The effects of ageing on gait and mobility

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GAIT & MOBILITY IN OLDER ADULTS

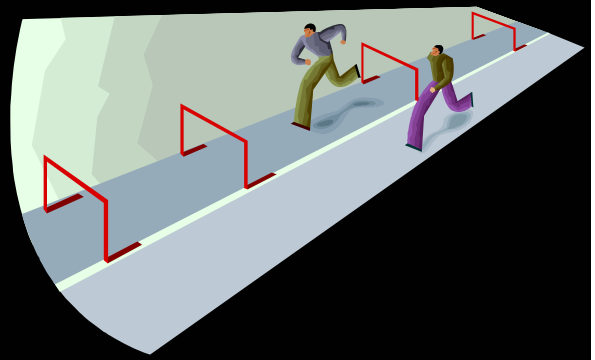
- **Falling is among the leading cause of morbidity and mortality in the elderly**
  (National Centre for Injury Prevention and Control, 2003)
- **Older adults must effectively control their body as they step over, walk around and duck under objects and as they change their travel direction**
- **Tripping or stumbling over obstacles is a major risk factor** *(Tinetti et al N Engl J Med 1989)*

Overview of Presentation

Obstacle course navigation – *results from the field & lab*

Step around, over, duck under fixed OBS heights & distances

Reed, Lowrey, & Vallis (*Gait & Posture,* 2005)
Lowrey, Reed-Jones & Vallis *(Gait & Posture, 2007*)



One or two obstacles in the travel path

Step Over: Scaled OBS heights & distances

Lowrey, & Vallis (under revisions, Experimental Brain Research)

Changing travel direction- *results from field & lab*

Proactive control of steering: Balance confidence?

Fuller, Adkin & Vallis (*Gait & Posture,* 2007)
Paquette, Fuller, Adkin & Vallis *(in preparation, EBR)*

Transient changes in travel direction

Reactive control strategies for steering behaviour?

Paquette & Vallis *(in progress)*

Obstacle avoidance

- **Obstructed travel paths: More common than you think!**
  - Single obstacle avoidance well studied (e.g. McFadyen & Winter 1991; Patla et al 1991)

- **Number of obstacles: Can this affect the avoidance strategy?**
  - Presence of a second obstacle, placed at a fixed distance apart, alters trail limb take-off distances (Patla & Krell 2002)

- **Older Adults: Age related degradation in sensory systems and muscle strength** (Winter 1991; Kovacs 2005).
  - Increased risk of falls: Costly to the Canadian Health System

Three studies:

1. Field obstacle course: 3 x (3 obstacles: duck, step around and over)
2. Lab obstacle course: 3 obstacles (step around, step over duck)
3. One or two obstacles: full kinematic analyses & visual gaze

1. Field obstacle course: Results

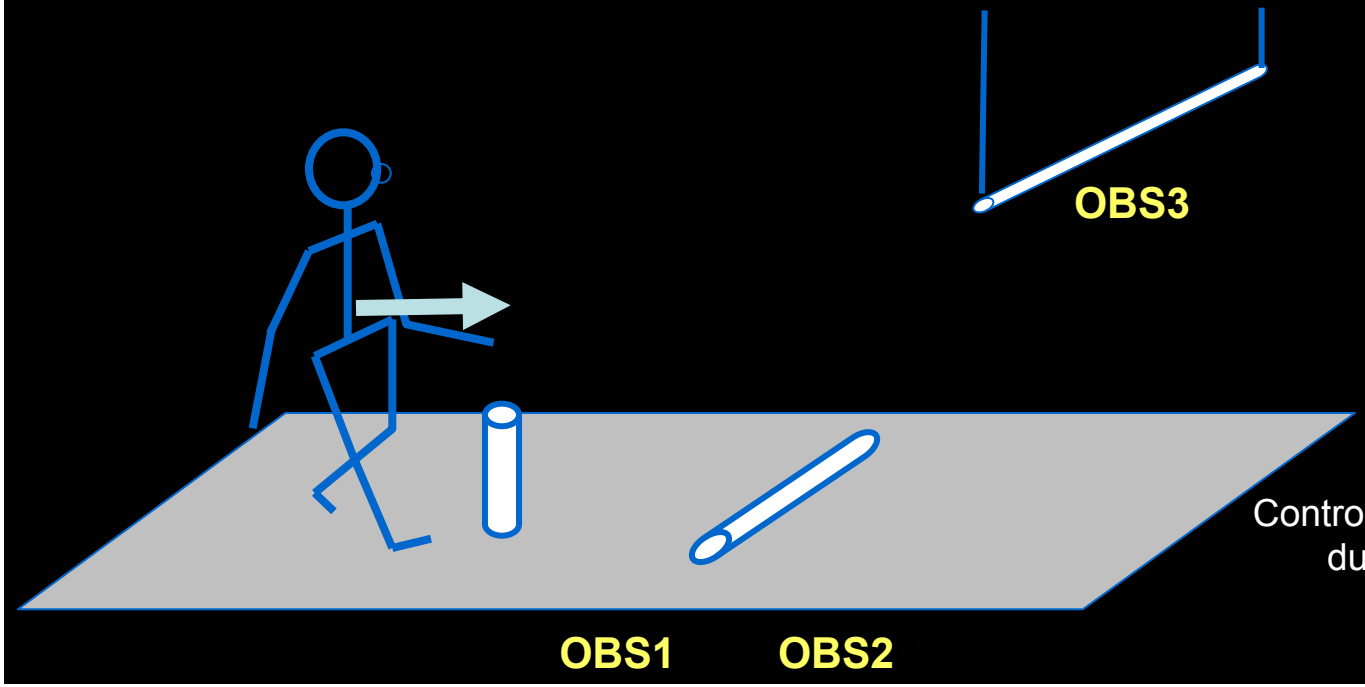
- **Old-old *(85+ years)* contacted more obstacles**
- **Old-old: contacted hanging obstacle**
- **Middle-old *(75-84 years)*: contacted step obstacle**
- **Similar reduced-speed strategy in low lighting**

Why? Differences in underlying control strategies? Reference frames?

Middle-Old and Old-Old Retirement Dwelling Adults respond differently to Locomotor Challenges (Reed, Lowrey & Vallis, *Gait & Posture,* 2006)

2. *Lab* Obstacle course: Results

- Older Adults are able to successfully navigate a functional OBS course
  - through ↑ in trunk motion and a reduction in average step velocity
- They also reduced step velocity in lower lighting conditions and were marginally affected by changes in obstacle contrast
- ↑ in trunk motion in the absence of corresponding changes in BOS may challenge the limits of stability in older adults
  - this strategy may ↑ their risk of falling when avoiding OBS



Optotrak:
3D gait analysis

Control strategies used by Older Adults during multiple obstacle avoidance (Lowrey, Reed & Vallis, *Gait & Posture*, 2007)

3. *One* or *two* obstacles: Methods

Control strategies used by Older Adults during multiple obstacle avoidance
(Lowrey & Vallis, *Experimental Brain Research*, under revision)

Subjects:

Young Adults (YA: 23.1 ± 2.3 years; N=8)

Older Adults (OA: 76.1 ± 4.3 years ; N=8)

Experiment: WALKING TRIALS (Obstructed and Unobstructed)

Six Unobstructed Trials
Six Single Obstacle Trials
Six Unobstructed Trials
Six Double Obstacle Trials

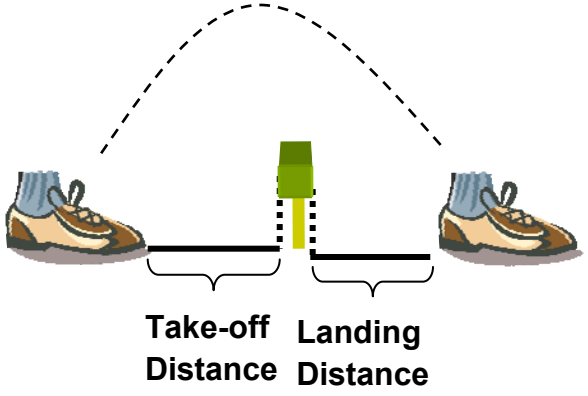
Kinematics: Optotrak

Gait Parameters: GAITRite

Visual Data: iScan

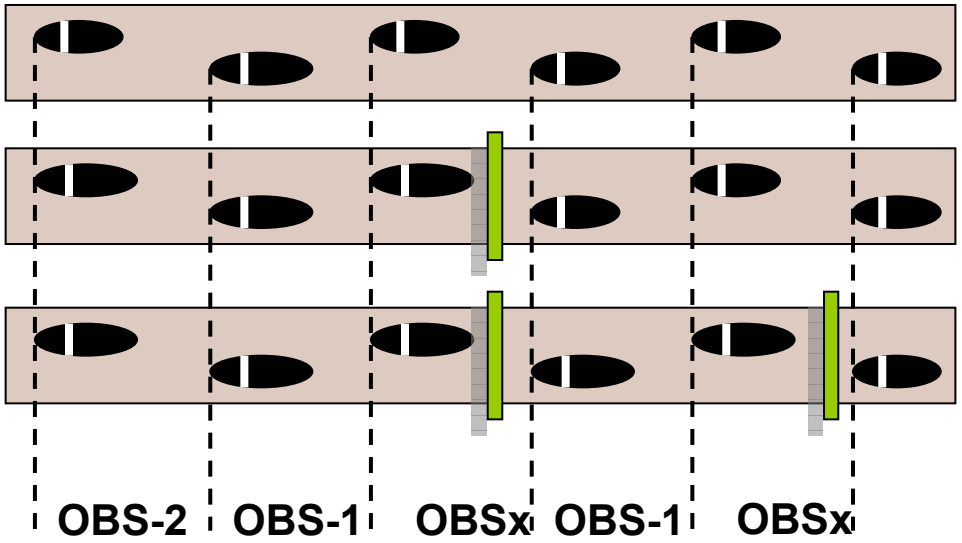
3. *One* or *two* obstacles: Methods I

OBSTACLE PARAMETERS



SPATIAL GAIT PARAMETERS

KINEMATIC, VISUAL & GAIT PARAMETERS



Controls 1 & 2

Single

Double

OBSTACLES

Scaled to 45% of each subject's lower leg length *(~ 21.5 cm)*

Dimensions: 1 cm x 1 cm wood suspended by two plungers

Starting distance: 3 step lengths

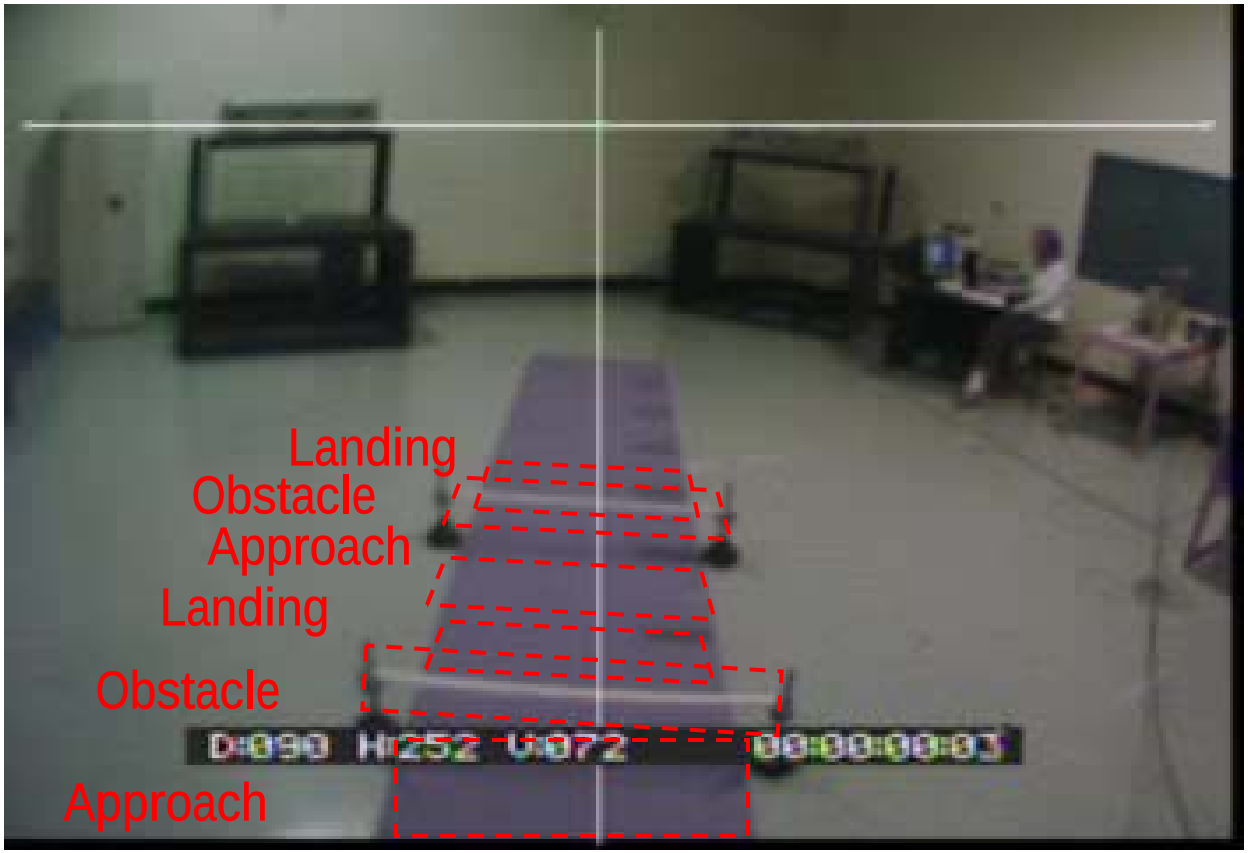
Inter-obstacle distance: scaled to 2 step lengths

3. *One* or *two* obstacles: Methods II

GAZE DATA:
Iscan

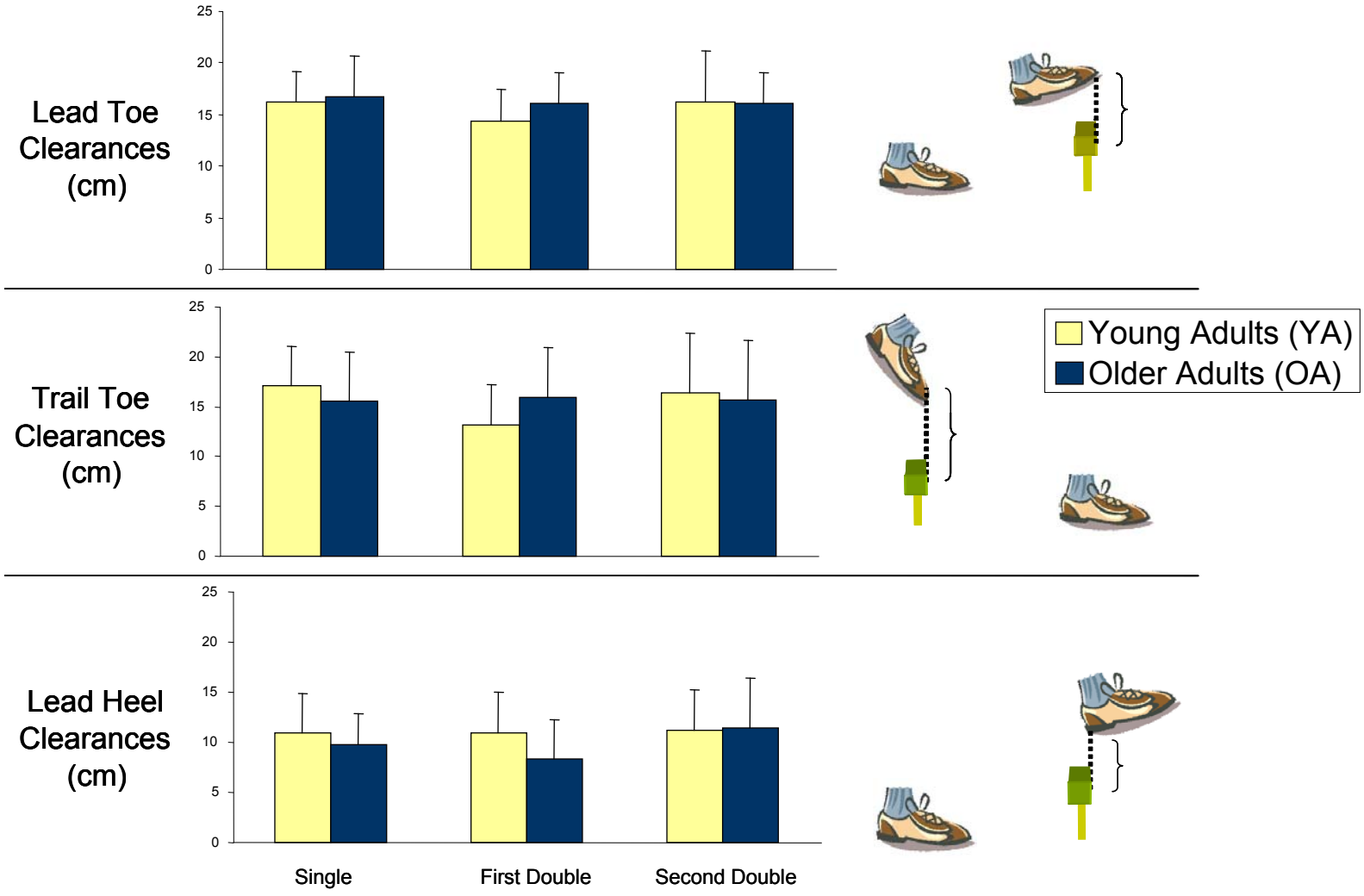
Areas of Interest (AOIs):

Approach, Obstacle, Landing

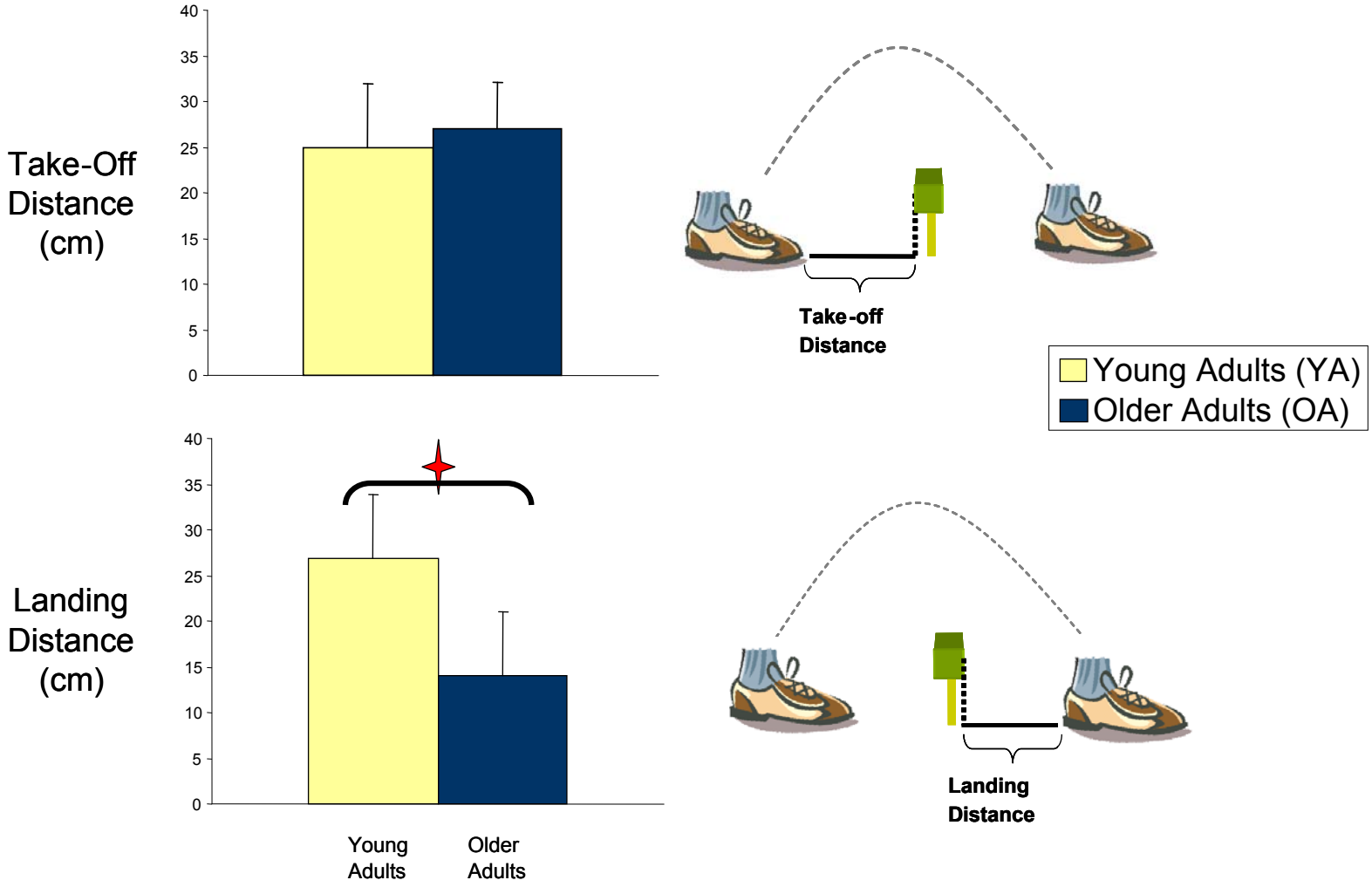


Percentage of each step duration spent looking at each AOI

Both age groups stepped over all obstacles in the travel path using a similar lead and trail toe and lead heel clearance values

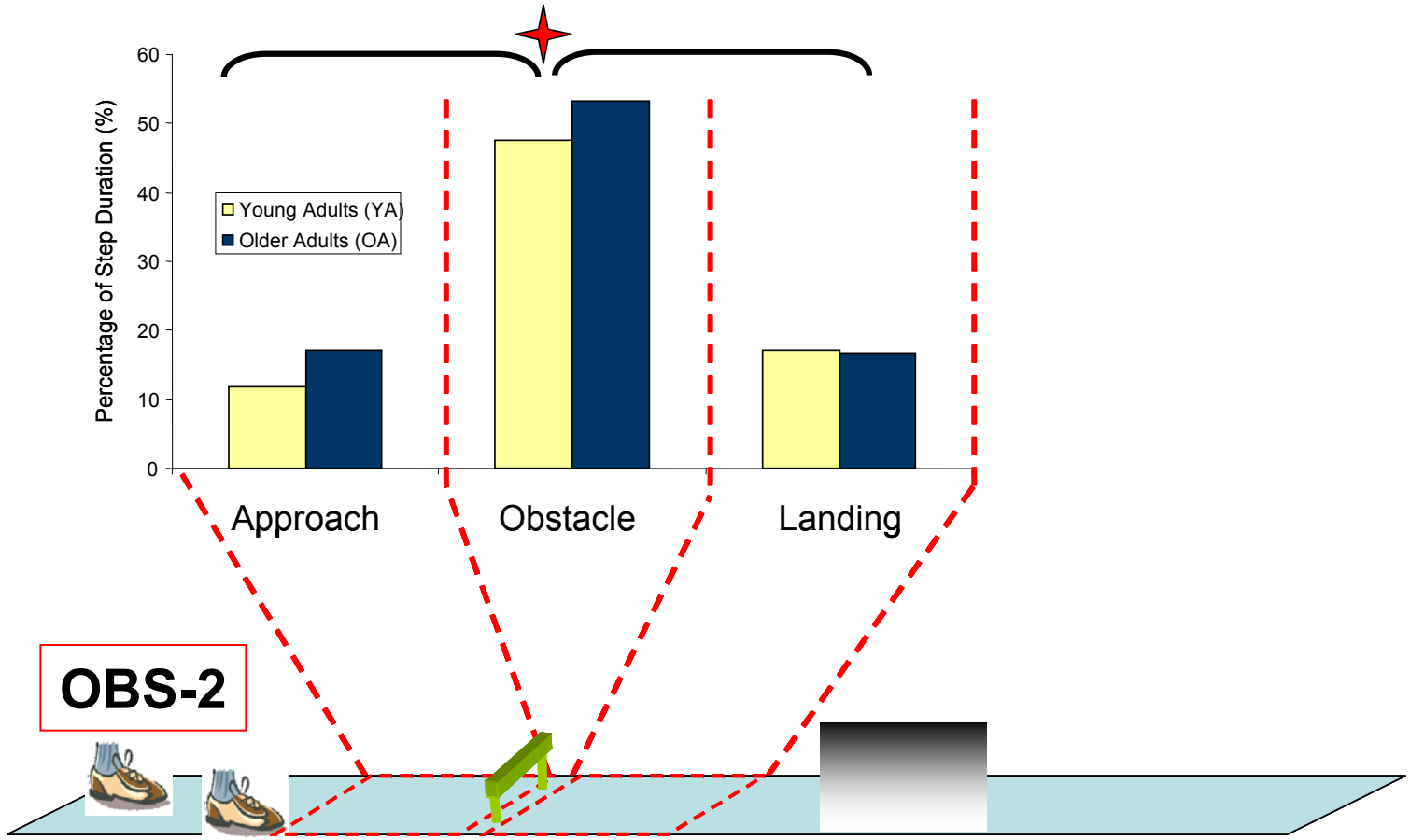


Similar Take-Off distances were produced by both age groups, however OA placed their heel significantly closer to the OBS during the Landing step



OBS-2

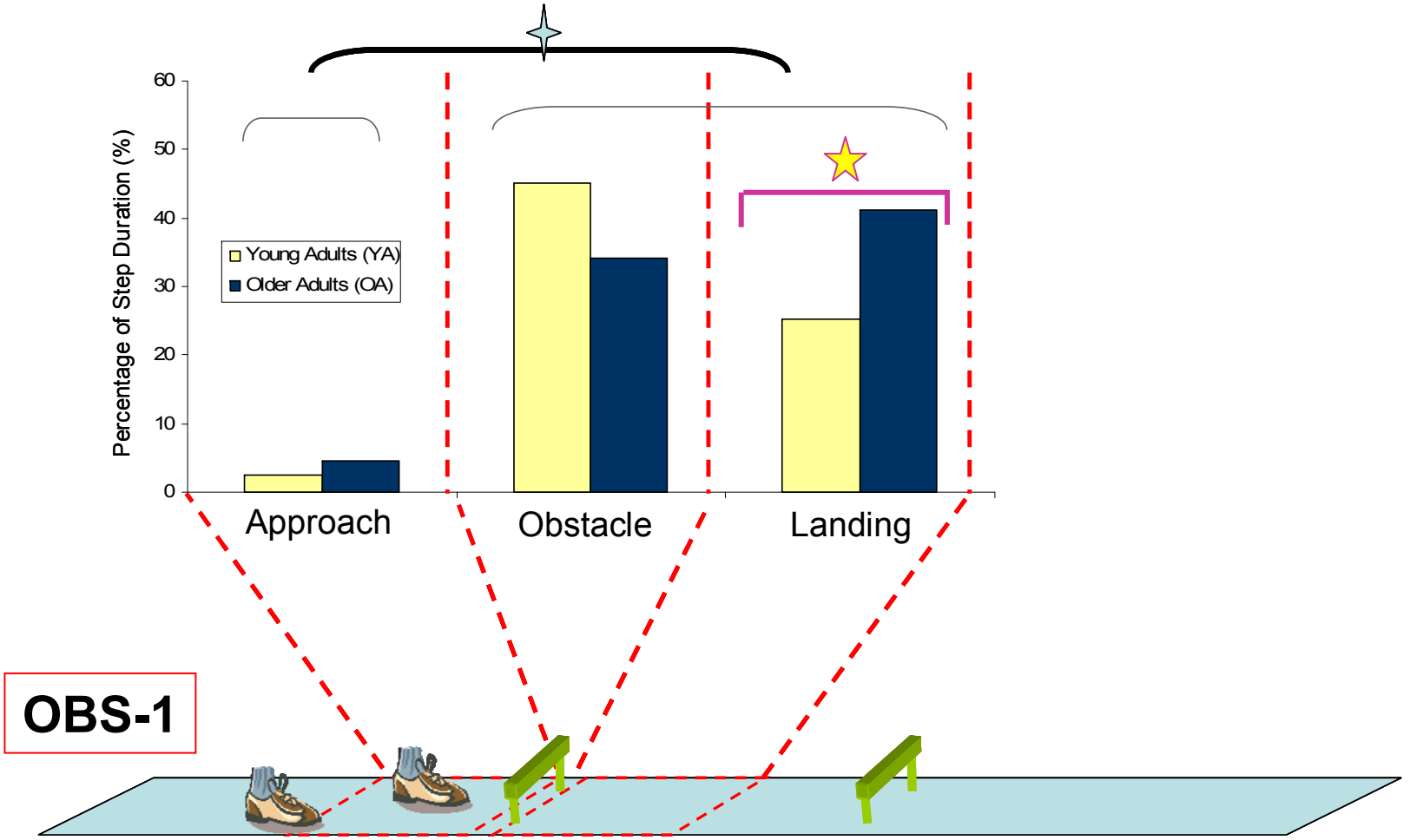
Both age groups looked at the obstacle 'area of interest' for a significantly greater percentage of the step than either the approach area or landing area.



OBS-1

Both age groups looked at Obstacle & Landing areas rather than the Approach AOI.

Also, OA looked at the landing AOI for a significantly greater period of time than YA.

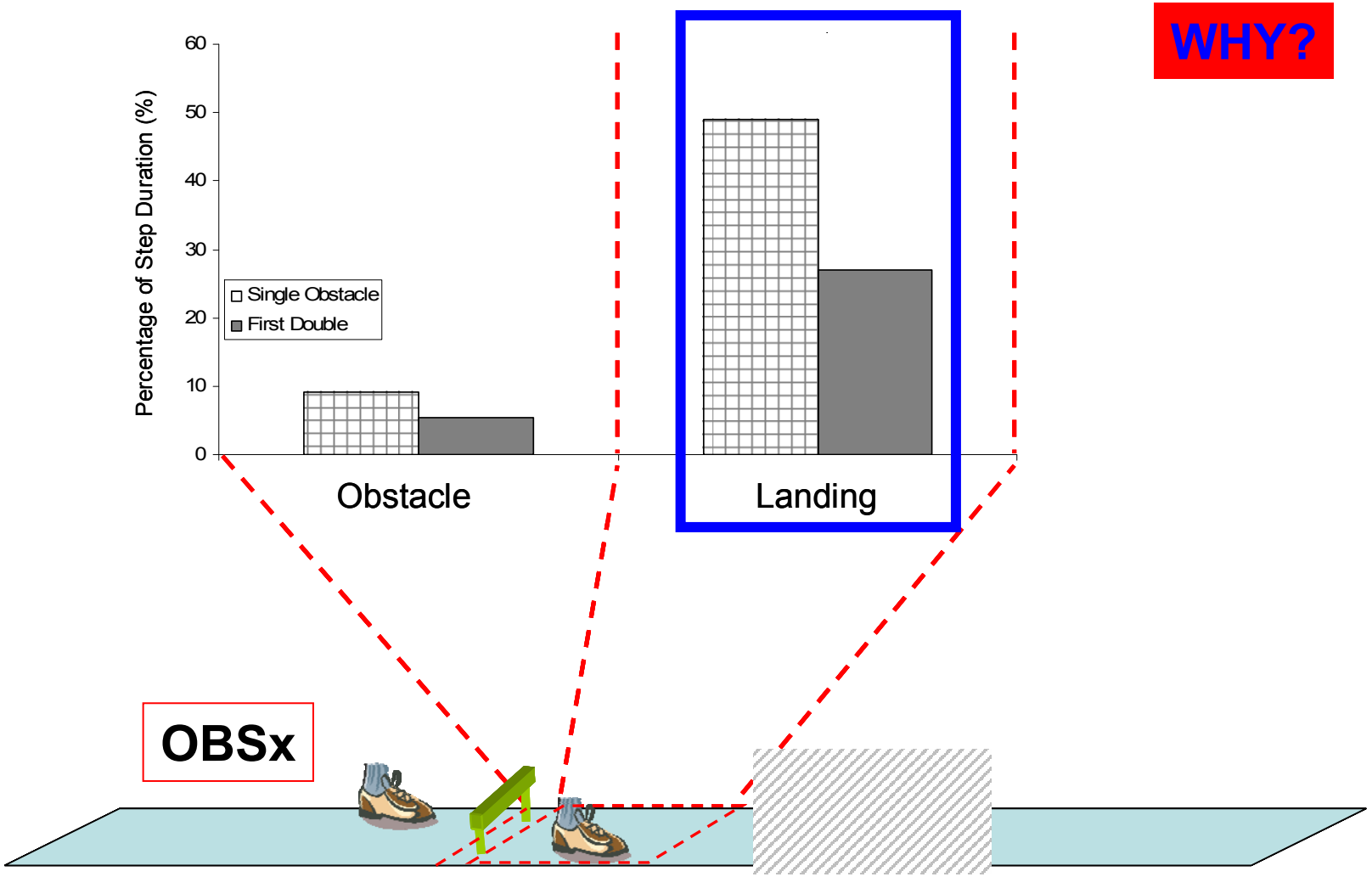


OBSx

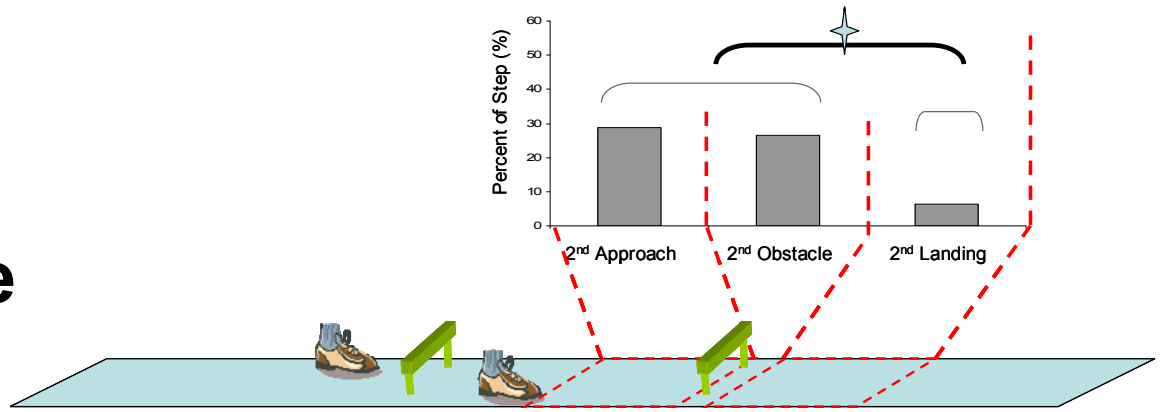
Both age groups focused more on the Landing compared to the Obstacle AOI.

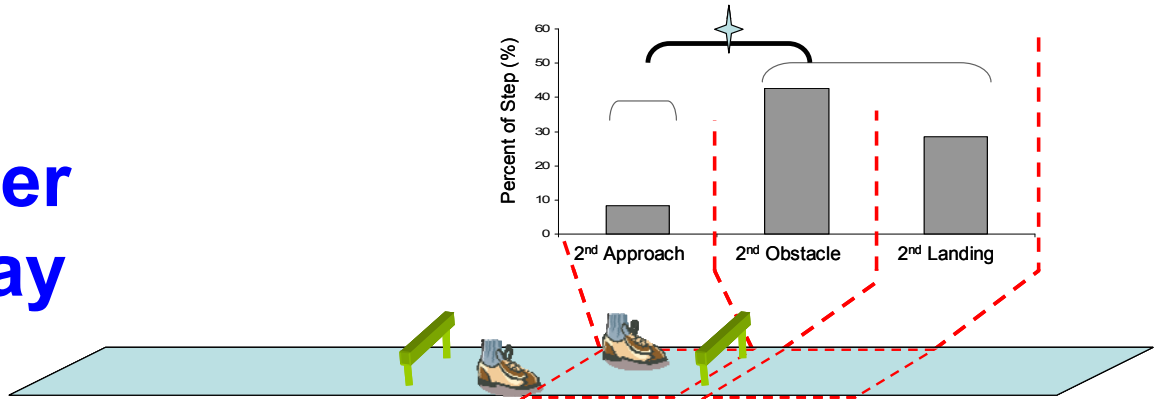
Both age groups also focused more on this respective AOIs when crossing the single obstacle vs. first double

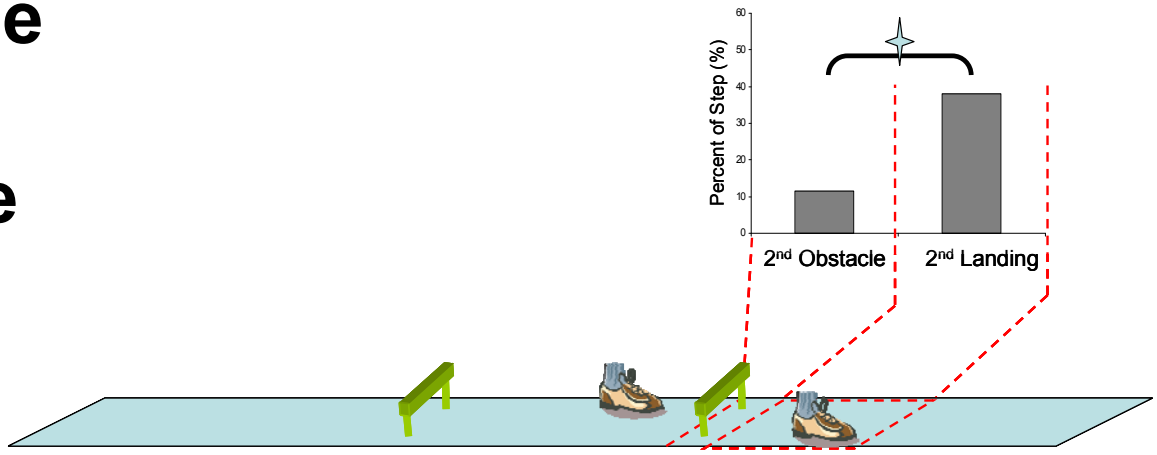
WHY?



When two obstacles were present along the travel path, both age groups directed their visual gaze further along the pathway towards the second obstacle during the crossing of the first obstacle







OLDER ADULTS use different strategies when crossing more than one obstacle in travel path

- Step prior to obstacle crossing, older adults gathered more visual information about landing area, but consistently placed lead heel closer to the trailing edge of the obstacle.
  - Are reduced landing distances due to older adults' inability to utilize online visual information to appropriately adjust step length?
- Older and younger adults gather important information regarding the obstacle in order to plan an appropriate crossing strategy two steps prior to the obstacle crossing step.
  - The presence of a second obstacle placed two steps after the first, required subjects to gather visual information regarding the second obstacle while stepping over the first.

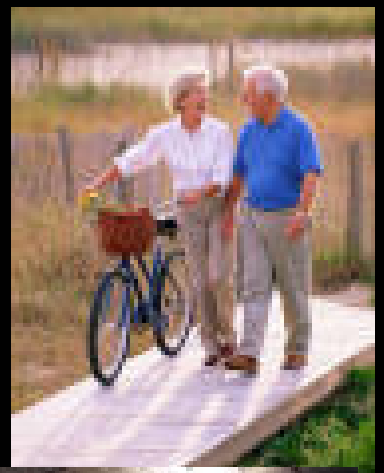
CONCLUSIONS:

Age related changes for obstacle avoidance

- Stepping over multiple obstacles appears to be more challenging than single obstacle avoidance tasks for **older adults**.
- Perhaps **older adults** break complex locomotor tasks into a series of smaller, simpler tasks, whereas **young adults** make limited adjustments in their locomotor avoidance strategies for complex locomotor tasks.
- Are these differences related to an inefficient/slow use of online visual information to adjust gait patterns to the surrounding environment?

Changing travel direction

An integral component of adaptive locomotor behaviour for Older Adults



Activities of Daily living

- Older adults who fell while performing a standing turning test more likely to have a subsequent fall resulting in hip fracture *(Cumming and Klineberg, 1994)*
- Descriptive studies characterize turning difficulty in older adults (Thigpen et al, 2000) – clinical test for falls prediction?

STEERING SYNERGY

Eyes → Head Yaw → Trunk Yaw → Trunk Roll → COM → Foot

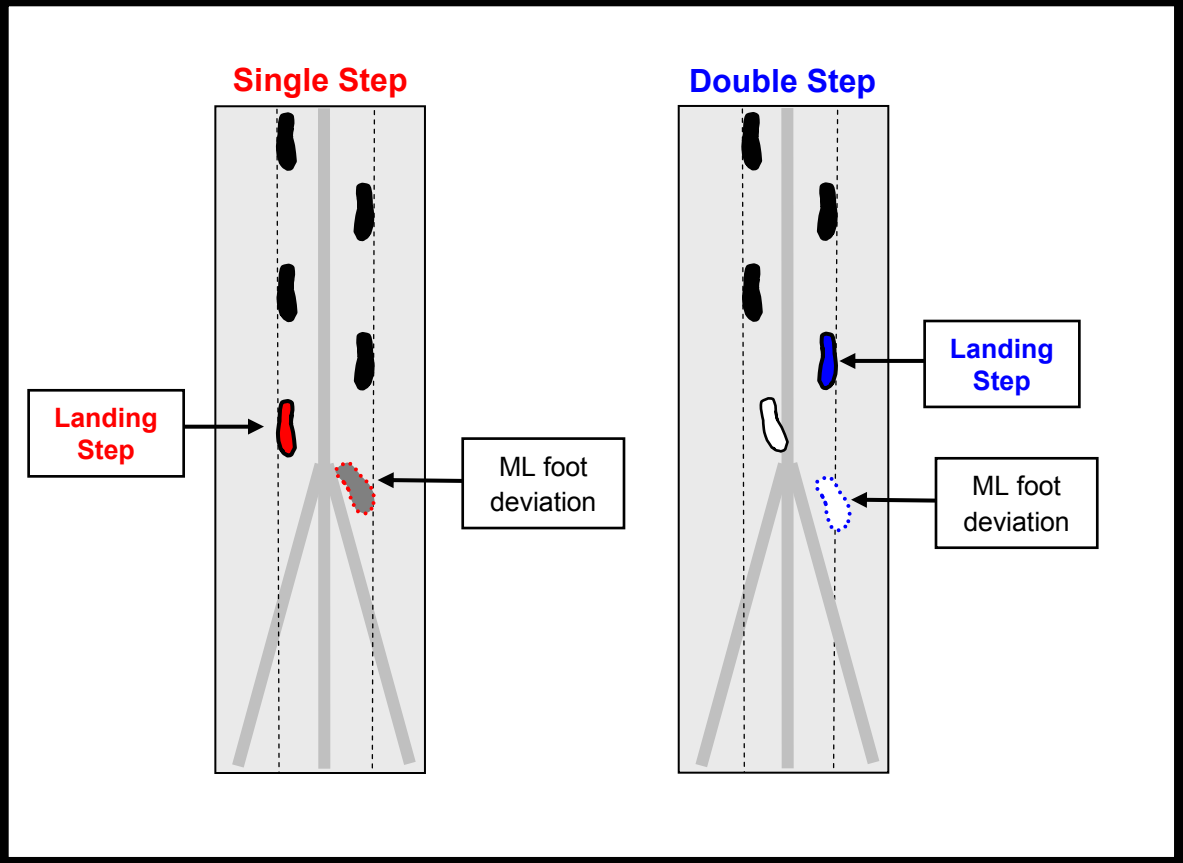
OBJECTIVE:

Characterize sequence and timing of body segment reorientation for steering tasks: <u>proactive</u> (planning!) and <u>reactive</u> (little to no planning time)

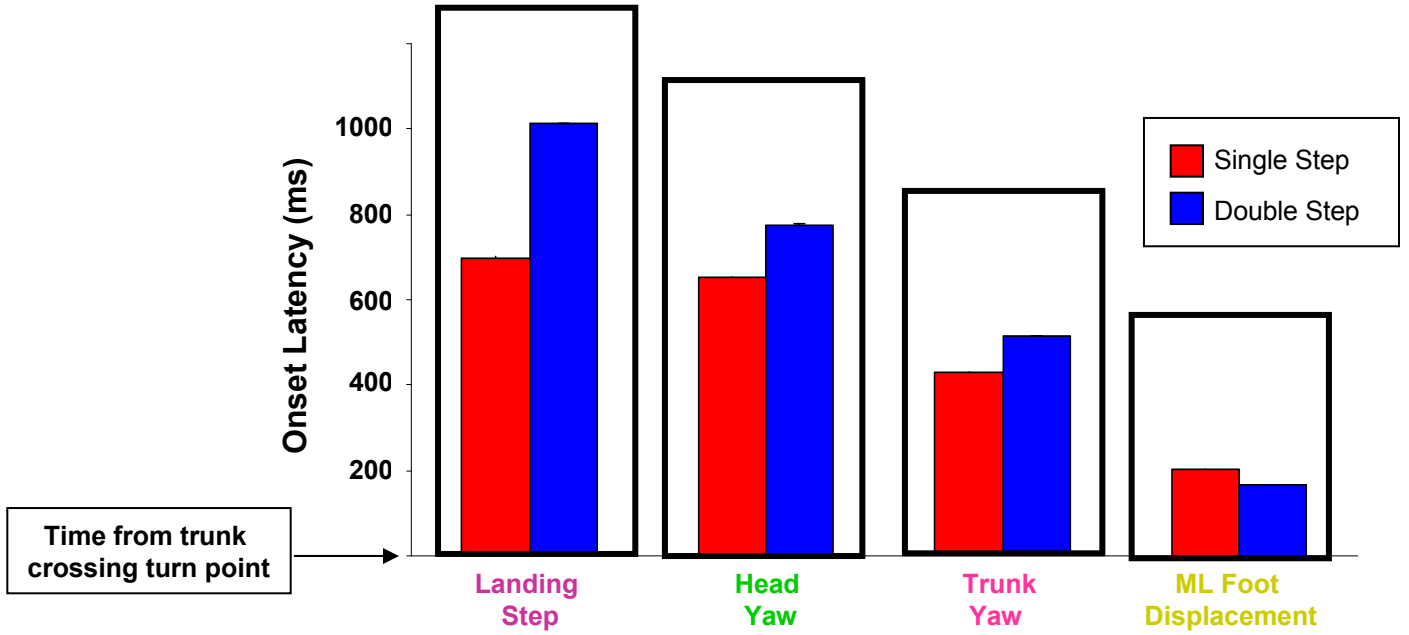
Field study: Change in travel direction

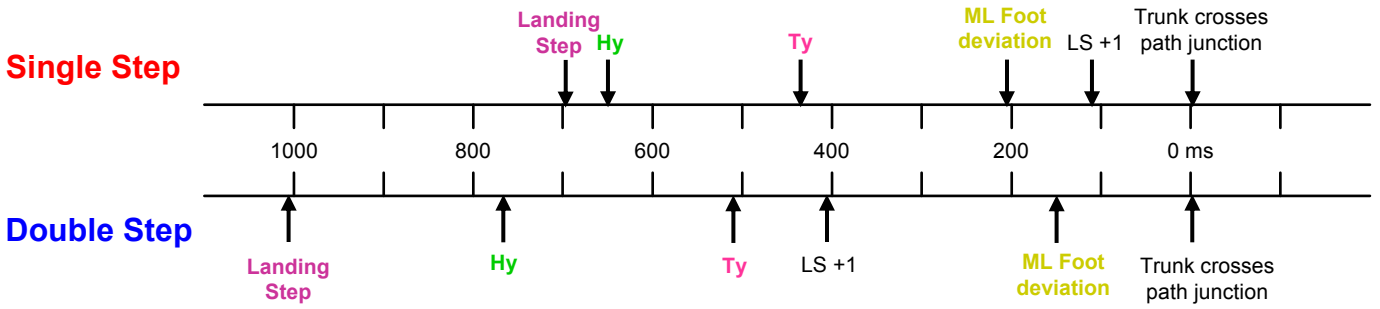
Strategies used by older adults to change travel direction
(Fuller, Adkin & Vallis, *Gait & Posture,* 2007)

- **N = 13 older adults (mean: 81.5 years)**
- **<u>Clinical Tests</u>: ABC, TUG, Dynamic Gait Index**
- **3-m path: straight, 40° left or 40° right**
- **30 randomized walking trials**



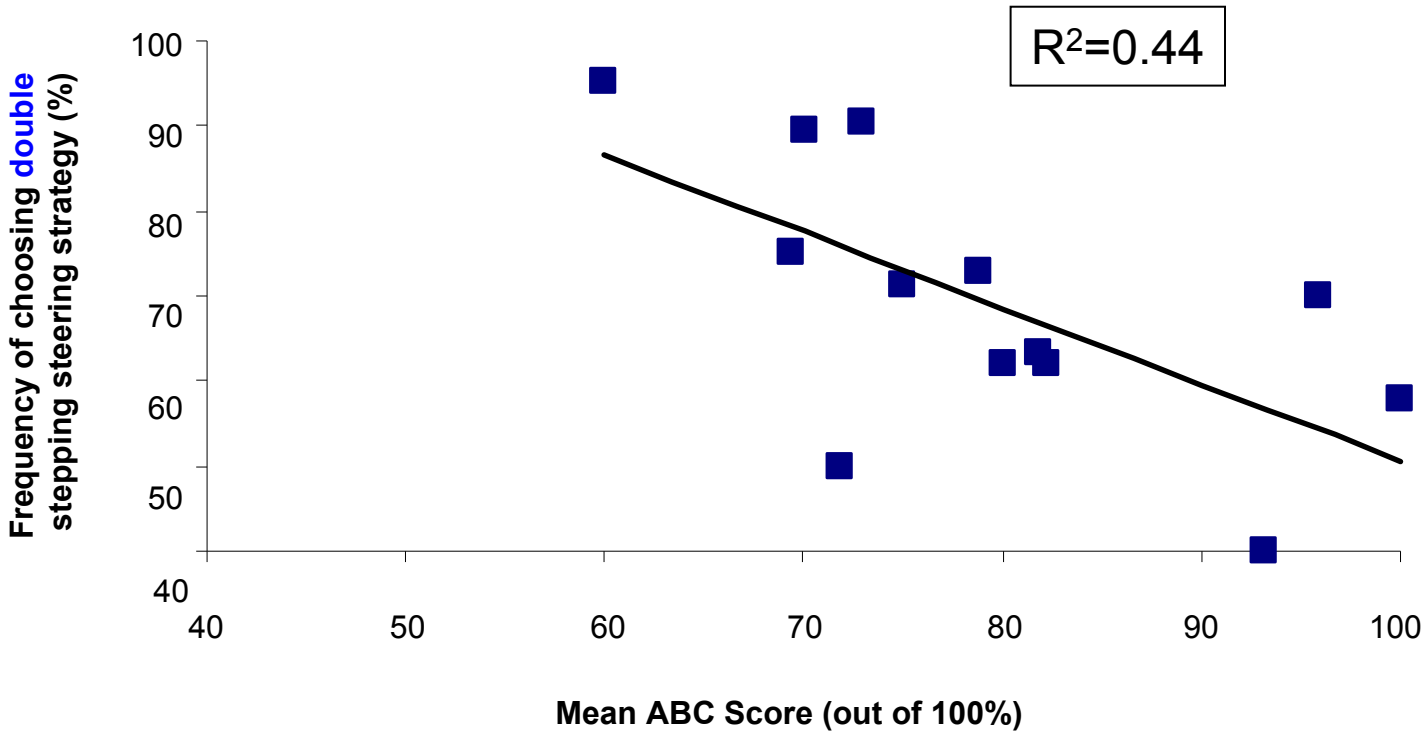
Older adults use a similar sequence as young adults to reorient their bodies in a new travel direction, though in $^1/_3$ of trials OA initiated reorientation of all segments in one step!





Strategies used by older adults to change travel direction (Fuller, Adkin & Vallis, Gait & Posture, 2007)

- For over $^{2}/_{3}$ of trials, body segments reoriented over 2 steps
- Functional mobility measures were NOT related to this choice
- Balance confidence was related to choice of reorientation of segments over 1 or 2 steps
    - *OA with lower balance confidence levels more often used a strategy that reoriented segments over 2 steps*

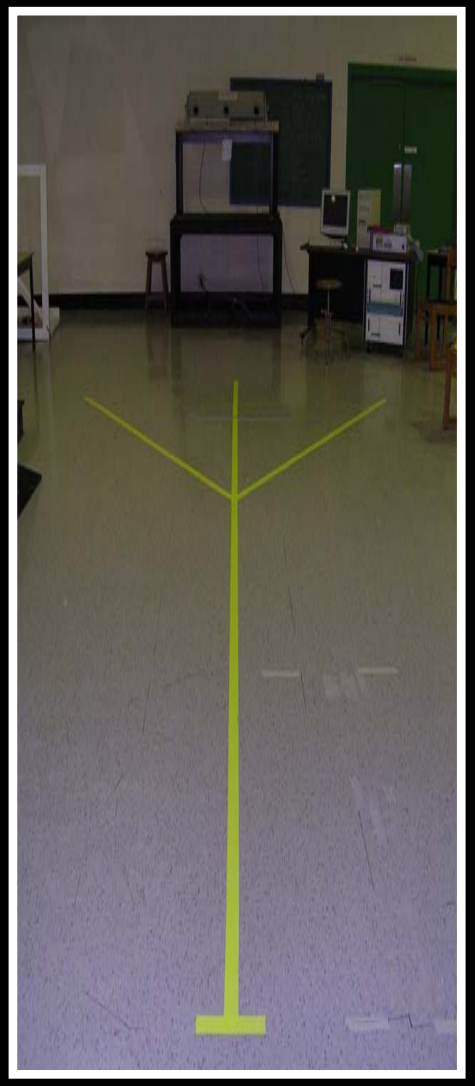


Strategies used by older adults to change travel direction (Fuller, Adkin & Vallis, Gait & Posture, 2007)

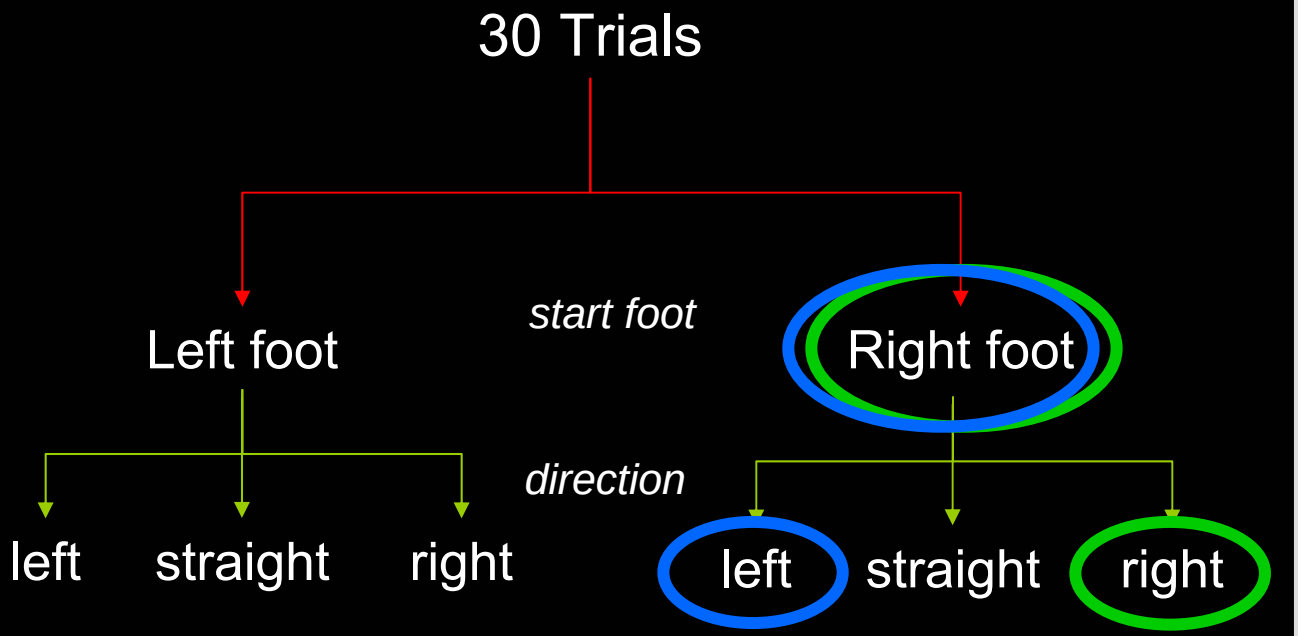
Lab study: Change in travel direction

Strategies used by older adults to change travel direction
(Paquette, Fuller, Adkin & Vallis, *in preparation*)

- Six “healthy” seniors (3 male, 3 female; 83.5 years, 168.3 cm, 72.2 kg) - all from a local retirement residence; Six healthy young adults (~ 21 years)
- Medical Questionnaire
  - Excluded: volunteers with self-reported neurological pathologies
- Clinical Screening
  - Excluded: volunteers with gait abnormalities and/or poor balance confidence and/or scores lower than
- Track movement with infrared diodes (Optotrak) at 60 Hz, yield kinematic data
  - Head, Trunk, Feet

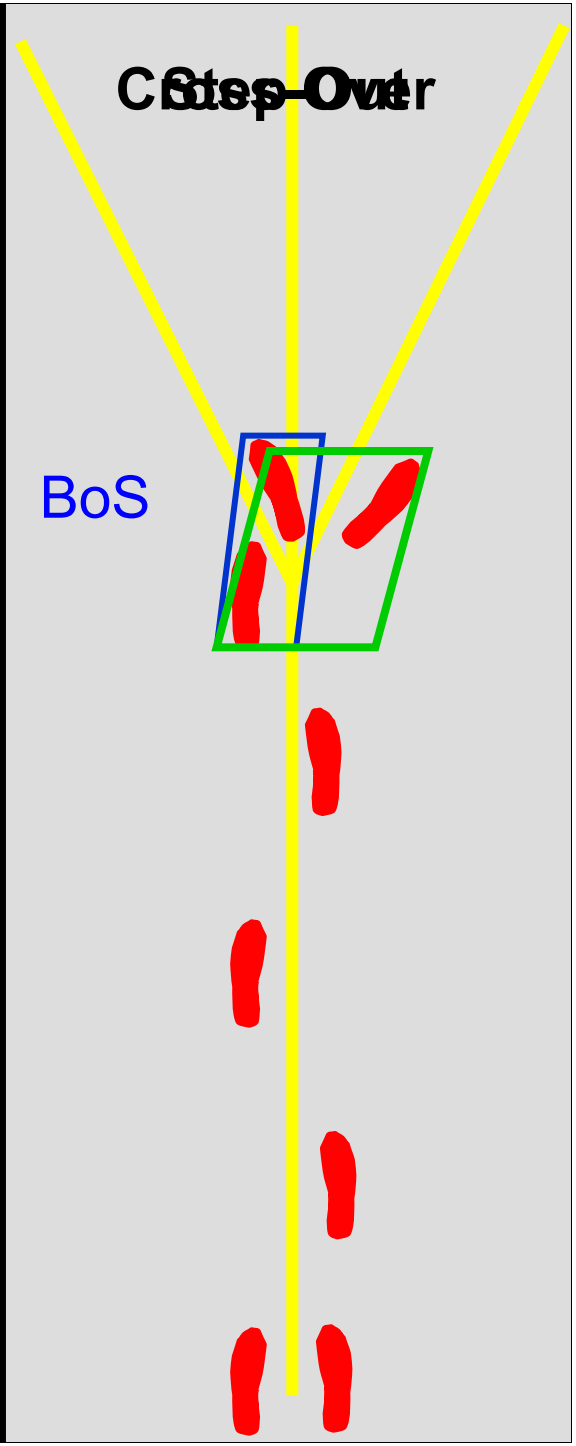


Challenge to Base of Support



Cross Over **Step Out**

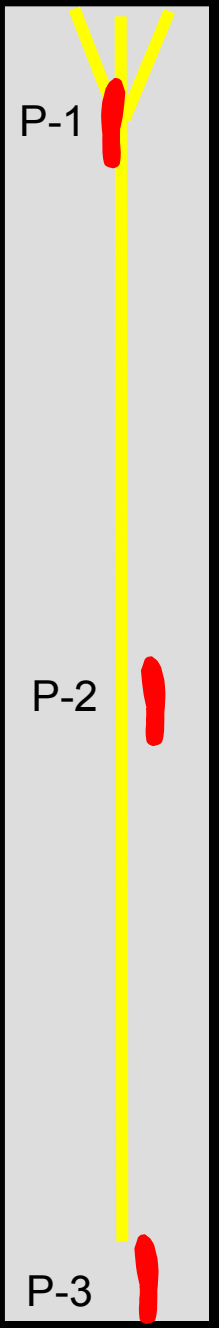
- Starting foot was separated into two blocks of 15 trials each
- 5 trials for each direction within each start foot block were randomly presented



Lab study : Results
Change in travel direction

- **Older adults make preparatory changes to segmental re-orientation 3 steps before turn for Cross Over**
  - → **P-3: SW and ML COM**
  - → **P-2: Trunk Roll**
  - → **P-1: SL, Head and Trunk Yaw, Trunk Roll & ML COM**

- **Older adults make preparatory changes to segmental re-orientation 2 steps before turn for Step Out**
  - → **P-2: SW, Trunk Roll**
  - → **P-1: SL, Head and Trunk Yaw, Trunk Roll & ML COM**

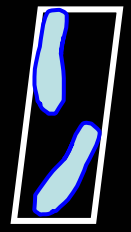


CONCLUSIONS

Earlier changes in body position and greater magnitude re-orientation of segmental angles occur for Cross Over turns

- *Why?* Perhaps related to balance confidence
- More cautious strategy?

Cross-Over



Further Analyses currently underway

- *Examine gait parameters after the turn step*
- *Sequence and timing of reorientation similar for both Cross Over and Step Out turning strategies?*

CONCLUSIONS:

Age related changes for changing direction

- **Older adults** use a similar top-down strategy for reorienting body segments as younger adults
- Two steering strategies observed: **Single** & **Double**
- **Earlier changes in body position and greater magnitude re-orientation of segmental angles for Cross Over turns**
- AND when able to choose: **OA** variable in their selection of their steering strategy **WHY?**

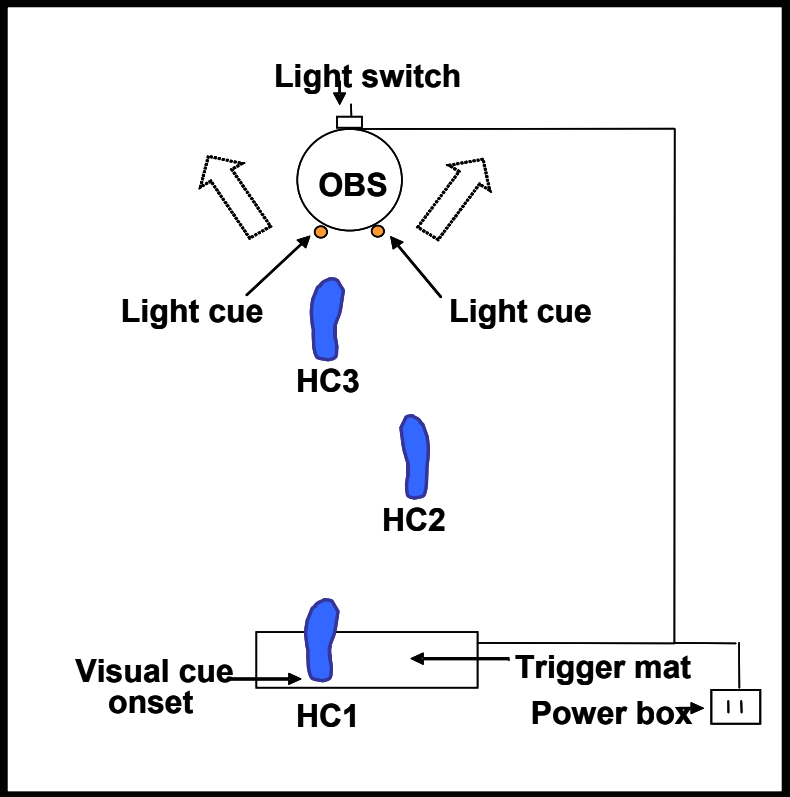
Reorienting segments in the new direction over **two steps**: a function of an interaction between age-related changes & lower balance confidence?

FUTURE DIRECTIONS

- What about real life situations where there is little time to respond? Proactive VS Reactive

  → Young adults complete; Older adults Summer 2007

Reactive, transient changes in travel direction



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Thank-You Questions?