Parkinson’s disease: Understanding causes, mechanisms and treatments for falls

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What is Parkinson’s disease?

• PD is one of the most common neurological disorders
• Affects roughly 100,000 Canadians
• Chronic, progressive, neurodegenerative condition
• Loss of dopaminergic neurons in the brain
• More common in men
• Multifactorial causes:
  – Genetic
  – Environmental
  – Aging
First described in 1817 by Dr James Parkinson, in ‘An Essay on the Shaking Palsy’
Classical signs/symptoms of Parkinson’s disease

- The movement problems associated with PD are characterised by four cardinal signs:
  - Tremor
  - Bradykinesia (slowness of movement)
  - Rigidity
  - Postural instability (loss of postural reflexes)
Parkinson’s disease

- Neurodegeneration – a form of accelerated aging? (Anderson et al., 2007)
  - Motor Symptoms – slower movement, stiffness, poor posture, balance & gait deficits
  - Cognitive Decline – memory, confusion, hallucinations, dementia
  - Autonomic function - bladder control, constipation, sexual dysfunction, cardiovascular issues

CHICKEN & EGG? Physical inactivity lead to secondary symptoms?
Neuroanatomy of Parkinson’s Disease

Motor Cortex

Thalamus

Globus pallidus

Substantia Nigra

Caudate Nucleus

Putamen

Locus Ceruleus

Raphe Nuclei

Brainstem

Pars Reticulata

Pars Compacta

Substantia Nigra (detail)
The Treatment?

- Responsiveness of dopamine medications?
  - Tremor, postural instability (balance and falls), freezing

- Limitations of dopamine replacement medications:
  - Wearing off with prolonged use
  - Motor fluctuations & difficulty maintaining optimal dose
  - Increased potential for dyskinesia

  - Alternatives (dopa-agonists)
    - Not as effective
    - Associated with addictive and compulsive behaviors
    - Potential valvular dysfunction (regurgitation)

  - Medications strategies associated with:
    - Decline in cognitive function (memory, hallucinations)
    - Postural hypotension and poorer overall BP control (falls risk)

(Almeida & Hyson, RPCN, 2008)
Non-Motor Symptoms of PD

- Loss of sense of smell (Braak, 1991)
- Numbness & Tingling
  - Precursor to tremor
- Pain
  - Stiff Shoulder Syndrome
- Decreased cutaneous sensitivity (Jenkins, Almeida et al, 2009)
- Weakness/Force Production
- **Visual Dysfunction???
  - Related proprioceptive dysfunction (Tan & Almeida, 2011)
Could Sensory Mechanisms Be a Core Factor That Underlies Freezing of Gait in Parkinson’s Disease?

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[Graph showing data on Total Number of FOG and Step Width Variability (CV) for different conditions: FRAME (DARK), FRAME, FRAME+BODY, NO FRAME (DARK), NO FRAME+BODY.]
Considerations:

- Why might FOG occur in doorways?
  - Does a faulty initial visual perception lead to poor planning?
  - How might poor distance estimation interact with movement toward an upcoming doorway?
  - Is the doorway a distracting stimulus (attention related)?
Measure visual processing speed without confounding it with movement speed…

- PD require 50-60msec longer to inspect their environment

Johnson & Almeida et al., Neuropsychologia, 2004
Are symptoms really “adaptations” in PD?

Original Article written in 1996
What are typical movements in “atypical populations”?

Synergies in Health and Disease: Relations to Adaptive Changes in Motor Coordination

Mark L Latash, J Greg Anson
Published August 2006
Considerations:

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Perceptual distance estimation deficits – only with proprioception?

Ehgoetz Martens, Ellard, Almeida (2013) Neuropsychologia
Disentangling perceptual judgment and online feedback deficits in Parkinson’s freezing of gait

Carolina R. A. Silveira¹,² · Kaylena A. Ehgoetz Martens¹,³ · Frederico Pieruccini-Faria¹,⁴ · Danielle Bell-Boucher¹,⁵ · Eric A. Roy¹,² · Quincy J. Almeida¹

Silveira et al., (J Neurology 2015)
BASAL GANGLIA OVERLOAD
Considerations:

• Why might FOG occur in doorways?
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  • How might poor distance estimation interact with movement toward an upcoming doorway?
  • Is the doorway a distracting stimulus (attention related)?
Cognitive overload from distraction can lead to increased trips and falls in Parkinson’s!

Cognitive impairment appears to be both a consequence of and a risk factor for poor diabetes self-management and associated glycemic outcomes.
Anxiety can overload the sensory processing of how your feet are walking, especially when OFF dopamine medications!

North American Outstanding Student Paper Award – 2015!

Virtually-induced threat in Parkinson's: Dopaminergic interactions between anxiety and sensory–perceptual processing while walking

Kaylena A. Ehgoetz Martens\textsuperscript{a, b}, Colin G. Ellard\textsuperscript{b}, Quincy J. Almeida\textsuperscript{a}.

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Special Issue: Sensory Motor Integration
“And scientists too have been busy in their labs. I did a search on PubMed, and there were 15,000 citations about Parkinson’s over the last seven years.

BUT. I’m not tying my tie any faster!”

(World Congress on Parkinson’s Disease, 2005)
Dopa-Responsive Balance Changes Depend on Use of Internal vs External Attentional Focus in Parkinson's Disease

Eric N. Beck, Quincy J. Almeida
Responsive Balance Changes During PD vs External Attentional Focus

Eric N. Beck, Quincy J. Almeida

2016 Gold Medal of Academic Excellence for PD SAFEx exercise rehab with EFA and IFA!
• Balance issues in Parkinson’s are the result of interactions between cognitive, sensory-perceptual and anxiety systems
  – PD are slower to make visual judgements
  – Distance/depth estimation is compounded when proprioception is needed to guide movement
  – Anxiety overloads our ability to process sensory information in PD

• To better understand PD, it may be just as important to ask: “How are resources being split when overloaded?”
Each of the members has distinctive expertise in exercise interventions/gait/physical activity and cognition.

Including 2 Canada Research Chairs in Exercise & Cognition.
Thank you!