Methods for Gait Assessment in the Elderly

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History of Gait Assessment

The Forgotten Thesis of Gilles de la Tourette

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Levels of Assessment

- Self-reported
  - Activity
    - Including exercise
  - Mobility
    - Change in gait and balance
      - Falls
- Clinical assessment
- Quantitative gait assessment
  - Spatio-temporal
    - Timed and measured
      - Distance and duration
      - Single/Dual task
    - Gait lab, foot switches, instrumented walkways, accelerometers
- Activity monitoring
- Home monitoring
- Community monitoring
  - Life space

Self-reported Mobility

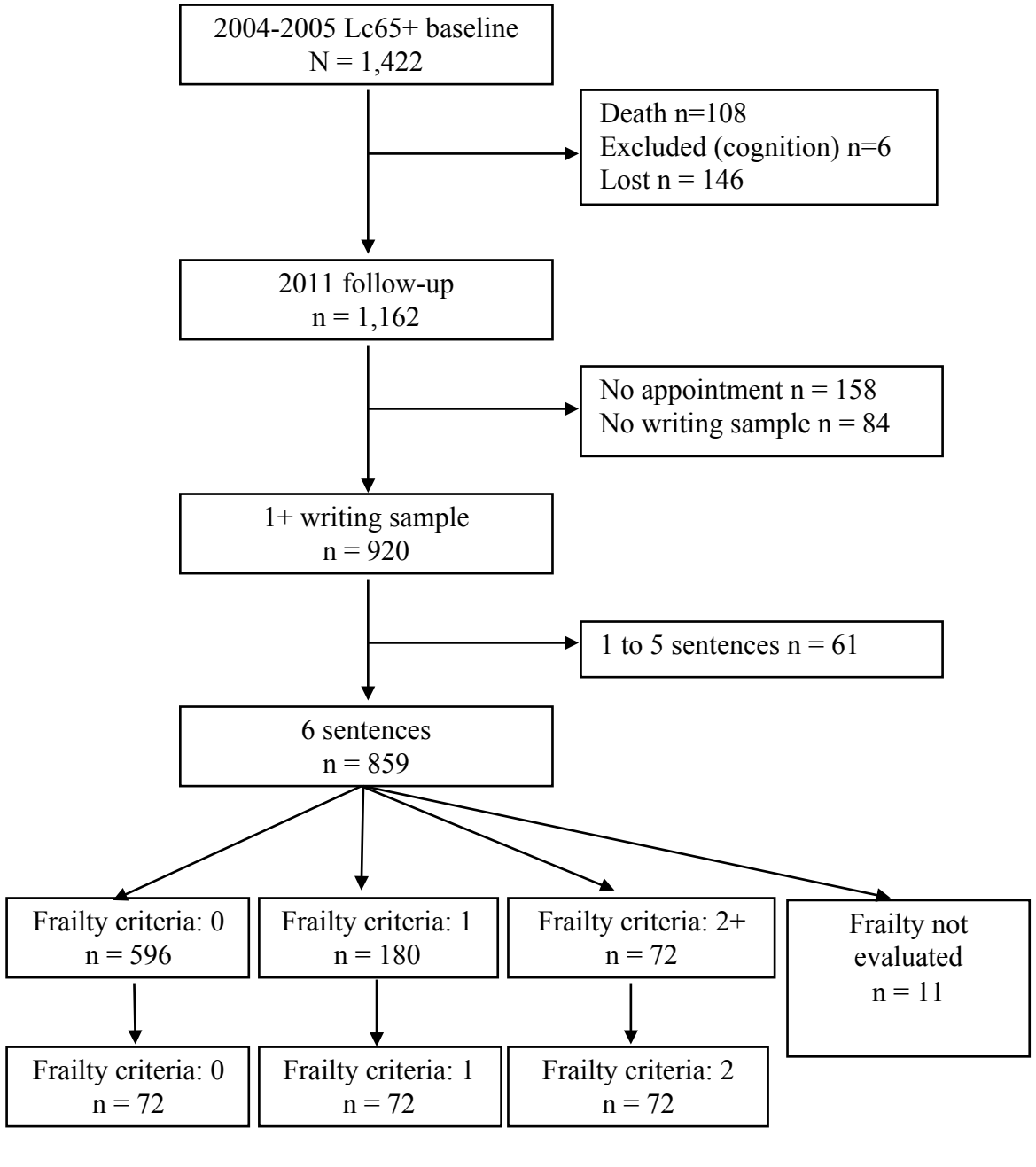
- Activities and mobility questionnaires
  - Accuracy and relation to objective measures?
  - Subject to recall bias
    - Concern in people with cognitive impairment
      - Same applies to recall of falls
  - Self-perceived activity/mobility is important
    - Related to confidence in mobility
      - Fear of Falling
    - Could this be used a “screening” question (s), like MCI
- Component of frailty
  - Weight loss, weakness, walking change, fatigue, inactivity

Criteria for Frailty

- Weight loss
  - Report of weight loss in the previous year
- Weakness
  - Linda Fried criteria
  - Lowest 20%ile of cohort based on gender and BMI specific cutoff
- Decreased energy
  - Answering much to the following
    - Did you have feelings of generalized weakness, weariness, lack of energy in the last four weeks?
- Slowness (walking)
  - Fried cutoff
  - Lowest 20%ile of cohort based on gender and height
- Decreased physical activity
  - self-report of doing <20 minutes of sports per week, walking <90 minutes per week and avoidance of climbing stairs or carrying light loads in daily activities.

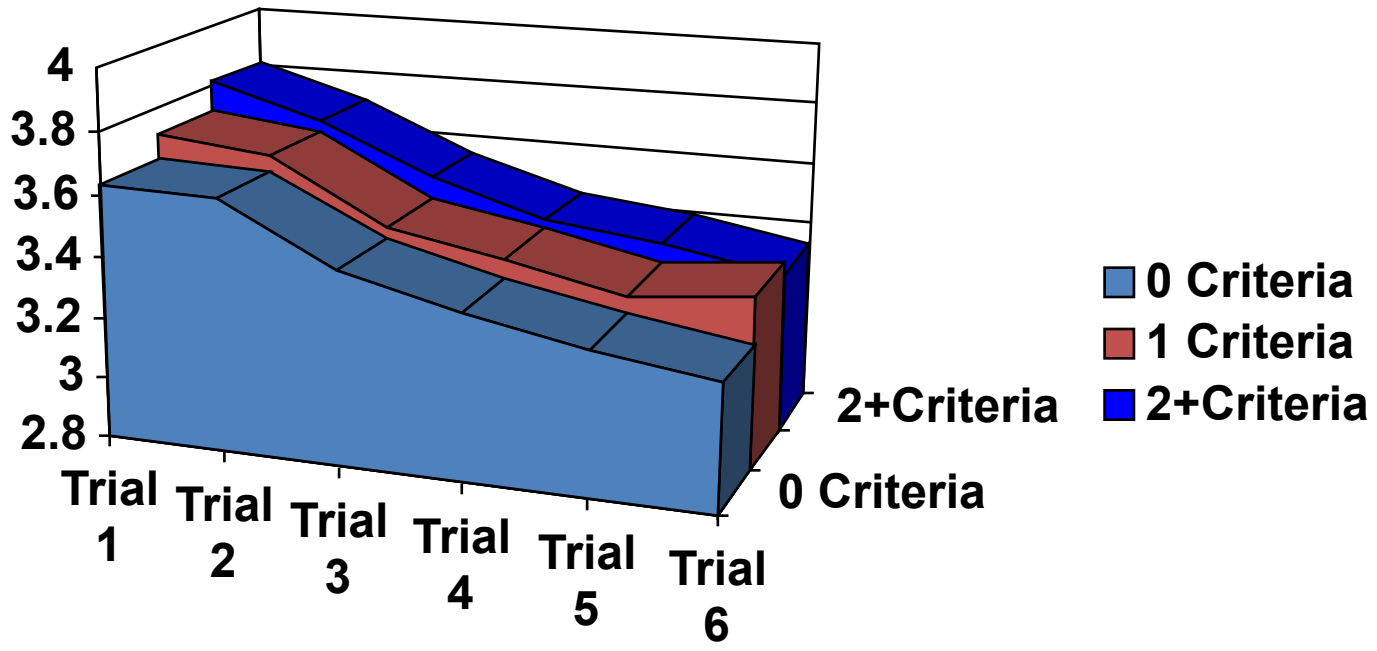
Danon-Hersch N JAGS 2012

Figure: Selection of the study sample from the Lausanne cohort 65+ (Lc65+)

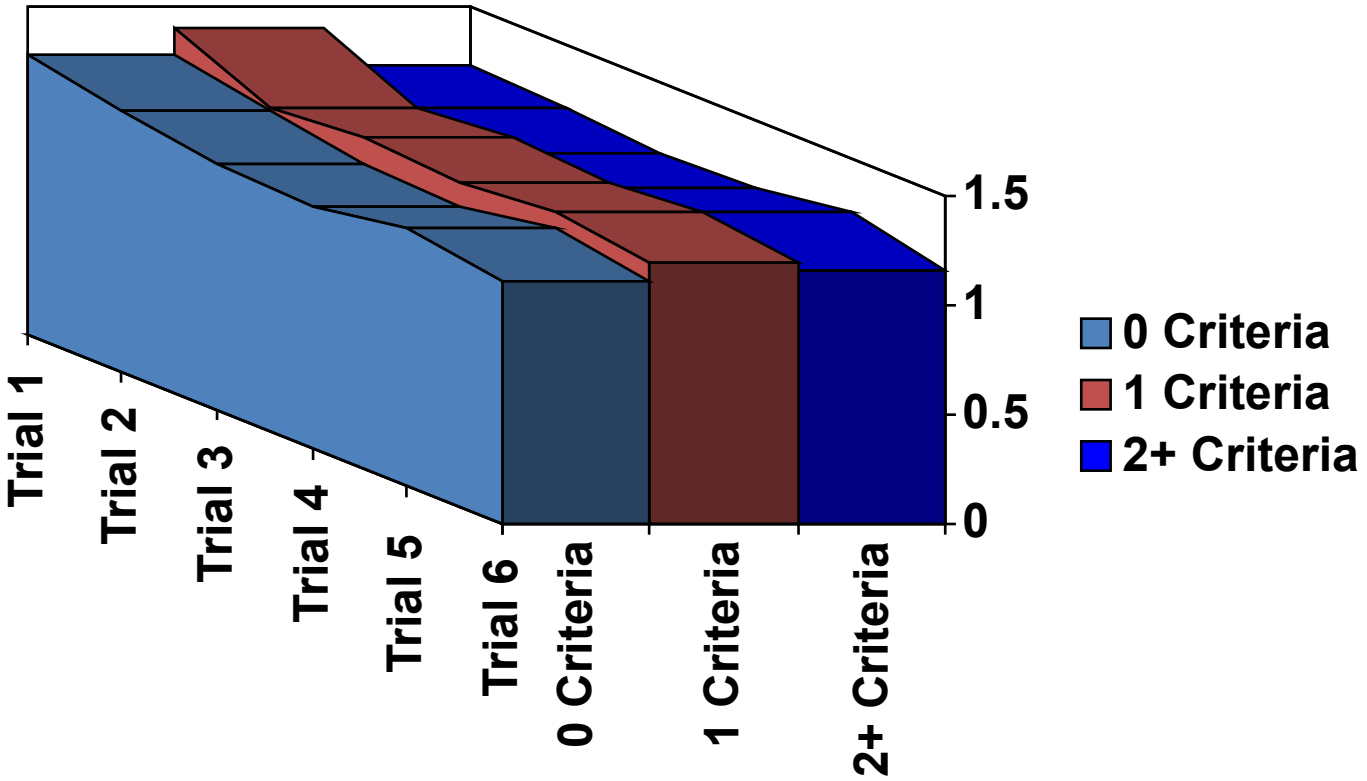


Handwriting Quantitation

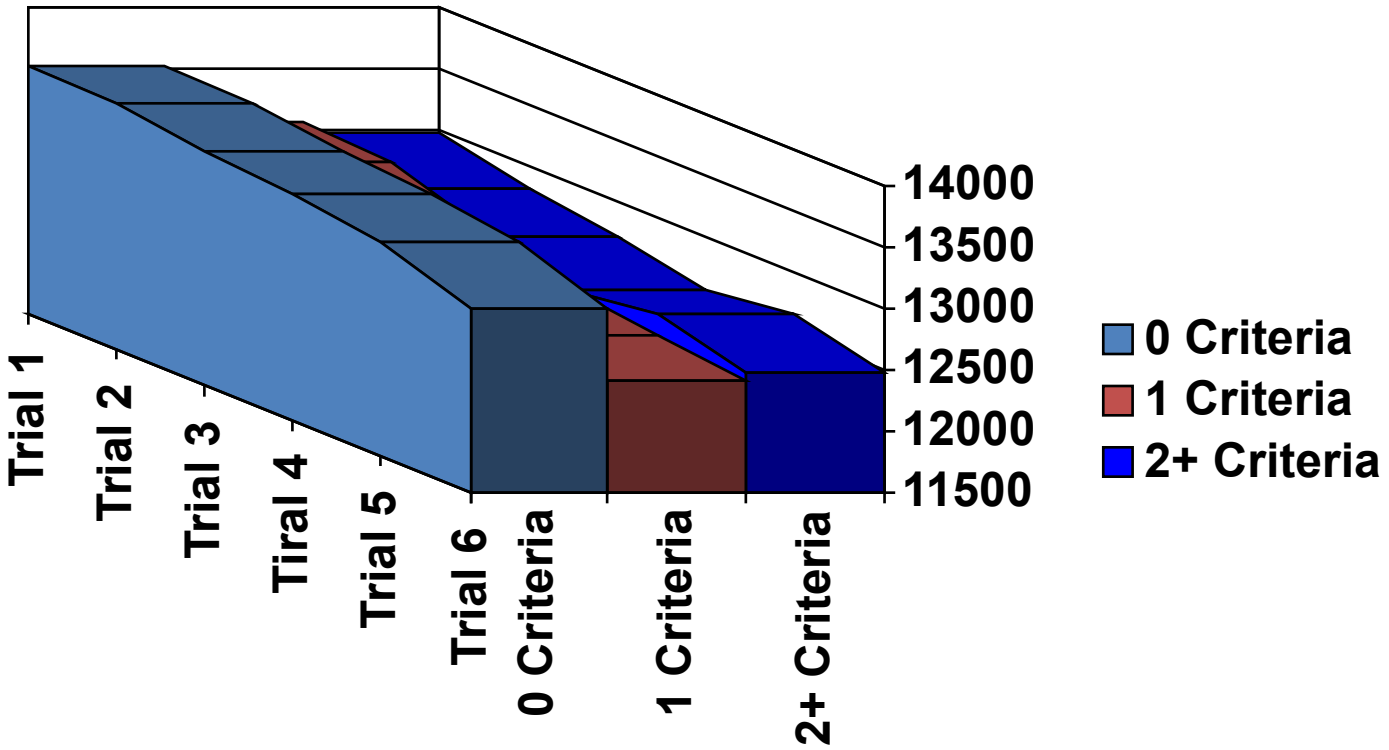
Writing Speed: On Paper (cm/sec)



Pauses (seconds)



Pressure (Unitless)



Inter-correlation between Measures

- Handwriting
  - Quantitative handwriting samples from Lausanne 65+ cohort (Arch Gerontol Geriatr, In press)
    - No relation between handwriting parameters (speed, pauses, pressure) and pre-frailty
    - No relation between handwriting speed and gait speed
    - Cognitive impairment (low MMSE or Trail Making, Part B)
      - No significant relationship with speed and pressure
      - Significant relationship with pauses while writing
        - » Consistent with literature on mild cognitive impairment and dementia (Rosenblum S, 2010, 2006; Schroter A, 2003)

Clinical Assessment of Gait

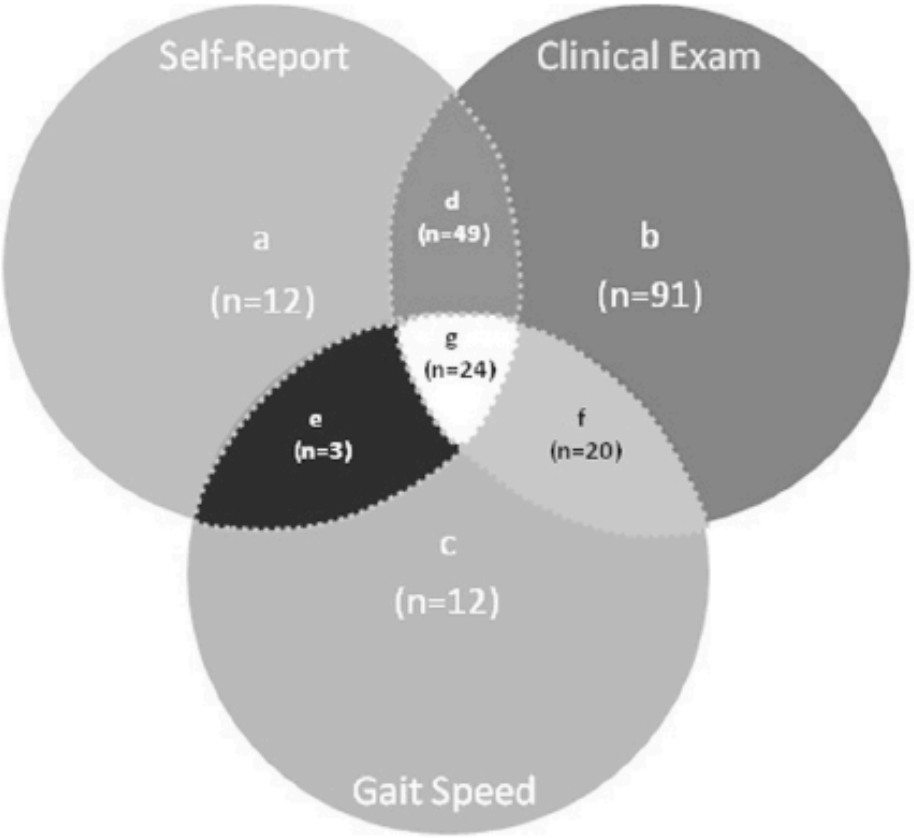
- Lower level
  - Antalgic (arthritis)
  - Myopathic
  - Neuropathic
- Middle level
  - Hemiplegic
  - Paraplegic
  - Parkinsonian
  - Ataxic
- Higher level
  - Frontal
  - Cautious
  - Psychogenic

Nutt J 1993; Snijders AH 2007

Clinical Assessment: Reliability

- Clinical classification (Verghese J J Neurol 2010; JAGS 2006; NEJM 2002)
  - Neurological gait: ataxia/unsteady (35%), neuropathic (19%), hemi-paretic (13%), spastic (10%), frontal (8%), parkinsonian (8%), others rare (myopathic, cautious, slow)
    - Non-neurological: arthritis, cardio-pulmonary
    - Test-retest reliability kappa = 0.6 (75% agreement)
    - Inter-rater reliability kappa = 0.8 (89% agreement)
    - Predictor of falls overall 1.49X (1.11-2.0)
    - Any gait impairment was a predictor of institutionalization and death 2.2X (1.5-3.2)
- Protocols
  - Tinetti Performance-Oriented Mobility Assessment (Cipirany-Dacko LM Arch PMR 1997)
    - Compared to quantitative tests (Panzer VP Arch PMR 2011)
  - Rating-scale for Gait Evaluation in Cognitive Deterioration (Martinez-Martin P JAlzD 2012)

Self-report Gait Change vs Other Methods



Healthy Older Adults (n=169)

Allali G Arch Gerontol Geriatr 2015

Spatiotemporal Gait Measures

- Speed
- Time
- Stride length
  - Variability
- Gait modulation and automaticity
  - Self-selected speed
    - Slow/Fast walking
  - Impact of/on dual task
- 3-D gait assessments: Kinematics and Kinetics

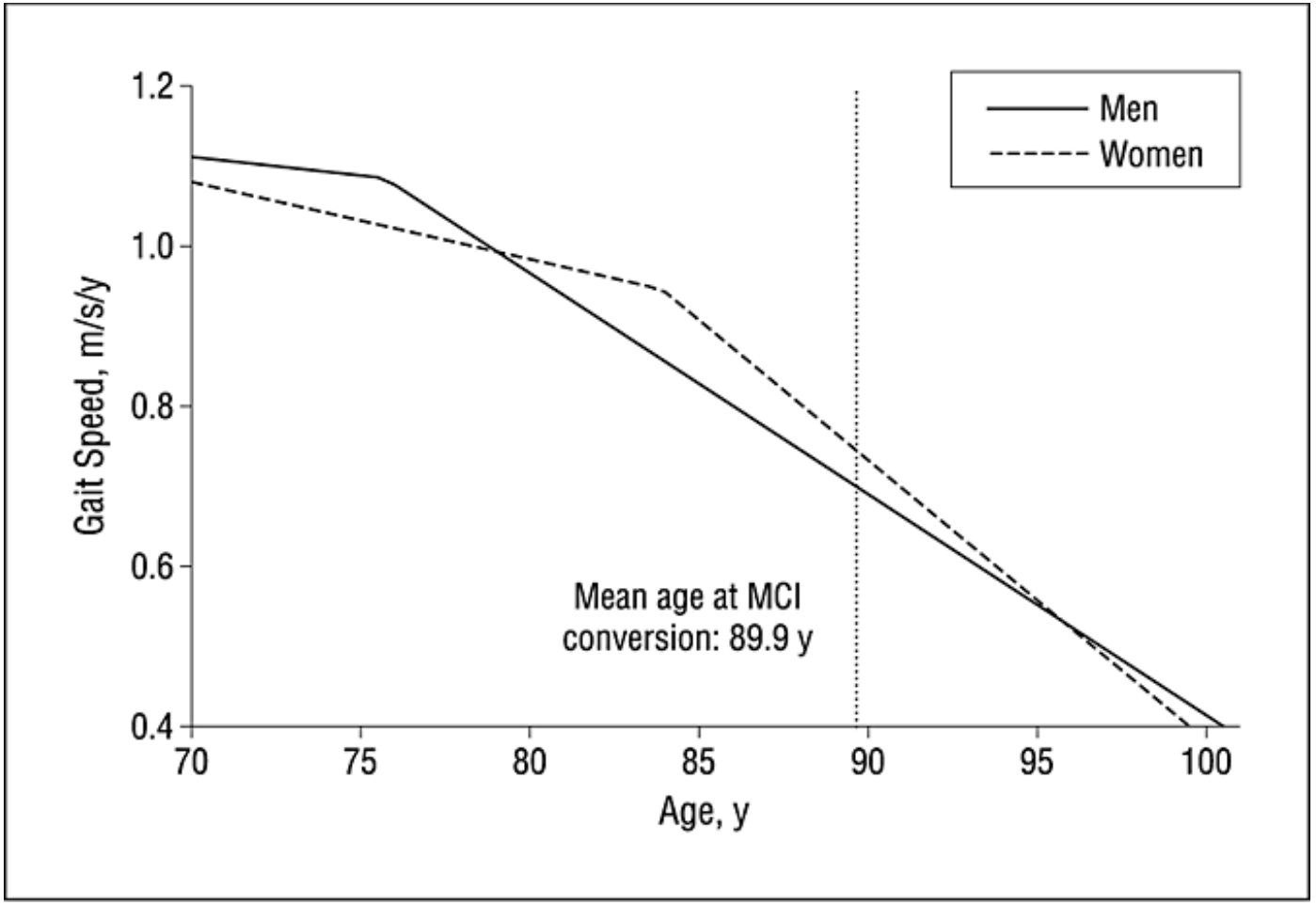
Timed Up and Go

- Time to get up from chair, walk 3 meters, turn, and go back to chair and sit down
- Pros: A fairly simple measure; easy to implement in clinic, predictive in some settings
- Cons: Crude, involves multiple separable aspects of mobility (balance, strength, etc), ignores stride length, variability, not clearly predictive of cognitive decline
- Modifications: for example, dual task may be enhance predictive abilities, could be instrumented (Mirelman A JAGS 2014)

Timed and Measured Walk

- Also simple to do with a stop watch
  - Can then have time and infer step-length (number)
  - Without an accelerometer or instrumented walk way lose variability measure
- How far?
  - 3, 5, 10, or more meters
    - Include turn? 5 meters out and back?
  - Walk for time 2 minutes, 6 minutes
- What instructions
  - Self-selected or fast?

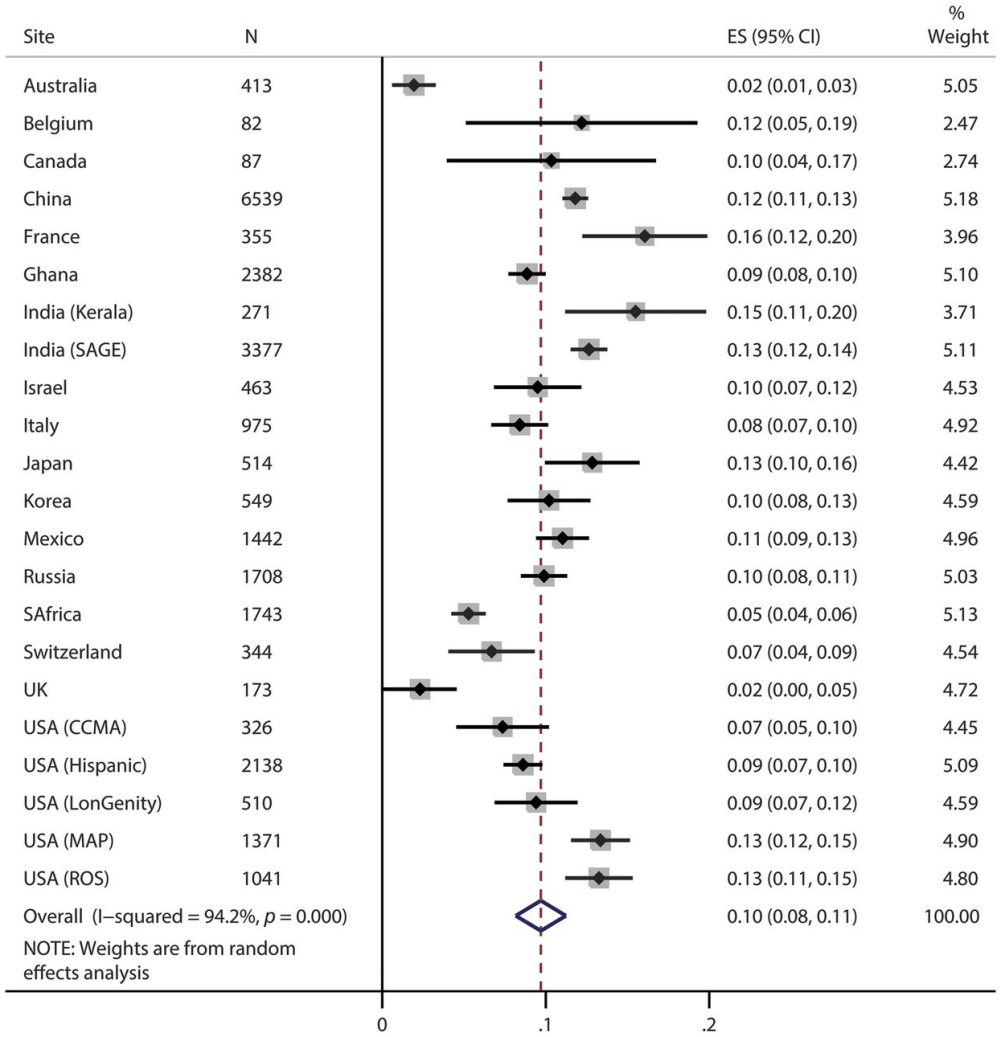
Change point example for gait speed in mild cognitive impairment (MCI) converters in relation to the mean age at conversion in men and women



Buracchio, T. et al. Arch Neurol 2010;67:980-986.

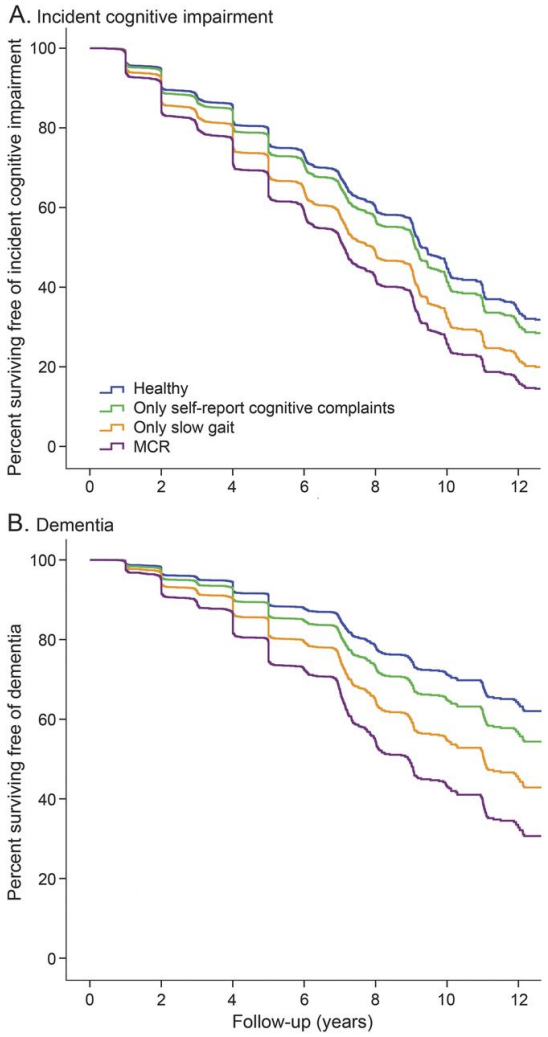
ARCHIVES OF NEUROLOGY

Figure 1 Prevalence of motoric cognitive risk syndromePrevalence estimates (ES) for each study are graphically represented by small diamonds and 95% CIs by horizontal bars.



Joe Verghese et al. Neurology 2014;83:718-726

Figure 2 MCR and risk of incident cognitive impairment (A) and dementia (B)Kaplan-Meier survival curves with 95% confidence interval over 12 years' follow-up in pooled samples.



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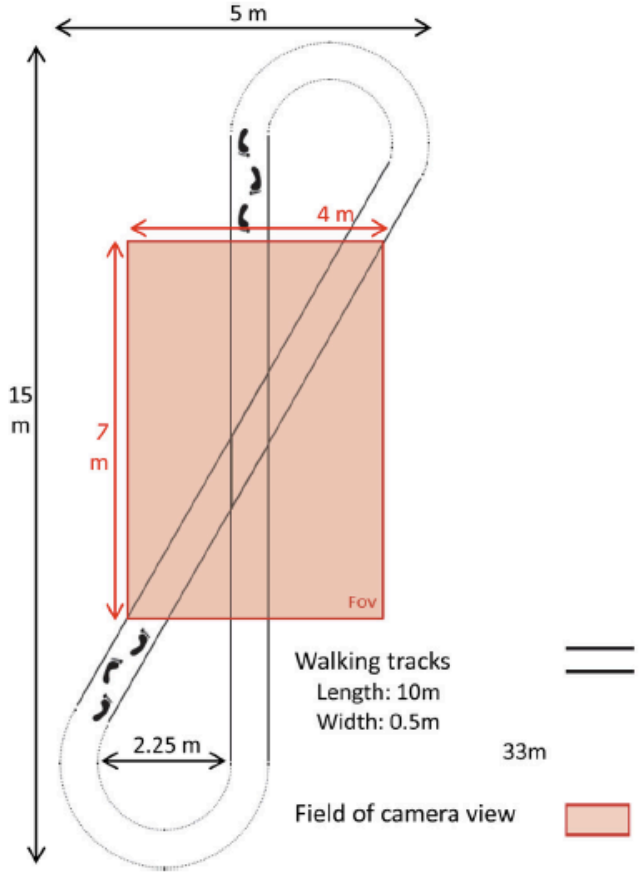
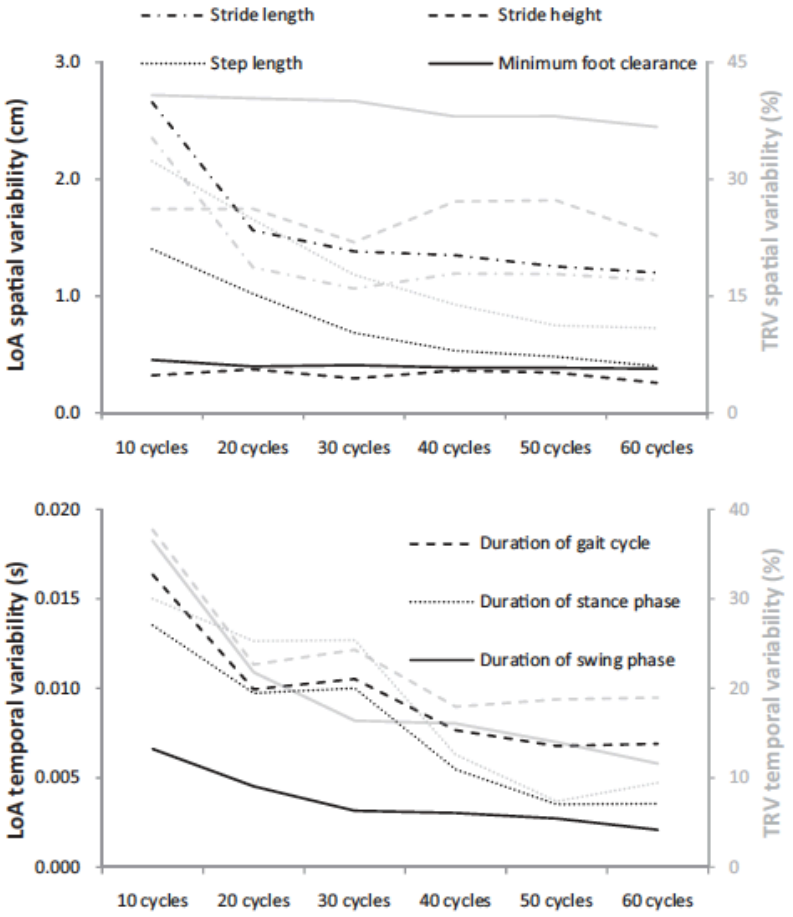
Variability





Konig N Gait Posture 2014

Journal of the International Neuropsychological Society (2012), **18**, 764–772.

doi:10.1017/S1355617712000422

Neurocognitive Speed and Inconsistency in Parkinson's Disease with and without Incipient Dementia: An 18-Month Prospective Cohort Study

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(RECEIVED May 23, 2011; FINAL REVISION March 1, 2012; ACCEPTED March 5, 2012)

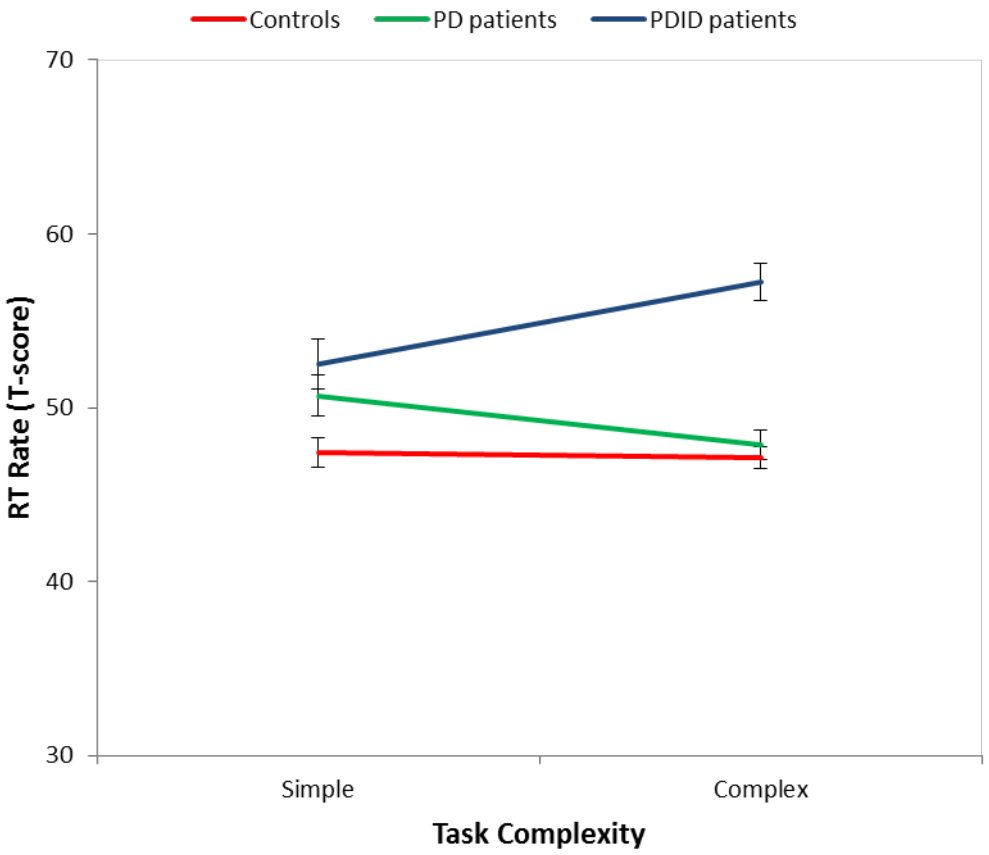

Controls
PD patients
PDID patients
70
60
50
40
30
RT Rate (T-score)
Simple
Complex
Task Complexity

Figure 2.

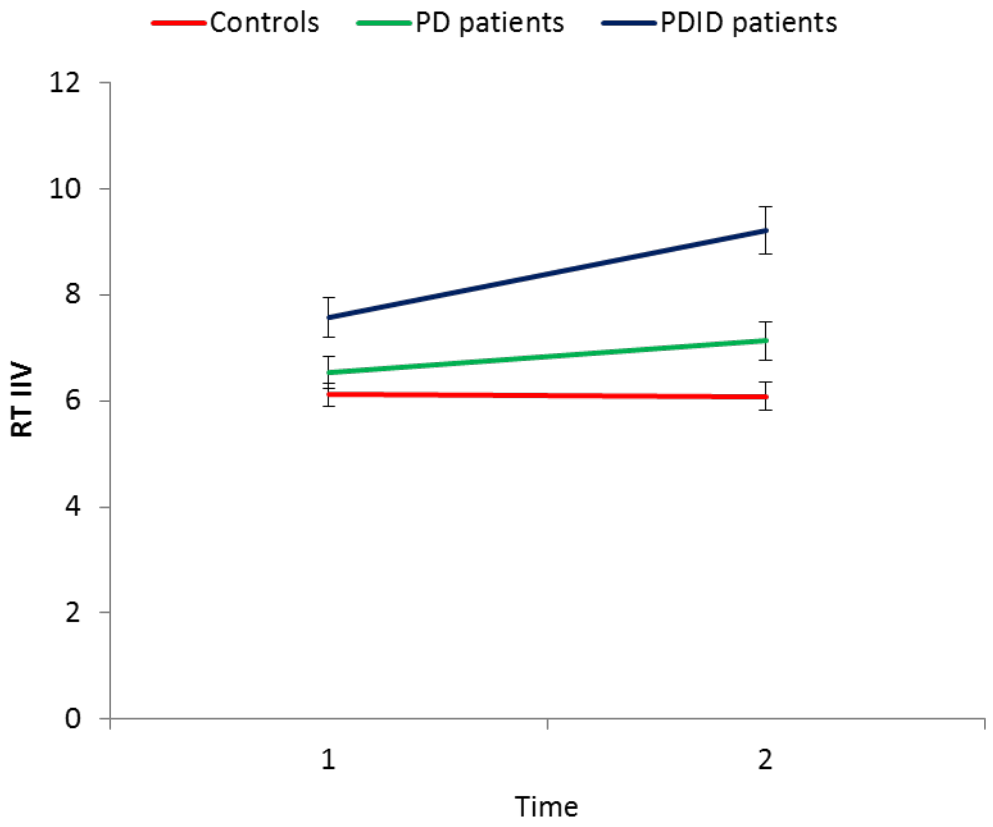

Controls
PD patients
PDID patients
12
10
8
6
4
2
0
RT IIV
1
2
Time

Figure 3.

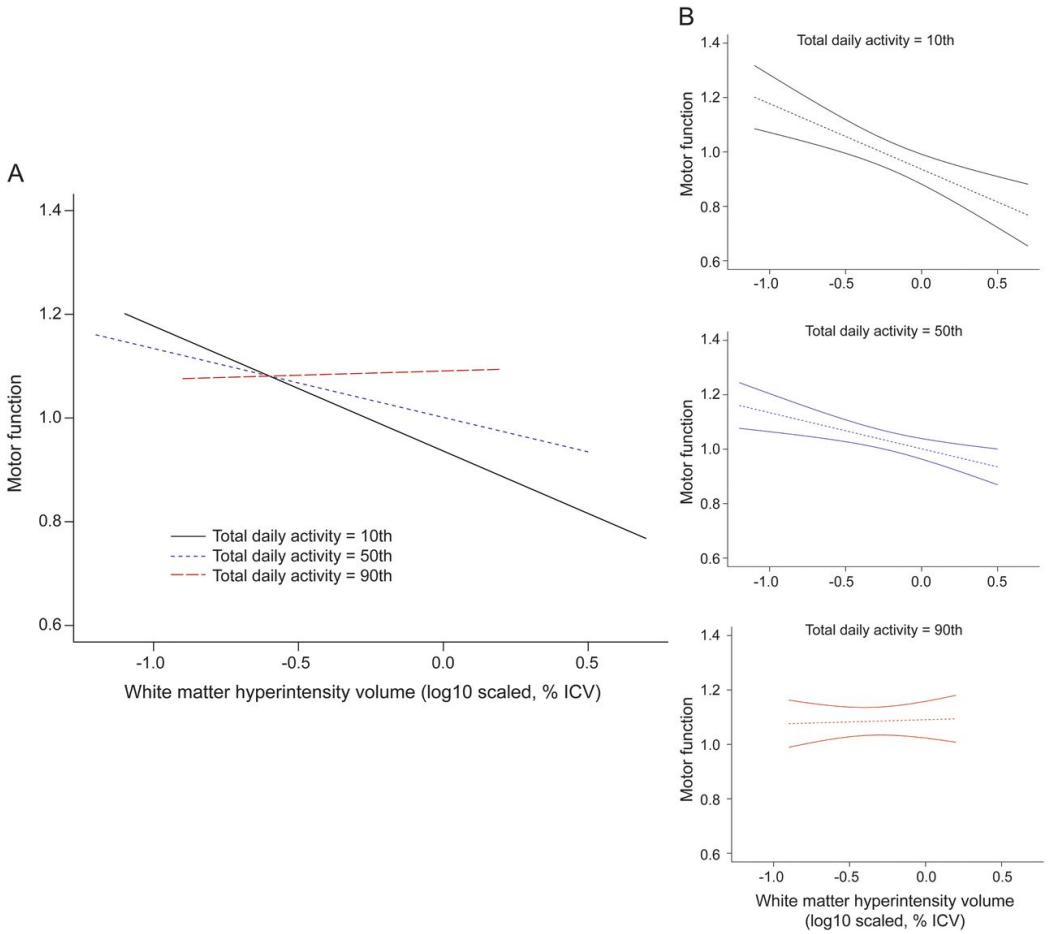
Dual Tasks

- Gait and Cognition “stress test”
- Need to consider both tasks (gait and cognitive task performance)
- Multiple versions
- Not clear that decrements in dual task performance adds to simple task
  - Likely depends on outcome, population and specifics of tasks

Actigraphy

- Advancing technology is allowing easier use and lower cost
- Can be used to measure time and stride length variables
- Since this approach isn't restricted to a narrow length limited walk way variability can be better measured

Figure Total daily activity modifies the association of WMH burden to motor functionThe x-axis is the log10 scaled volume of WMH, corrected for ICV, and the y-axis is the motor function based on 11 motor performance tests that were scaled and averaged to obtain a summary measure.



Debra A. Fleischman et al. Neurology 2015;84:1294-1300

EDITORIAL

Physical activity, white matter hyperintensities, and motor function

Bringing out the reserves

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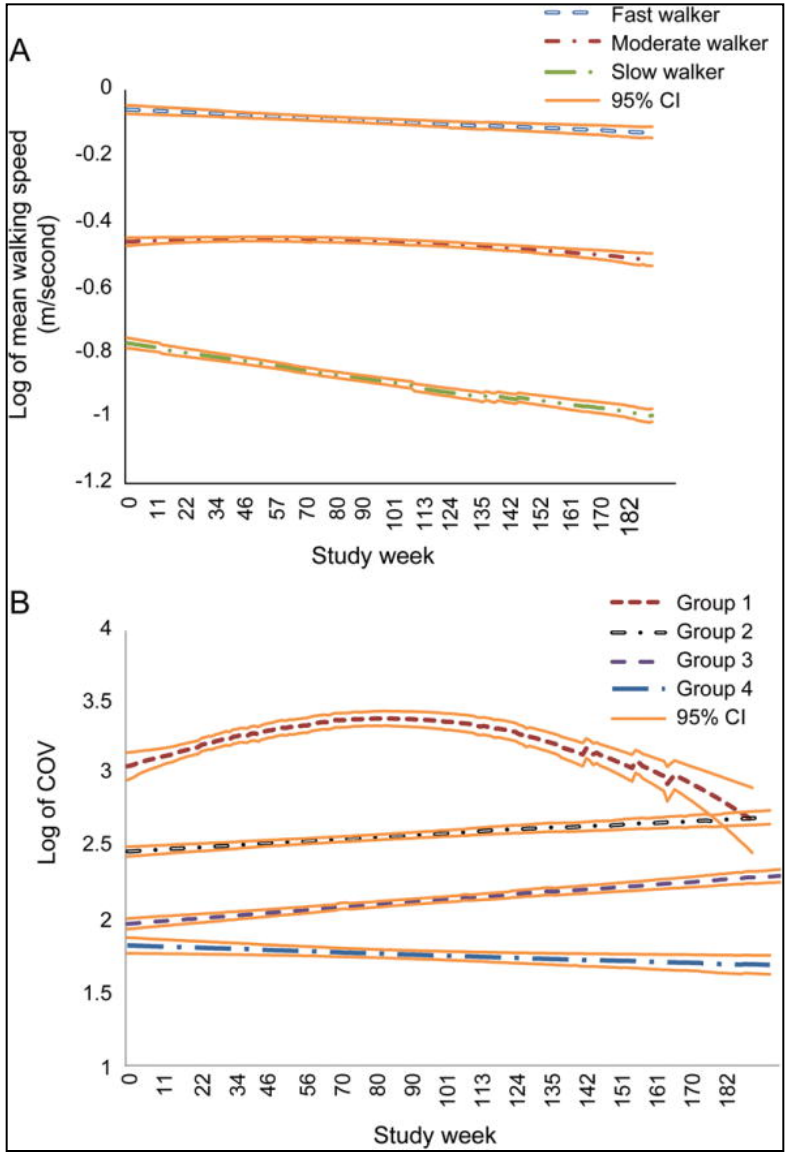
Fleischman et al.[1] provide data that they interpret to suggest that daily physical activity may provide a reserve against the deleterious effects of white matter hyperintensities (WMH) on motor function. Numerous previous studies demonstrated that a range of motor functions, particularly walking speed, are correlated with the presence of white matter disease, as the authors acknowledge cannot be used to determine causality. The authors do not perform a formal mediation analysis, which might be considered a more robust approach to analyzing the data and inferring potential causality. Moreover, since actigraph measures provide total activity, it is difficult to know which aspects of the activities were protective; the nature (aerobic or

Life Space

- Questionnaires exist to gage community activity
- Activity monitoring gives idea of motion
- But…doesn't say where activity is occuring
- Devices we have (watches, cell phones, or purpose built devices) can monitor such activities
- In home monitoring may be more sensitive indictor of cognitive decine

In-home Monitoring



In-home walking speeds and variability trajectories associated with mild cognitive impairment.
Dodge, HH; Mattek, NC; Austin, D; Hayes, TL; Kaye, JA

Neurology. 78(24):1946-1952, June 12, 2012.
DOI: 10.1212/WNL.0b013e318259e1de

Trajectories of in-home walking speed and variability based on latent trajectory analysesFigure 1. (A) Trajectories of mean weekly walking speed. (B) Trajectories of coefficient of variation (COV) of weekly walking speed. CI = confidence interval.

So What to Choose

- Depends on question
  - Outcome of interest
- Depends on population
- Depends on feasibility
- Depends on budget
- A work in progress