What goes wrong with balance in Parkinson’s Disease?

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Course Objectives

- Understand different types of balance systems affected by PD
- Discover studies demonstrating balance impairments with progression of PD
- Consider how cognitive deficits affect functional mobility in PD
- Learn about why intense Cognitive-Agility exercises may help mobility in PD
Balance problems can differ among people with PD

BRADYKINESIA AND RIGIDITY

Mobility

Threshold for balance or gait problem

Progression of PD
Types of Balance Control

- Postural Alignment
- Postural Responses
- Anticipatory Posture
- Dynamic Balance

PD Impairments

- Rigidity
- Bradykinesia
- Kinesthesia
- Freezing
- Executive

Postural Responses are weak (bradykinetic)

150 N·m

Control

83 N·m

Park OFF Dopa

50 N·m

Park ON Dopa
Forward sway in response to backward surface motion

Postural Alignment-
Stooping worsens balance

Upright Control
Stood Control
Parkinson’s disease
STOOPED INITIAL POSTURE REDUCES POSTURAL STABILITY IN RESPONSE TO PERTURBATIONS, ESPECIALLY BACKWARDS (LIKE PD SUBJECTS).

DBS Surgery worsens postural responses

St. George, et al
The effects of STN and GPi DBS on postural responses in patients with Parkinson's disease.
J Neurosurgery 2012
Jun;116(6):1347-56

Stability limits

p=0.055°
DBS impairs Postural Responses
St. George et al, J Neurosurg

Pre ON Dopa
Post ON / ON

Levodopa does NOT improve postural responses in Parkinson’s Disease

OFF Dopa Pull Test
ON Dopa Pull Test
Freezing when a step is needed for stepping response


Poor Kinesthesia (body sense) impairs balance

Reduced perception of surface angle

60% correct instead of 85%

PD need to see foot to step to target

People with PD can learn to improve postural responses with practice standing on a translating surface.

VOLUNTARY STEPPING

Control  PD Narrow  PD Wide
Difficulty changing postural set for initial conditions

Patients with Parkinson's Disease do not scale up the size of APAs for wide stance

Rocchi, Laura, et al

Turning is harder than straight walking, esp. for PD
We make over 1,000 turns a day

Quantity of activity is similar in PD and controls, but quality of turning is different
Figure-8-task in PD with low and high neck rigidity

Franzen, et al, Reduced performance in balance, walking and turning tasks is associated with increased neck tone in Parkinson’s disease
Exp Neurol 219(2):430-8, 2009

LOW NECK TONE

Earliest signs of PD gait:
lack of arm swing
and lack rotation trunk/neck

HIGH NECK TONE

Gait Variability across day and across week larger in people with PD than people 20 yrs older

ORCATECH elderly participant

PD patient
Cognition and Balance

- Cognitively impaired older people fall twice more than cognitively intact

- PD patients with worse cognitive deficits have more falls (Segev-Jacubovski et al. 2011)

- Gait and balance are not automatic processes in older people, esp with PD (Stuss et al. 2000)

Same parts of brain for thinking and balance

- Fronto-basal ganglia circuits, vital to control gait are also involved in executive functions (Stuss et al. 2000)

- Increased demands (stress, anxiety or challenging task), can lead to freezing of gait (Vandenbossche et al. 2000)
Cognitive problems related to mobility in Parkinson’s disease

**EXECUTIVE FUNCTION**

- Attention
- Response Inhibition
- Updating
- Shifting
- Movement Coordination
- Functional Mobility

**Dual Tasking**

“Dual-Task Interference”
Walking slows when talk
Thinking slows when walk

More difficult with Parkinson’s Disease:
- Need more attention to walk and balance
- Reduced working memory
- Difficult to switch between tasks
- Make not prioritize balance

Owen et al., 1997; Lewis et al 2005
Balance and walking require more attention in PD

Gait Velocity

Controls

PD

Month 0  Month 3  Month 6  Month 9  Month 12

No Cognitive Task  With Cognitive Task
Postural stability when walking is more affected by a dual-task in people with PD


Dual Tasking can improve with training!

Gait speed during serial subtraction of 3’s improved with practice in people with PD.

Pichierri et al 2011; Yogev et al. 2012
Conflict Resolution

Difficulty inhibiting inappropriate responses while activating the correct response

Flankers Task: name the direction of the middle arrow

Stroop Test- conflict resolution

Look at the chart below and say the COLORS, not the words. Try to say them fast!

YELLOW  BLUE  ORANGE  BLACK  RED  GREEN  PURPLE  YELLOW  RED  ORANGE  BLACK  GREEN  BLUE  RED  PURPLE  GREEN  ORANGE  BLUE
Impairment of cognitive inhibition could contribute to FoG

- In gait, lifting of the stepping leg must be delayed until the APA is complete, but no longer.
- Failure to release inhibition of the stepping program and to inhibit the APA may lead to akinesia or repeated weight shifts without stepping, “trembling of the legs” associated with FoG.

Posture/Locomotor Network Overlaps with Cognitive Network

**Hypothesis:** FoG is due to abnormal connections between Medial-Frontal Cortex and Midbrain Locomotor Centers

PPN is atrophied but more active fMRI during imagined walking in Freezers Snijders et al., 2011

Freezers have difficulty releasing inhibition so can “Go”
Missing Connectivity of the Right Locomotor Network and bilateral Cerebellum in Freezers

FoG subjects show reduced fiber tracts from PPN to RIGHT thalamus, putamen, GPI, cingulate, pre and post-central gyrus, SMA and preSMA, Prefrontal and BILATERAL Cerebellum

Asymmetry of White Matter Tracks from PPN

Fling et al. Brain 2013
Asymmetry of white matter from PPN to medial frontal relates to Executive Inhibition in FoG+

Fling et al. *Brain* 2013

**WHY RIGHT SIDE FOR FOG?**

Response Inhibition Circuit: Right STN-PreSMA Healthy

Decreased Right Default Mode Network in PD (related to cognitive)

Coxon, et al, J Neurosci 2012

Tessitore, Neurology, 2012
What goes wrong with balance in PD?

- Bradykinesia
- Rigidity
- Kinesthesia
- Freezing
- Executive

Progression of disease

• Alignment
• Responses
• Anticipatory
• Gait

Does intense cognitive-agility exercise for PD improve

• Balance/Gait
• Executive Function
• Brain Functional Connectivity

Hypothesis:
Make balance and gait more automatic, (ie; less cortical control of locomotion circuit) so more attention for cognitive function.
Balance Disorders Lab OHSU and VA 2014

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