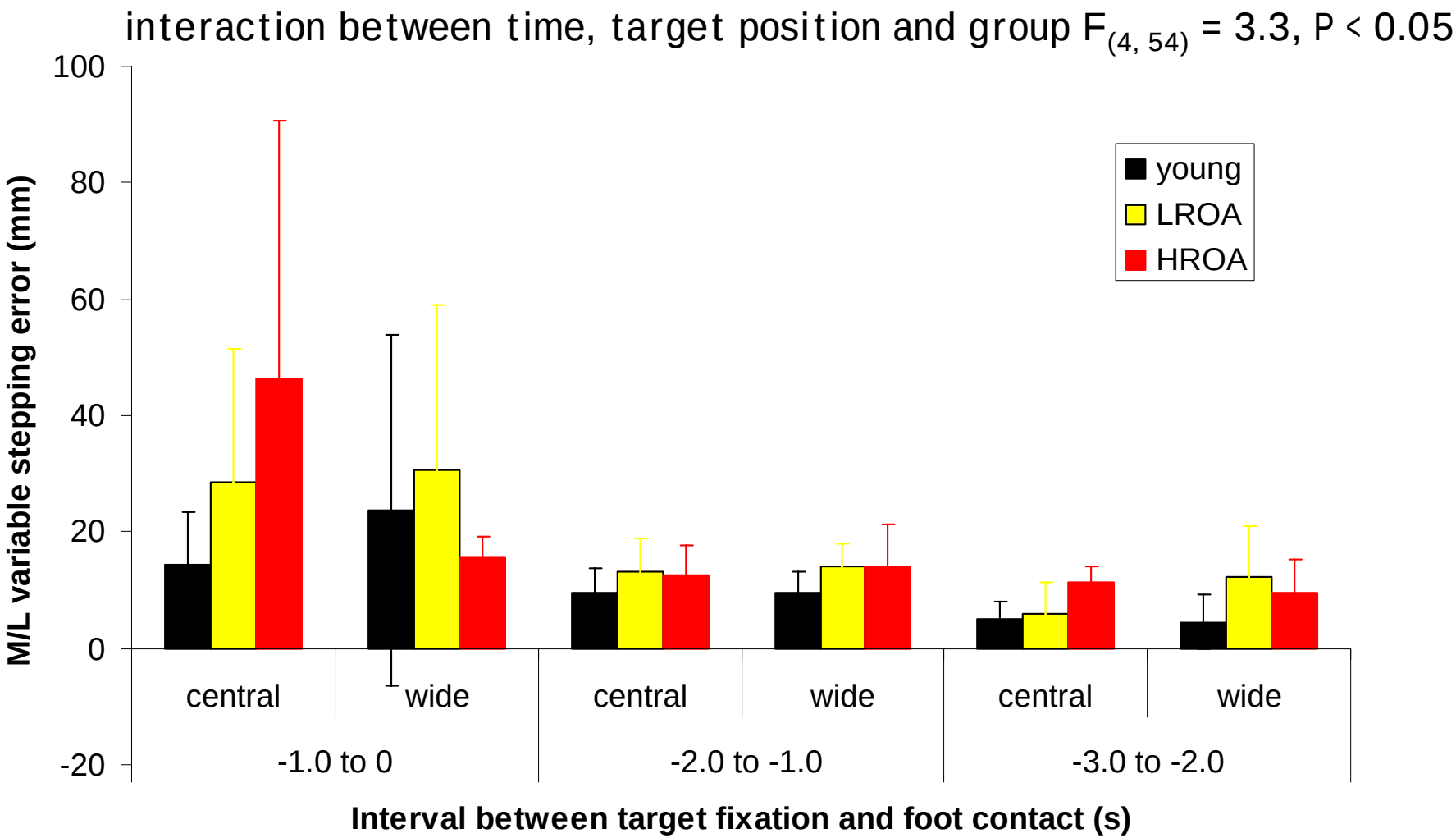
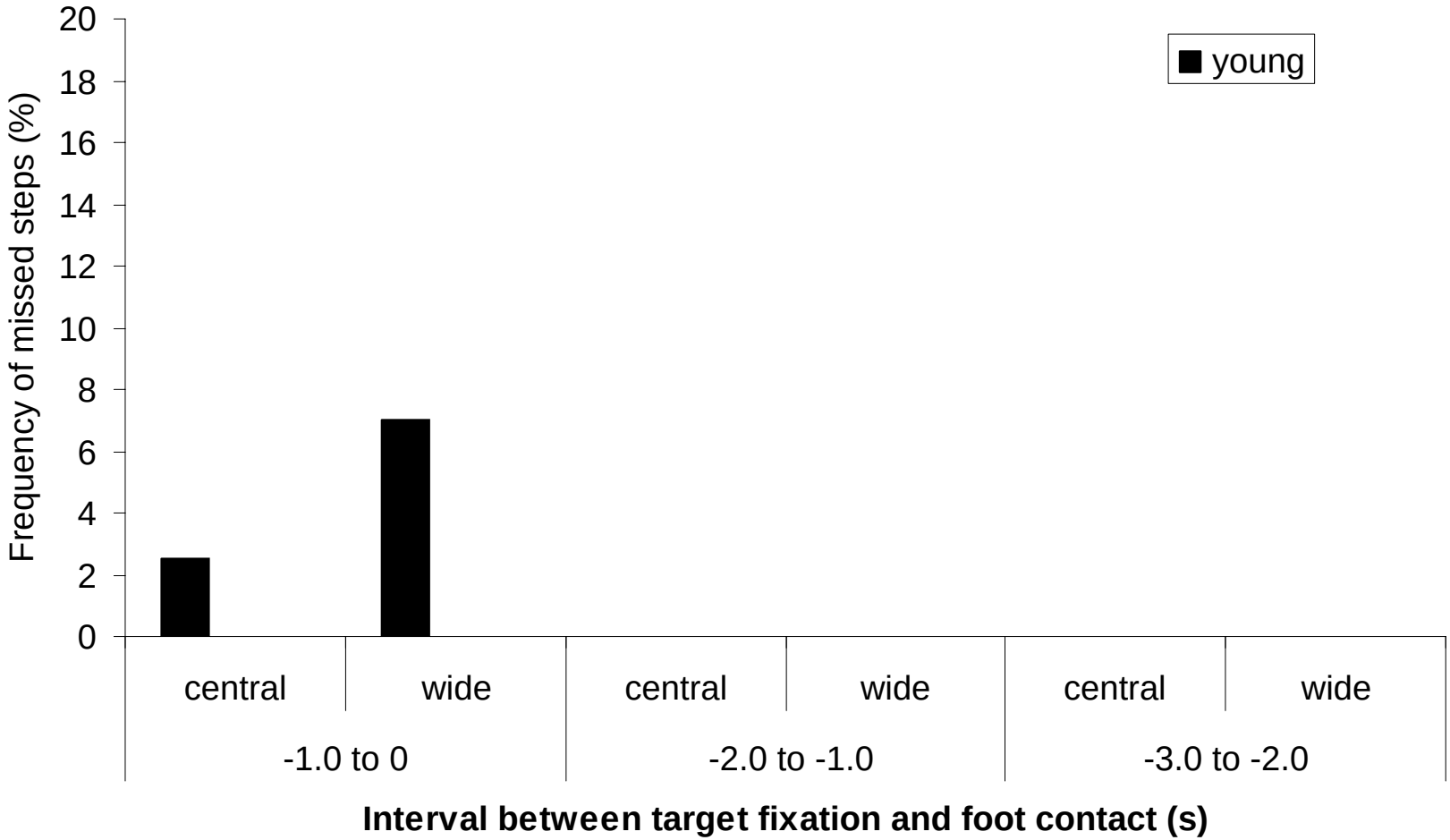


# results summary
# constant m/l stepping errors

- high-risk older adults significantly more variable in m/l foot placement than other groups
- all groups show show increased m/l foot placement variability when receiving less than one second fixating target (especially high-risk older adults)

# how much time is needed looking at a target to avoid missing it completely?



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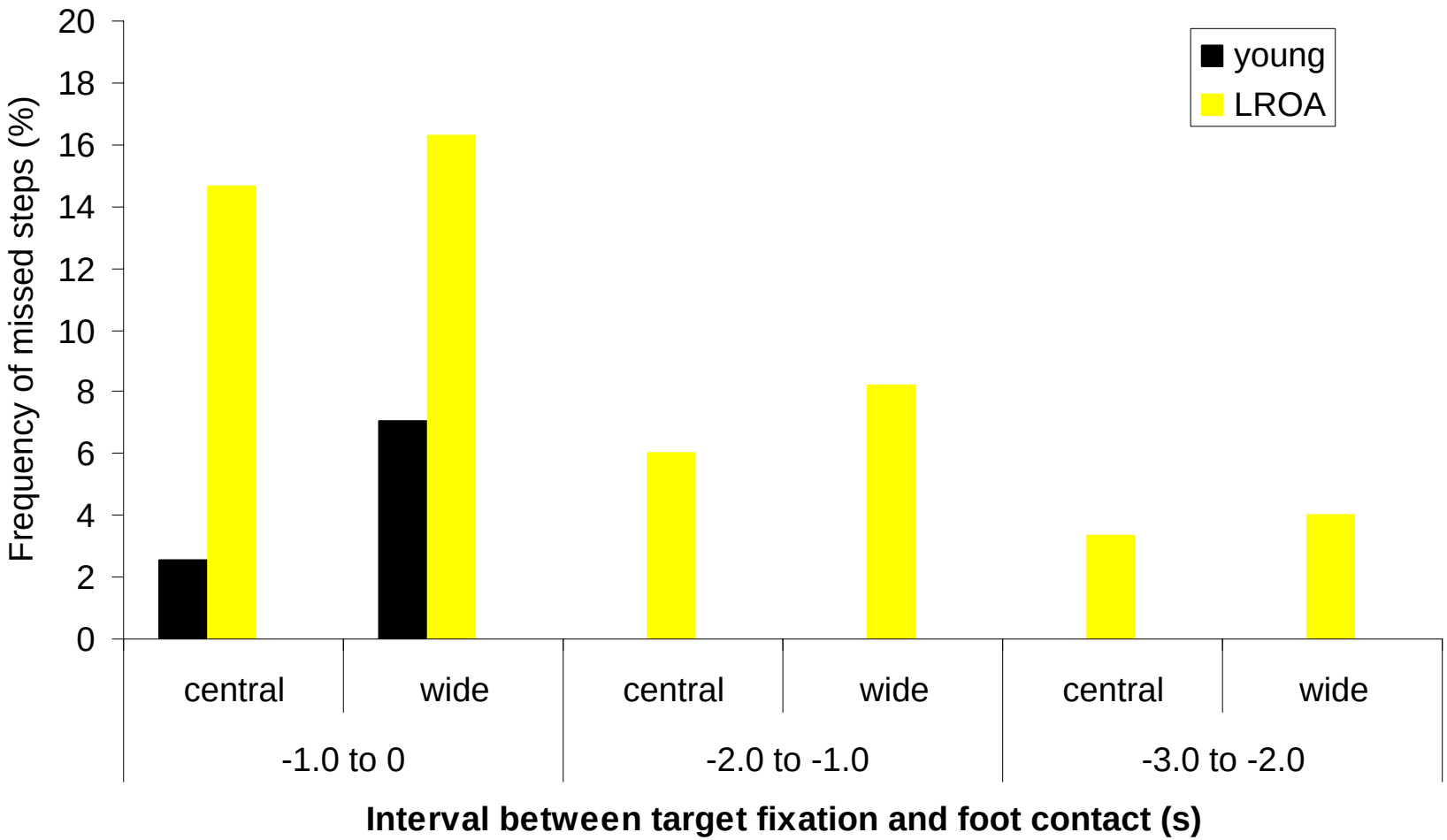

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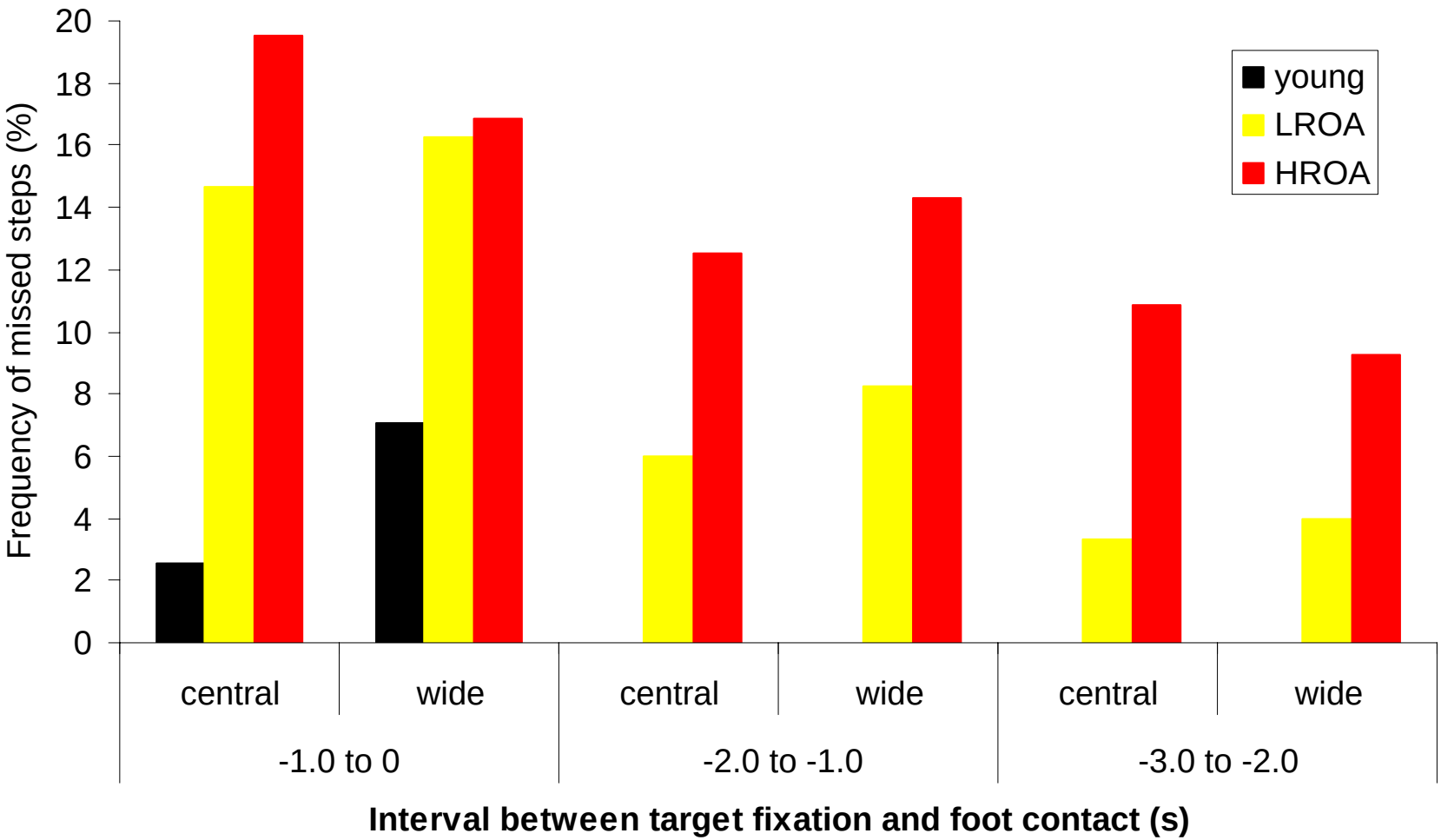
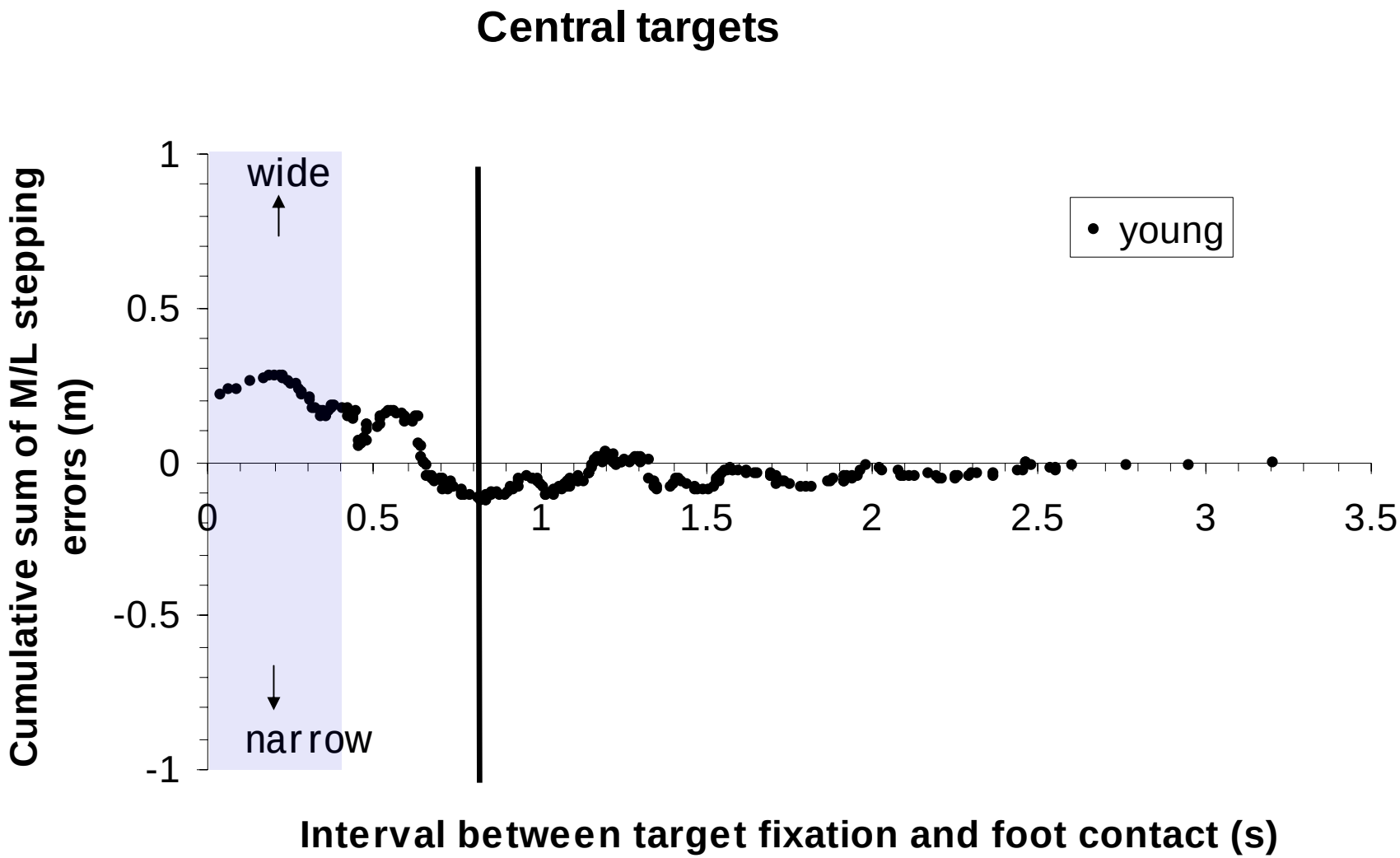


# results summary
# missed targets

- young adults only missed targets when received less than 1 second fixation

- older adult groups missed progressively more targets when given less time to fixate them

# is there a threshold of target fixation duration below which step width errors start to accumulate?



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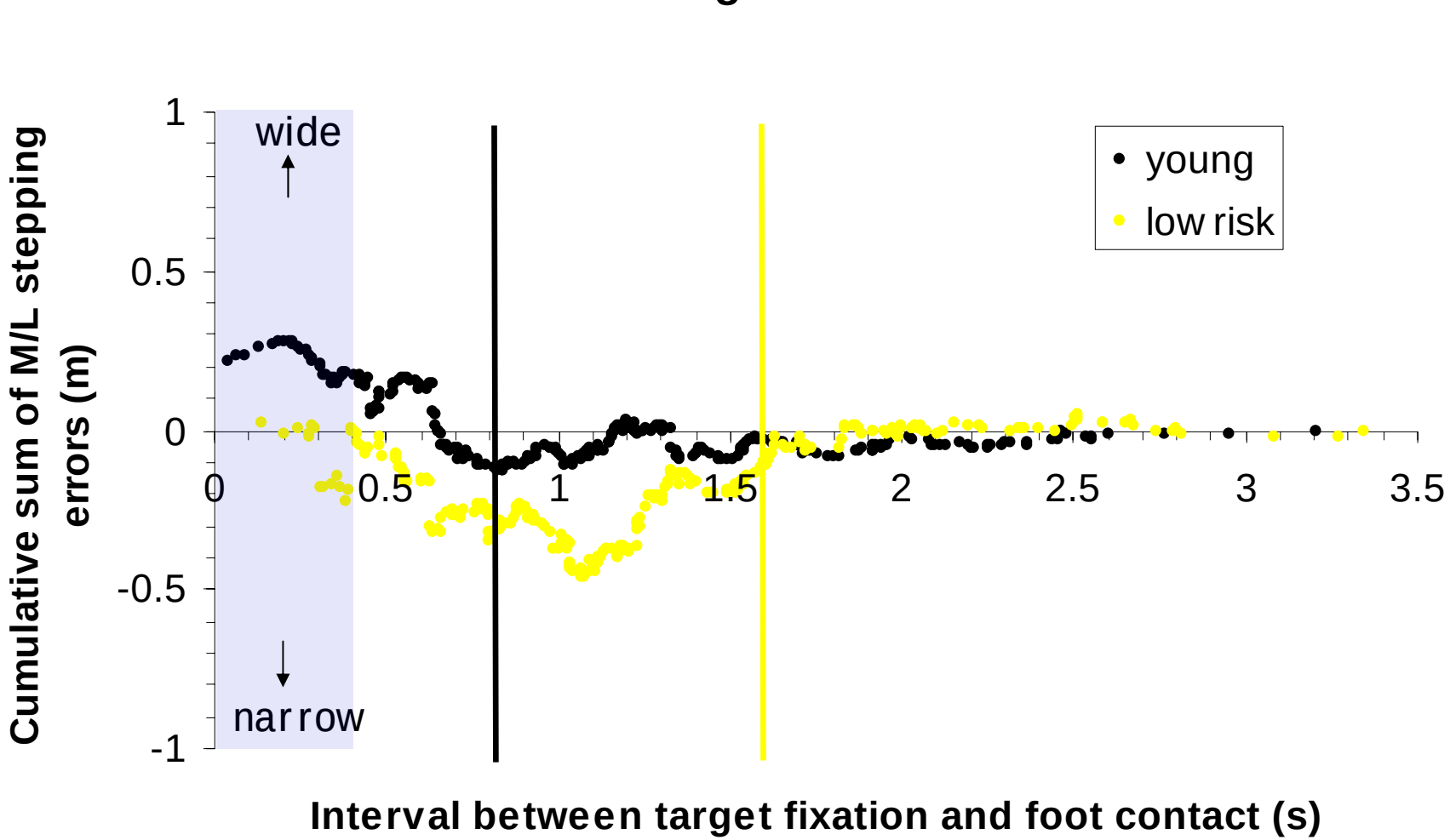

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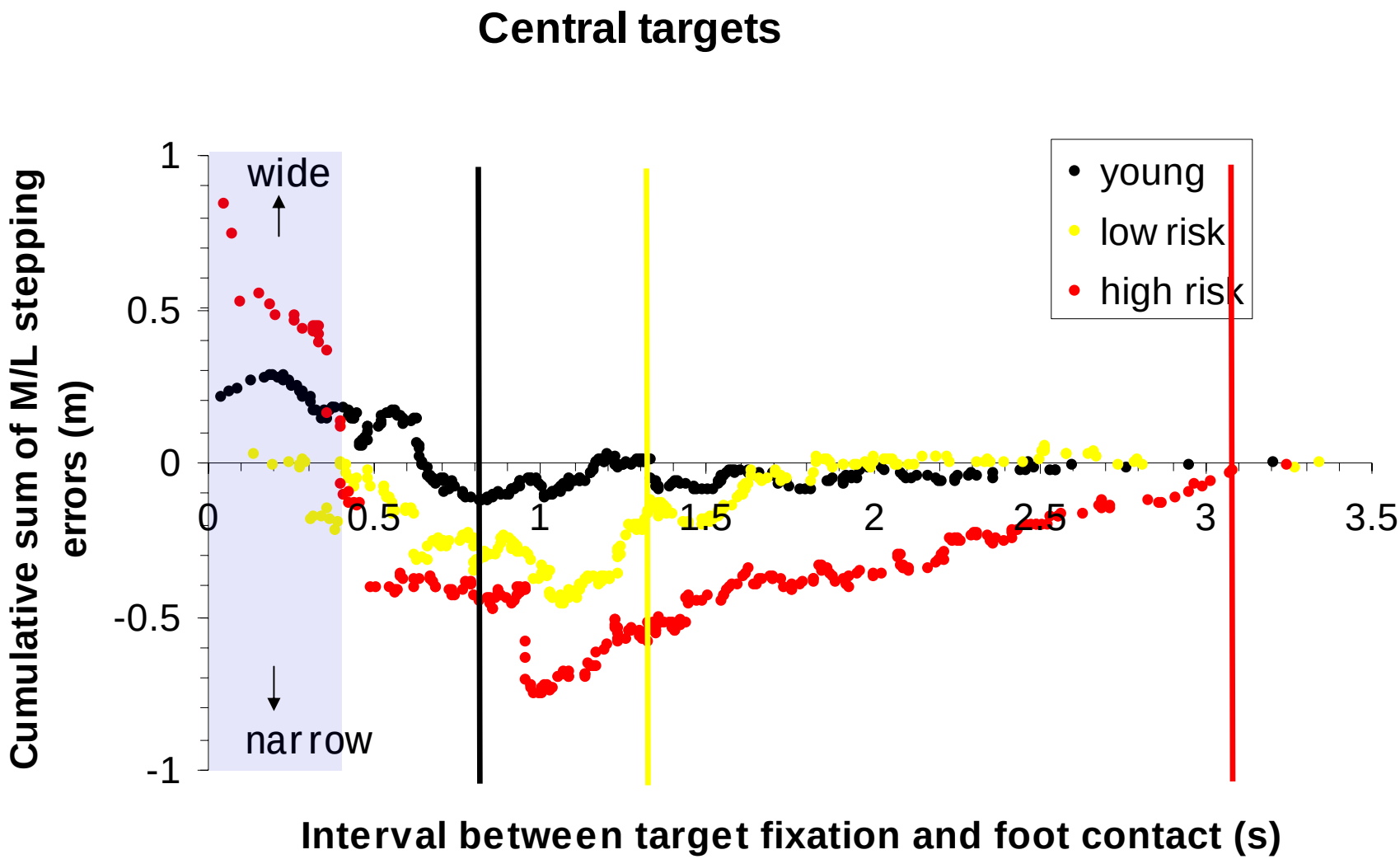

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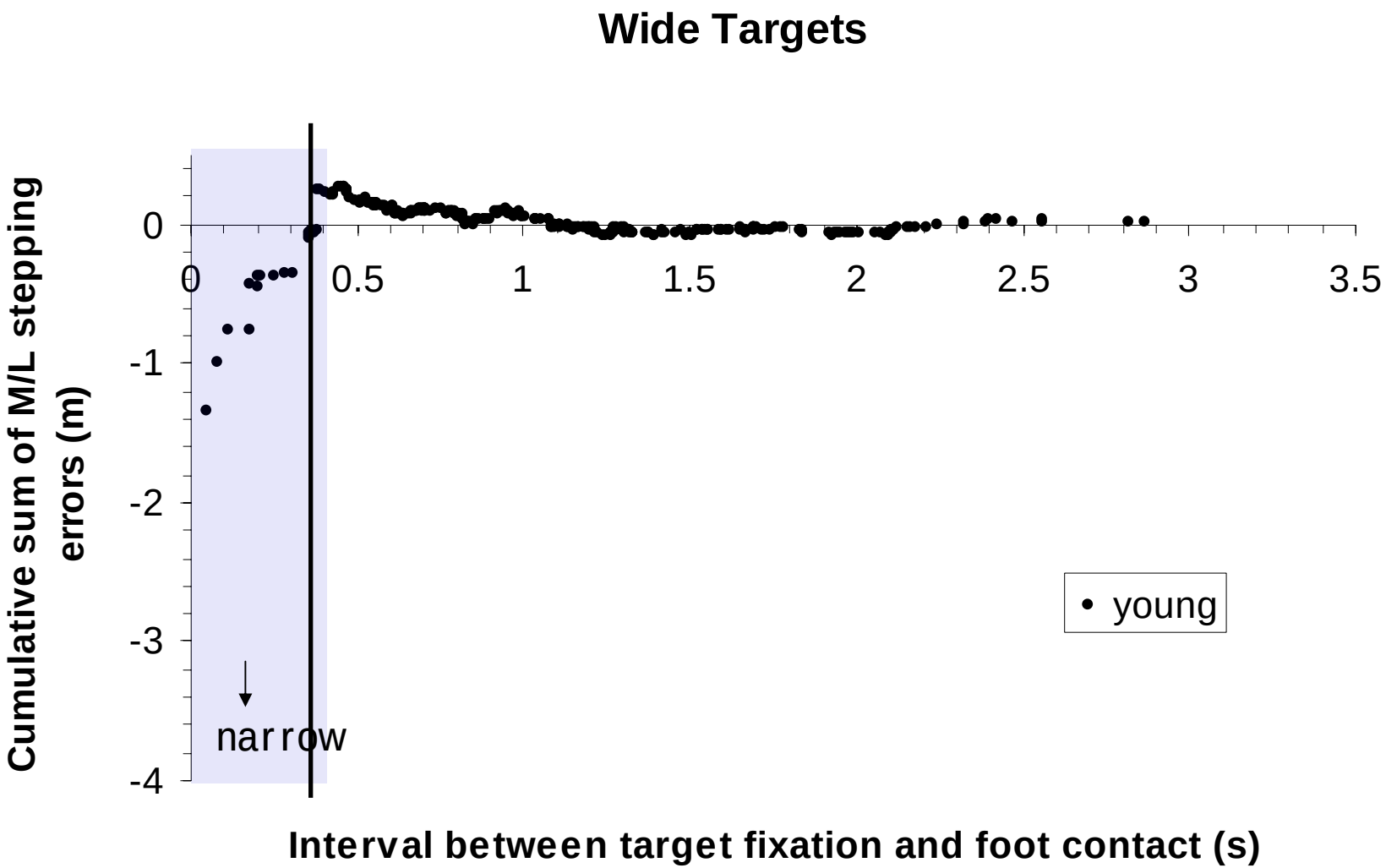

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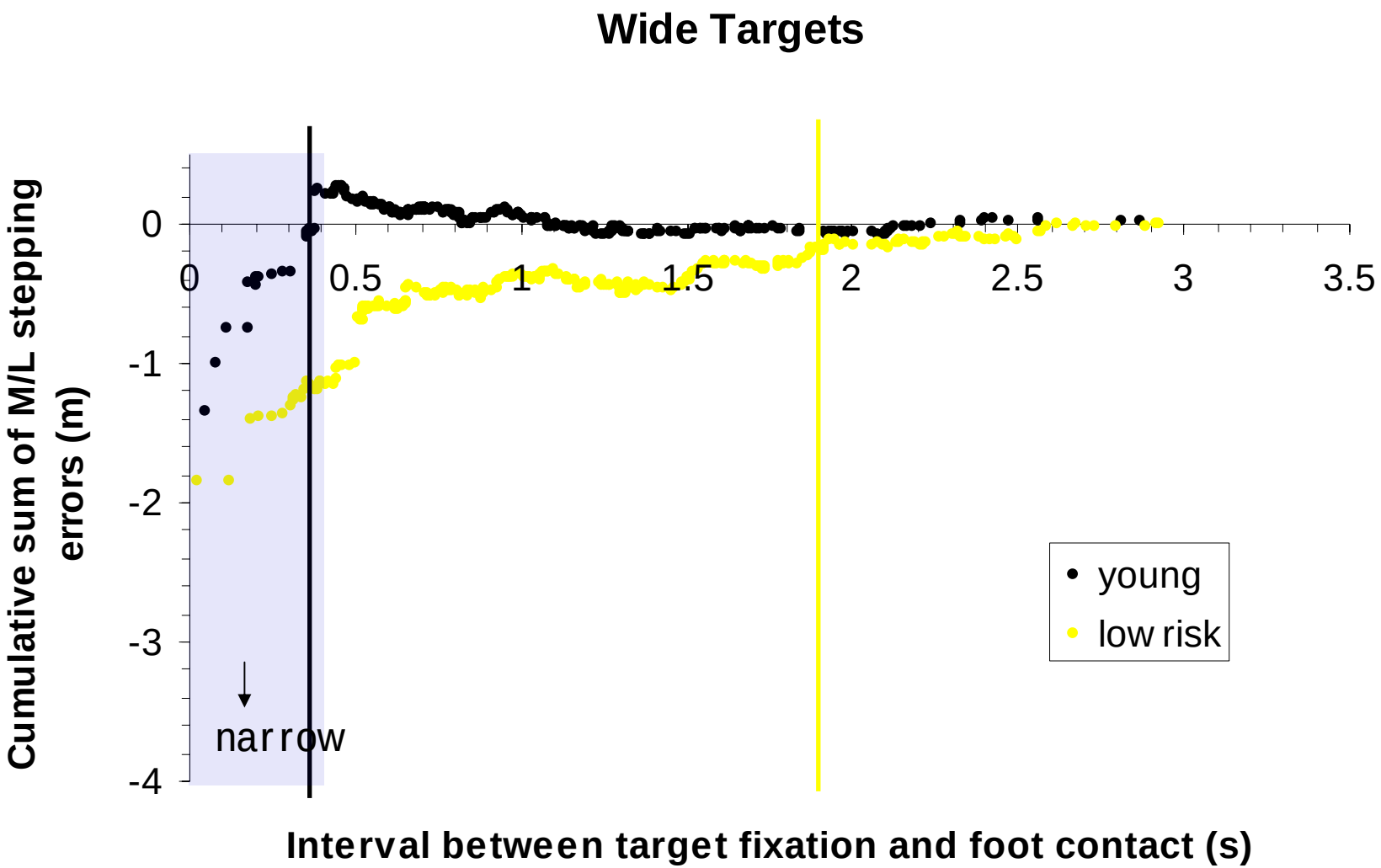

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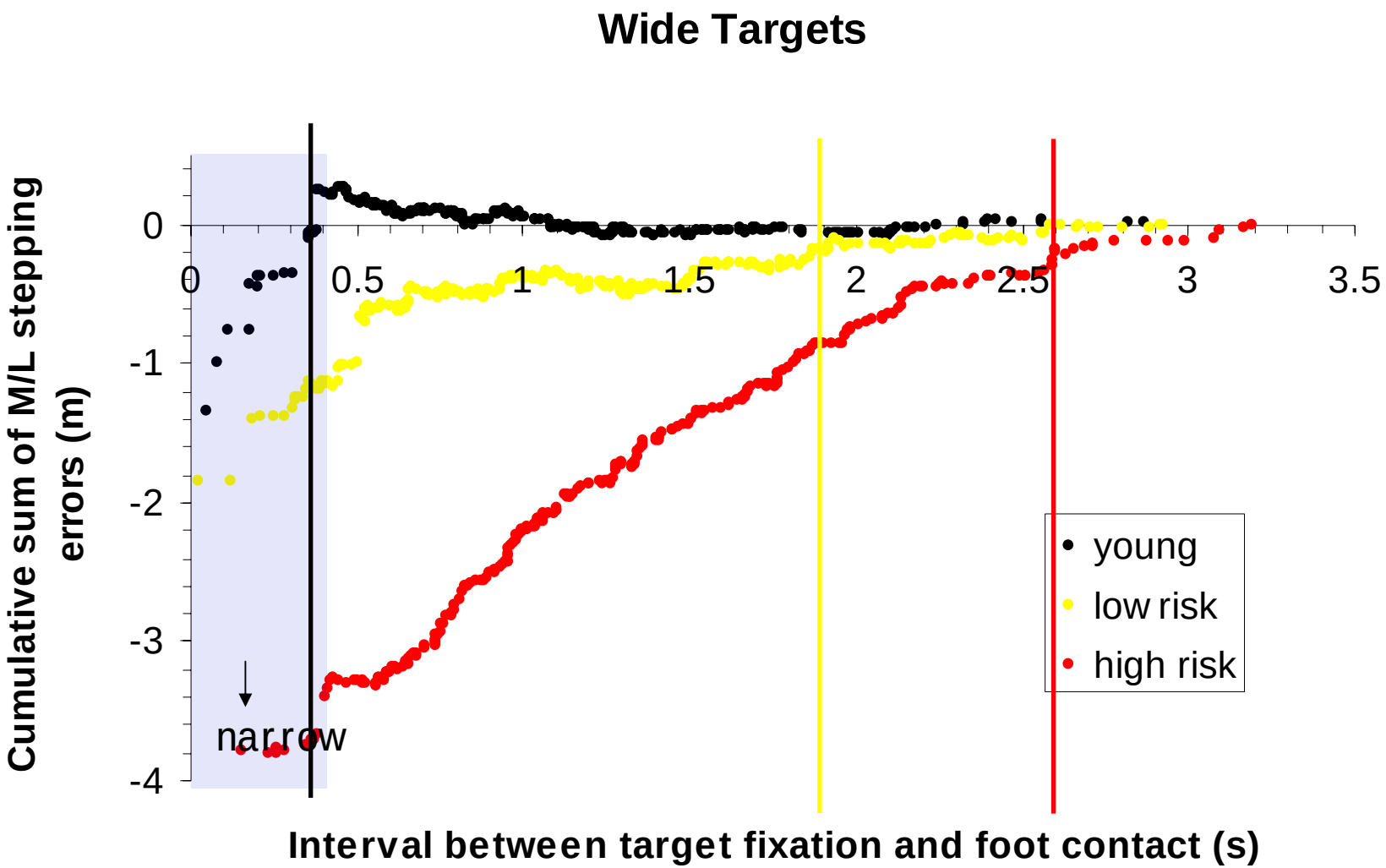

# discussion

- older adults (particularly high-risk) require longer fixating a target in order to step accurately
- stepping inaccuracies constrained to errors in step-width rather than step length
- implications for increased prominence of sideways falls in older adult populations

# conclusions

- differences between young, low-risk and high-risk older adults in eye movement behaviour during walking
- likely reflect age-related changes in time required for effective visuomotor planning and/or biomechanical factors
- implications for diagnosis of falls risk, elucidation of underlying neurophysiological and psychological mechanisms and rehabilitation

# what next ?

- to what extent can individuals adjust stepping trajectories during swing?
  - are there age- and risk of fall-related differences

- are there age-related differences in the biomechanics of stepping wide?

# acknowledgements


- School of Sport and Exercise Sciences
- Dr Graham Chapman

**Symposium on Gait, Posture and Balance: Function, Dysfunction and Rehabilitation**

School of Sport and Exercise Sciences
University of Birmingham
27th and 28th May 2008

**Keynote Speakers**

**CNS control of Posture and Balance**
Professor Richard Fitzpatrick
(Prince of Wales Medical Research Institute, New South Wales, Australia)

**CNS control of Gait**
Professor Jacques Duysens
(Department of Rehabilitation, Radboud University Nijmegen Medical Centre, The Netherlands)

**Gait Recovery in Neurological Rehabilitation**
Dr Cordula Werner
(Department of Neurological Rehabilitation, Charité University Hospital, Germany)

http://gaitandposture.googlepages.com/home