Linking cognition & mobility

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Walking in the real-world

Hickey et al., in review
Non-motor substrates\textsuperscript{1,2,3}
- Frontal cortex
- Anterior cingulate
- Hippocampus
- Visual cortex
- Association areas

Role in ageing and disease

\textsuperscript{1} Holtzer et al., 2014; \textsuperscript{2} Annweiler et al., 2012; \textsuperscript{3} Hamacher et al., 2015

Domains of cognitive function

Axons carry cognitive domains:
1. Pictur memory - ability to learn and recall new information
2. Language - oral comprehension or expression
3. Visuospatial function - ability to orient and get to desired location
4. Executive function - ability to plan, perform simultaneous tasks, ignore or suppress irrelevant stimuli

CNS involvement in mobility in aging

1. Role of CNS in gait/mobility in subclinical disease
2. Neuropathological mechanisms of gait impairment
3. Temporal course
4. Non-linear effect - Role of underlying resilience/reserve

(Resco et al., 2013)
Gait
- a cognitive task?
- a measure of cognition & falls?
- rehabilitation should address cognitive impairment?

Cognitive function contributes to gait & understanding of mechanisms of gait impairment
Conversely gait characteristics tell us about cognition
Gait changes with age

Is slow gait speed an inevitable consequence of ageing?

- Mental imagery of locomotion and stance
- 60 adults
- 24-78 years
- Functional activation of basic locomotor network preserved in ageing (Prefrontal cortex, basal ganglia, brain stem cerebellar locomotor centre)
- Increased multisensory activation (vestibular, visual, somatosensory)
- Multisensory cortical control of gait increases with age
- Increased conscious gait and postural strategy

Jahn et al., 2010
↑ HbO2 levels – WWT

↑ HbO2 levels – Young all walking conditions

↑ HbO2 levels – Young > WWT

11 young and 11 older adults
Walking and walking while talking

• OA utilise PFC less during attentionally demanding locomotor tasks
• Cognitive control less efficient

Methods to detect
• Association
• Dual-task protocols

Manuscript of cognition in gait

Manifestation
Continuous gait disturbance (single and dual-task)
Episodic – FOG

Association

Robust association older adults, MCI & PD
Executive function and attention are associated with gait speed and variability

Amboni et al., 2013; Al Yahya et al., 2012; Buchner et al., 2006; Lord et al., 2003; Lord et al., 2011; Amboni et al., 2016
ICICLE-GAIT

Lord et al., 2012; Lord et al., 2013

Gait model

Lord et al., 2012; Lord et al., 2013

- Independent domains
- Validated in PD
- Domains robust

Gait model and associated neuroanatomical areas.
Gait and cognition in PD: Does testing during free-living change the relationship?

- Relationship with spatial memory – navigation
- Variability more evident – environmental impact
- More sensitive predictors of cognitive decline/dementia?

Lord et al., 2014; Rosie Morris, PhD student

A window into brain?

Deep and Frequent Phenotyping: Combinatorial Biomarkers for dementia experimental medicine
Manifestation of cognition in gait

- Manifestation
  - Continuous gait disturbance (single and dual-task)
  - Episodic – FOG

- Methods to detect
  - Association
  - Dual-task protocols

Dual-task Protocols

- Demonstrate in real-time
  - Attention/working memory as a compensatory feature
  - Ability to prioritize task (EF)
- Limits of compensation
- Present in all age groups and pathology
- Dual-task interference
  - ↓Speed, ↑Variability
Falls – attention and executive function

Mirelman et al., 2012

Fluctuating attention is associated with increased fall frequency

Allcock et al., 2009

Dual tasks predict falls

Beauchet et al. (2009)

Cognition and falls in PD
Cognition & Gait

- Association between severity of age-related WM & severity of gait/motor changes
- Not specific to mobility limitations
- Information processing & executive function
- Accumulation of abnormalities in CNS networks could lead to mobility decline

Structural abnormalities contributing to mobility decline (Annweiler & Montero-Odasso, 2012)

- Periventricular (mainly frontal horns)
- Corona radiata (anterior, superior, posterior)
- Corpus Callosum ( genu, truncus, splenium)
- Internal Capsule (anterior and posterior)

Location of WMH associated with reduced gait speed
• Gait & cognitive deficits related to integrity of fibers in genu
• Importance of prefrontal hemispheric communication for lower extremity control in neurological patients with cog dysfunction

Cholinergic disturbance contributes to early gait impairment in PD
Attentional mechanism

Rochester et al., 2012
Stark et al., 2013

Muller et al., 2013

Cognition

& Gait

Intervention

Cognition & Gait

Intervention

Integrated assessment

Integrated Intervention

Cognitive Impairment

Dementia

Gait impairments

Falls/immobility
• Exercise (aerobic and strength training) reduces risk factors and improves resilience
• Cognitive training may improve cognitive + motor function
• Pharmacological therapies also may improve cognitive function (cholinergic) and motor function

Task orientated therapy may particularly benefit OA with WMH in brain tracts that influence gait and cognition

Complex cognitive-motor training
• Not a direct or linear relationship between neuropathology and functional deficit
• Related to underlying resilience (reserve)
3 propositions

- A cognitive task
- A measure of cognition & falls
- Rehabilitation should address cognitive impairment

✓ Behavioural & mechanistic
✓ Emerging behavioural evidence
✓ Emerging area of research

Summary

Cognition & Gait

Brain & Behaviour

Mechanisms

Intervention

- Robust behavioural relationship
- Consider implications for assessment and intervention
- Evidence of multiple neurodegenerative change
- Multiple risk factors
- Target risk factors identified through pathology
- Combination of pharmacological and non-pharmacological
- Physical and cognitive training in isolation and combination

Clinical messages

Gait is a cognitive task
- Assess cognitive performance and compensation during gait – using dual task testing

Include cognitive training
- Cues or attentional strategies
- Component practice + whole practice + dual/multi-practice
- Complex cognitive – motor training

Extended role for physiotherapy
- Enhancing diagnosis
- Outcome measures
- Rehabilitation – a contemporary approach
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