Aging, Mobility and the Health Care Team

June 2018
Maine Geriatrics Society
Stephanie Studenski MD MPH

Agenda

• Why is mobility important for clinicians?
• Aging and speed of movement
• Gait Speed: Clinical applications
• Assessment and management
• New developments

Mobility

• Mobility is fundamental to virtually all animal species and is intimately linked to health, function and survival

• Despite extensive evidence, mobility status is not yet routinely incorporated into clinical care
Active Life Expectancy
The ability to get around is key to functional independence a goal of aging research and care is "More good time"

<table>
<thead>
<tr>
<th></th>
<th>Active</th>
<th>Impaired</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>6.4</td>
<td>5.2</td>
</tr>
<tr>
<td>Women</td>
<td>18.6</td>
<td>14.4</td>
</tr>
</tbody>
</table>

Population Impact
The ability to think and to move are essential for independent living. Loss of either or both lead to disability and dependence. Disorders of cognition and movement are common and often coexist in older people

Cognitive Impairment
- Prevalence age 75: 5% M and F
- Prevalence age 85: 12% M 20% F
- Major contributor to disability, need for caregiver, long term care

Mobility Impairment
- Prevalence age 75: 20% M 30% F
- Prevalence age 85: 40% M 60% F
- Major contributor to disability, need for caregiver, long term care

Guralnik and Ferrucci Epidemiology of Aging in Hazard text 6th Ed

An Unrecognized Clinical Reality

An 86 year old man is brought to clinic by his son for a several year history of decline. He has withdrawn from life and spends all his time sitting in a chair dozing. He has had several recent falls.
PMH diabetes on oral agent, HBP Meds HCTZ, glipizide
Exam shows deficits in cognition specifically construction, sequencing, recall and language. He has a slow shuffling gait and increased tone. He is apathetic and he states that life is not worth living.
He is diagnosed with dementia and depression and given a cane.

Brain-related gait abnormalities in older people are often ignored or attributed to "normal aging". "Senile gait"
If you saw this person clinically, what would you think about her gait?

Aging doesn’t have to mean slow walking

Movement slows with age
Speed of movement declines with age in all species. Among similar aged animals, slower die sooner. Even among genetically identical, same age organisms in a supportive environment, slower die sooner.

Huang et al. PNAS 2007
Carter et al. JGMS 2002

Speed of Movement and Survival

Why does mobility slow with aging?

- Movement requires integration of multiple systems: energy sources, timing/coordinating, force production
- Optimal movement speed requires all systems to be operating together efficiently
- Aging increases the likelihood of damage and degeneration of systems
- **Movement is a sensitive final common pathway that reflects damage and loss of integration across systems**
- Slow movement is sensitive to system deficits but not specific to causes

Walking is Fundamental
**How to Measure Gait Speed?**

**Distance**
Standing start vs constant velocity

**Instructions**

For clinical use, consider 4 meter standing start, usual pace, recorded to the closest 0.1 sec

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**What do the numbers mean?**

Gait velocity reflects function and fitness

<table>
<thead>
<tr>
<th>Walking speed (m/s)</th>
<th>METS</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.67</td>
<td>1.5</td>
<td>&lt; 2 self care</td>
</tr>
<tr>
<td>0.89</td>
<td>2.0</td>
<td>2.5 household activities</td>
</tr>
<tr>
<td>1.11</td>
<td>2.5</td>
<td>3.0 Carry groceries, light yard work</td>
</tr>
<tr>
<td>1.33</td>
<td>3.0</td>
<td>3.5 Climb several flights of stairs</td>
</tr>
</tbody>
</table>

*People who walk > 1.0 m/s are rarely dependent in self care: likely to be healthy.*

*People who walk < 0.6 m/s are virtually never independent in all functions: they have disability.*
What do the numbers mean?

Gait Speed and Survival: Consortium analysis of over 34,000 older adults followed for up to 21 years

CHS EPESE Health ABC HEPESE In Chianti MrOS NHANES PEP SOF

| Year | 16 | 21 | 10 | 12 | 8 | 8 | 12 | 12 | 21 |

JAMA Jan 5, 2011

Gait Speed and Survival: Forest Plot and Pooled Survival Nomograms

Median survival for age and gender at about 0.8 m/sec

JAMA Jan 5, 2011

Median survival for age and gender at about 0.8 m/sec

JAMA Jan 5, 2011

ROC Curve analysis accuracy comparable to more complex models that include common diseases and function

Diseases: heart, diabetes, cancer, arthritis

JAMA Jan 5, 2011
What is the potential role of slowed mobility in clinical care and research?

- Predictor of health, function, survival and utilization
- Marker of disease severity
- Summary indicator of co-morbid burden of illness
- Detect change
- Presenting problem for diagnosis and management
- Framework for inquiry into novel problems of aging

Physical Performance Measures in the Clinical Setting

Outpatient clinics in Kansas City Missouri
n=487
gait speed predicts probability of one year hospitalization
decline in function
decline in self-reported health

Gait Speed in Hospitalized Older People

Inability to walk or slow walking on hospital admission predicts increased LOS and decreased probability of discharge to home. These effects are independent of functional status.

Ostir et al Arch Int Med 2012
Gait Speed and risk of cardiac surgery

J Am Coll Cardiol. 2010 Nov 9;56(20):1668-76.

Surgical risk score with > 30 factors

5 meter walking speed dichotomized at 6 sec about 0.83 m/sec

PostOP Morbidity= stroke, renal failure, prolonged ventilation, deep infections or need for reoperation

Gait speed alone did as well as 30+ factor risk score
Both together were better than either alone

JAMA cardiology 2016

Over 15,000 heart surgery patients
30 day mortality
Post-op morbidity and mortality during the index hospitalization

602 patients undergoing elective ambulatory surgery
Outcomes: ready for home discharge within 90 minutes after surgery and admission
**COPD**

Gait speed and readmission following hospitalization for acute exacerbations of COPD: a prospective study

Somato S. C. W.,*1,2 Saez F. E.,*1 Saez F. J.,*1 Schuberg J. W.,*1 Wander B. J.,*1
Mendy J. D.,*1,2 and C. A. R. N. C.*1

Thorax (online August 2015)

The 90 day hospital admission rate was 11.5% in those walking > 0.8 m/sec vs 48.5% in those walking < 0.4 m/sec.

Gait speed remained an independent predictor after accounting for demographics, comorbidities, prior hospitalization and FEV1.

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**Gait Speed and Hemodialysis**

One and two year mortality lowest in faster walkers

Hospitalization and disability lowest in faster walkers

Am J Kidney Disease 2015

> 750 hemodialysis patients from the US Renal Data System.

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**Do we need the long walks?**

Determinants of Gait Speed in COPD

2014

Gait speed < 0.9 predicts 6MWT < 350 meters

<0.8 predicts 6MWT < 200 meters
The meaning of change

<table>
<thead>
<tr>
<th>Magnitude of change</th>
<th>Clinical</th>
<th>SEM</th>
<th>Anchor-Based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gait Speed (m/sec)</td>
<td>small</td>
<td>0.04-0.06</td>
<td>0.05-0.06</td>
</tr>
<tr>
<td></td>
<td>substantial</td>
<td>0.06-0.17</td>
<td>0.08-0.10</td>
</tr>
<tr>
<td>SPPB score points</td>
<td>small</td>
<td>0.54</td>
<td>1.27-1.61</td>
</tr>
<tr>
<td></td>
<td>substantial</td>
<td>1.04-1.41</td>
<td>1.42-1.78</td>
</tr>
</tbody>
</table>

Meaningful improvement

% died over 5 years

Mobility measures in routine primary care

- 14 Primary care offices: space available, staff can perform during routine care
- Gait speed measure takes < 2 minutes during intake as part of “vital signs”.
- Reliability comparable to slightly worse than BP coefficient of variation
  
  interobserver  |  test-retest
  4.5% gait      |  3.0% DBP  
  15% gait, 10% DBP

AHRQ R03 Woolley
507 T+ in 14 primary care offices in Kansas

does not equal better than BP

Diagnosis of dismobility for gait speed < 0.6

A Diagnosis of Dismobility—Giving Mobility
Clinical Visibility
A Mobility Working Group Recommendation

Cummings Studenski Ferrucci JAMA 2014

Increase clinical awareness
Begin to allow for coding in inpatient and outpatient records
Allow for evaluation of utility in care planning
Evaluate intervention effects
Differential Diagnosis of Abnormal Walking Speed

Three main systems:
• Cardiopulmonary
• Neurologic
• Musculoskeletal

Symptoms

<table>
<thead>
<tr>
<th>System</th>
<th>Symptoms limiting walking</th>
</tr>
</thead>
<tbody>
<tr>
<td>cardiopulmonary</td>
<td>Dyspnea, fatigue</td>
</tr>
<tr>
<td>neurological</td>
<td>Unsteady, hesitant</td>
</tr>
<tr>
<td>musculoskeletal</td>
<td>Pain, stiffness</td>
</tr>
</tbody>
</table>

Many older adults have multiple contributing factors

key clinical findings

<table>
<thead>
<tr>
<th>System</th>
<th>Clinical Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiopulmonary: lung, heart, blood</td>
<td>FEV1, O2 sat with activity, Hg, EF, rate-pressure product?</td>
</tr>
<tr>
<td>Neurologic: frontal, primary motor, extrapyramidal, peripheral</td>
<td>tone, timed tapping, executive cognitive function, peripheral sensation</td>
</tr>
<tr>
<td>Musculoskeletal: Weight bearing structures, muscle</td>
<td>Knee, hip, low back range of motion, pain Manual muscle tests, chair rise</td>
</tr>
</tbody>
</table>

Many older adults have multiple contributing factors
Nursing

- Current and recent change in mobility function: bed mobility, transfers, walking, wheelchair mobility, stairs, community mobility
- Symptoms
- Assessment of bed mobility, transfers, walking, stairs
- Depends on setting: nursing home, home, hospital

Physical Therapy

- Current and recent history
- Strength, ROM, balance, endurance, coordination, cognition
- Specific gait abnormalities
- Use of aids

Pharmacist

- Current and recent change
- Review medication list for agents that affect attention (especially CNS active drugs), endurance, orthostasis, muscle problems (steroids, lipid lowering agents)
Interventions for slow gait speed

- Medical care: CHF, COPD, anemia, arthritis, pain, extrapyramidal conditions...
- Medication adjustments for side effects (dizzy, slow, stiff...)
- Vision services
- Exercise: rehab referral if very slow, community programs if mild
- Many novel interventions in development

Therapeutic exercise to improve gait efficiency

Jessie VanSwearingen, PhD, PT
Subashan Perera, PhD
Jennifer Brach, PhD PT
Reke Champ PhD
Caterina Rosano, MD, MPH
Stephanie Studenski, MD MPH

Departments of Physical Therapy, Division of Geriatric Medicine, Bioengineering, and Epidemiology, University of Pittsburgh; Pittsburgh Pepper Center NIA P30 AG024827.

Gait Efficiency and the Energy Cost of Walking
(Wert, VanSwearingen)

- Efficiency depends on optimal use of momentum and stored energy from the passive elements (pendulum effects) of movement cycles: pendulum base is foot during stance and hip during swing
- Changes in pace and stride length decrease energy efficiency
- There is a U shaped curve relating gait speed to energy use with an optimal nadir for gait efficiency. Slowing beyond optimal pace increases energy cost
Age, Gait Disorders and Gait Efficiency

- Age and gait disorders decrease gait efficiency
- With Age, energy cost is higher at any gait speed
- Nadir for optimal efficiency moves to the left
- Can examine effect of biomechanical and physiological abnormalities on energy cost and efficiency
- Variability and loss of smoothness of movement are contributors to loss of efficiency

Therapeutic exercise to improve gait efficiency

TC: timing & coordination in walking
WEBS: walking endurance, balance & strength

TC improves efficiency, variability, gait speed and clinical gait alterations

- TC n=23, WEBS n=24; *TC better than WEBS, p<.05

Effectiveness of a Timing and Coordination Group Exercise Program to Improve Mobility in Community-Dwelling Older Adults
A Randomized Clinical Trial
Brach, JS et al

<table>
<thead>
<tr>
<th>Measure</th>
<th>Baseline to Follow-up Change Estimate (SE)</th>
<th>Adjusted Difference (SE)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LLFDI overall function</td>
<td>0.4 (5.7)</td>
<td>-0.6 (5.8)</td>
<td>0.8 (0.7)</td>
</tr>
<tr>
<td>LLFDI disability frequency</td>
<td>0.7 (5.0)</td>
<td>0.3 (0.6)</td>
<td>0.3 (0.6)</td>
</tr>
<tr>
<td>Six-minute walk distance, m</td>
<td>20.6 (57.1)</td>
<td>4.1 (65.6)</td>
<td>16.7 (7.4)</td>
</tr>
<tr>
<td>Instrumented walkway gait speed, m/s</td>
<td>0.05 (0.13)</td>
<td>-0.01 (0.11)</td>
<td>0.05 (0.02)</td>
</tr>
</tbody>
</table>

Cluster-randomized, single-blind intervention trial. Thirty-two independent living facilities, senior apartment buildings, and senior community centers were randomized to On the Move (16 sites; 152 participants) or usual care (16 sites; 146 participants).

Interventions to reduce health care complications via mobilization
Marsh et al JAGS 2016
LIFE study- no effect of exercise on risk of hospitalization
Clinical Trial of a Hospital Mobilization Program
Eat Walk Engage

Future Directions
Nervous System Aging and Movement

“My legs don’t move when my brain tells them to. It’s very frustrating.”

GHW Bush

Thinking and Moving must be studied together

- Extensive epidemiological evidence supports interrelationships between cognition and movement
- Brain networks for movement overlap with networks for cognition
- Thinking and Moving share behavioral and etiological factors that can drive new insights into prevention and treatment

PSYCHOMOTOR SLOWING

- Controversial concept
- Is processing speed an indicator of fundamental brain function?
- What is actually being measured: perception, retrieval, movement initiation...?

Digit symbol substitution test

Table: Digit symbol substitution test results

<table>
<thead>
<tr>
<th>Trial</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>5</td>
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<tr>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
</tr>
</tbody>
</table>
Psychomotor slowing and incident overt and subclinical problems with cognition, movement and mood

Motor Skill
a link between gait and cognition

What is Motor Skill?
Smooth efficient learned movement created through motor maps
Signs of Loss of Motor Skill

**OVERT**
- Generalized Slowing
- Motor function
- Psychomotor function

**SUBCLINICAL**
- Inefficient
- Increased energy cost
- Variable
- Reduced reserve
- Dual task cost
- Reduced plasticity
- Slow and incomplete motor learning

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### Aspects of Gait Variability and Aging

**Stance Time Variability Predicts Decline in Mobility**

<table>
<thead>
<tr>
<th>Model</th>
<th>Stance Time Variability Variations</th>
<th>( \beta )</th>
<th>( p )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.20 (1.15, 1.25)</td>
<td>( \ast )</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>2</td>
<td>1.15 (1.10, 1.20)</td>
<td>.07</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1.15 (1.10, 1.20)</td>
<td>.01</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1.15 (1.10, 1.20)</td>
<td>.00</td>
<td></td>
</tr>
</tbody>
</table>

Model 1: Stance time variability
Model 2: Model 1 + gait speed  
Model 3: Model 2 + age, gender, and race
Model 4: Model 3 + chronic conditions, medications, health status, physical activity

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### Contributors to Variable Gait

<table>
<thead>
<tr>
<th>Cognitive Domain</th>
<th>Stance Time Variability</th>
<th>Step Length Variability</th>
<th>Step Width Variability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.20 (1.15, 1.25)</td>
<td>( \ast )</td>
<td>&lt;.0001</td>
<td></td>
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<tr>
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<td></td>
<td></td>
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<td>.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.15 (1.10, 1.20)</td>
<td>.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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### BLSA: Does amyloid burden affect age-related slowing independent of cognitive change?

- Slowing precedes cognitive decline and dementia often by a decade or more
- Amyloid buildup in the brain also precedes dementia by a decade or more
- Early amyloid deposition areas are often not related to memory areas (hippocampus) but rather to associative and planning areas.
Greater β-amyloid burden is associated with steeper subsequent decline in mobility

Predicted lower extremity performance decline in PiB+ and PiB-. Predicted longitudinal change in usual gait speed (a), HABC-PB score (b), and 400m walk time (c) for participants with high mean cortical distribution volume ratio (mDVRs) (red, PiB+: mDVRs≥1.066) and those with low mDVRs (blue, PiB-: mDVRs<1.066).

Figure 2. Mean cortical distribution volume ratio images by tertile of gait decline.
Summary
Measures of mobility are useful in clinical settings
The CNS is a major contributor to abnormal gait

- Gait speed is a generic indicator of function, health status, prognosis, utilization.
- Change in gait speed is clinically meaningful and affects future status.
- Gait speed may help busy clinicians attend to mobility assessment. It is quick and easy to measure in clinical settings.
- Slow walking could be a billable diagnosis “bradypedia”, “dismobility”
- Cognition and gait are both affected by age-related changes in the nervous system

- For optimal and efficient care, objective measures of function like gait speed should be incorporated into clinical care and medical record systems