Gait Speed as a Vital Sign in Geriatric Rehabilitation

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Objectives

• Understand how gait speed can be viewed as the sixth vital sign

• Understand the predictive capacity of usual gait speed to functional status in older persons

• Understand the application and interpretation of results for usual gait speed testing
Why Gait is Important

• Rehabilitation goal most often stated by patients (Kus et al 2011)

• Limitations have a major impact on independence, participation and quality of life. (Schmid et al, *Stroke*. 2007)

• 25-45% of physiotherapy time is spent on it (Latham et al, *APMR*. 2005)
Walking Speed Across the Life Span

Self selected walking speed categorized by gender & age: 6-12 & teens (Waters, Lunsford et al. 1988); 20s-50s (Bohannon 1997); & 60’s-80’s (Bohannon 2008)
Walking Speed at Usual Pace

• In older adults walking speed is a powerful predictor of:
  • Survival
  • Disability
  • Hospitalization
  • Institutionalization
  • Dementia
  • Falls
Walking Speed

• Gait is a complex task

• Walking requires:
  • Body support, timing, and power

• Walking places demands on:
  • Brain
  • Spinal cord
  • Peripheral nerves
  • Muscles and joints
  • Heart and lungs
Walking Speed

• Walking speed reflects simultaneous working and integration of many systems
  • estimate of overall disease burden
    • Diagnosed
    • Unrecognized

• Total disease burden may be the mechanism by which gait speed predicts multiple health status outcomes
  (Studenski 2009)
Contributors to Walking Speed

1. Individual’s health status (Lord 2005)
2. Motor control (Gerin-Lajoie 2006)
4. Sensory & perceptual function (teVelde 2003)
5. Endurance & habitual activity level (Langlois 1997)
7. Motivation & mental health (Lemke 2000; Fredman 2006)
8. Characteristics of the environment in which one walks (Robinett 1988)
Assumptions

• For any individual, given their set of unique “resources”

• Self-selected (comfortable) walking speed:
  ▪ Is most energy efficient
  ▪ Minimizes metabolic cost per unit distance walked

• Ability to increase walking speed:
  ▪ Index of “functional reserve”
  ▪ Allows individual to better meet changing demands of activity and environment
Why a Vital Sign?
Walking Speed as a Vital Sign

Vital sign is:

• Summary indicator that can predict future events & reflects multiple underlying physiological processes and overall health of individual (Studenski 2003, 2009)
• In general, there are normal & abnormal ranges
• Differential diagnosis of an abnormal vital sign is based on contributing systems e.g. causes of hypertension

Walking speed is:

• A summary indicator capable of predicting future events as a result of multiple physiologic inputs will be demonstrated
• Ranges of normal & abnormal values will be defined
• A differential diagnosis, based on contributing systems, can be developed
Walking Speed as a Vital Sign

General indicator that can predict future events & reflect various underlying physiological processes (Studenski 2003)

- Walking speed cannot stand alone as the only predictor of functional abilities, just as blood pressure is not the only sign of heart disease.

- Walking speed can be used as a functional “vital sign” to help determine outcomes such as:
  - functional status (Perry 1995; Studenski 2003)
  - discharge location (Rabadi 2005)
  - need for rehabilitation (Montero-Odasso 2005)
  - speed necessary for function in the community (Perry 1995)
Walking Speed: Predictive

- Future health status (Studenski 2003; Purser 2005)
- Functional decline (Brach 2002)
- Hospitalization (Montero-Odasso 2005)
- Discharge location (Salbach 2001; Rabadi 2005)
- Mortality (Hardy 2007; Cesari 2005)
- Post-operative morbidity (Afilalo 2010)
- Functional and physiological changes (Perry 1995)
- Potential for rehabilitation (Goldie 1996)
- Assists in prediction of:
  - Falls (Guimaraes 1980)
  - Fear of falling (Maki 1997)
Crossing the Street

2 traffic lanes (8 m)
Critical speed: 1.14 m/sec

4 traffic lanes (16 m)
Critical speed: 1.33 m/sec
Walking Speed
[meter per second (m/s)]

0 mph
Dependent in ADL’s and IADL’s
0.4 mph
More likely to be Hospitalized
0.9 mph
Need Intervention to Reduce Falls Risk
1.3 mph
Less likely to have Adverse Event
1.8 mph
D/C to Home more likely
2.2 mph
Cross Street & Normal WS
2.7 mph
D/C to SNF
3.1 mph
Household Walker
0 mph
Limited Community Ambulator
0.4 mph
Community Ambulator
0.9 mph
0 mph
1.3 mph
1.8 mph
2.2 mph
2.7 mph
3.1 mph
10 meter walk
50 sec
25 sec
16.7 sec
12.5 sec
10 sec
8.3 sec
7.1 sec
10 foot walk time
15.2 sec
7.6 sec
5 sec
3.8 sec
3 sec
2.5 sec
2.2 sec
Red Flag: ≤ 0.6 m/s

**Walking Speed**

- Dependent in ADL’s and IADL’s
- More likely to be Hospitalized
- Need Intervention to Reduce Falls Risk
- D/C to SNF
- Household Walker

<table>
<thead>
<tr>
<th>Walking Distance</th>
<th>10 meter walk</th>
<th>10 foot walk time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>50 sec</td>
<td>15.2 sec</td>
</tr>
<tr>
<td></td>
<td>25 sec</td>
<td>7.6 sec</td>
</tr>
<tr>
<td></td>
<td>16.7 sec</td>
<td>5 sec</td>
</tr>
<tr>
<td></td>
<td>12.5 sec</td>
<td>3.8 sec</td>
</tr>
<tr>
<td></td>
<td>10 sec</td>
<td>3 sec</td>
</tr>
<tr>
<td></td>
<td>8.3 sec</td>
<td>2.5 sec</td>
</tr>
<tr>
<td></td>
<td>7.1 sec</td>
<td>2.2 sec</td>
</tr>
</tbody>
</table>
Red Flag: $\leq 0.6 \text{ m/s}$

Walking Speed
[\text{meter per second (m/s)}]

- Dependent in ADL's and IADL's
- More likely to be Hospitalized
- Need Intervention to Reduce Falls Risk
- D/C to SNF
- Household Walker

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<th>50 sec</th>
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<th>8.3 sec</th>
<th>7.1 sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 foot walk time</td>
<td>15.2 sec</td>
<td>7.6 sec</td>
<td>5 sec</td>
<td>3.8 sec</td>
<td>3 sec</td>
<td>2.5 sec</td>
<td>2.2 sec</td>
</tr>
</tbody>
</table>
Yellow Flag: 0.6 – 1.0 m/s

Walking Speed
[meter per second (m/s)]

- 0.6
- 0.8
- 1

0
0.2
0.4
1
1.2
1.4

Dependent in ADL's and IADL's

More likely to be Hospitalized

Need Intervention to Reduce Falls Risk

D/C to SNF

Household Walker

Limited Community Ambulator

Community Ambulator

10 meter walk time
50 sec
25 sec
16.7 sec
12.5 sec
10 sec
8.3 sec
7.1 sec

10 foot walk time
15.2 sec
7.6 sec
5 sec
3.8 sec
3 sec
2.5 sec
2.2 sec
Green Flag: > 1.0 m/s

Walking Speed
[meter per second (m/s)]

- Independent in ADL's
- Less likely to be Hospitalized
- Less likely to have Adverse Event
- D/C to Home more likely
- Cross Street & Normal WS

10 meter walk
- 50 sec
- 25 sec
- 16.7 sec
- 12.5 sec
- 10 sec
- 8.3 sec
- 7.1 sec

10 foot walk time
- 15.2 sec
- 7.6 sec
- 5 sec
- 3.8 sec
- 3 sec
- 2.5 sec
- 2.2 sec
Cut Points: Adverse Outcomes For Aging Adults

- **> 1.3 ms⁻¹**: Extremely fit [24]
- **> 1.0 ms⁻¹**: Healthy older population; Lower risk of health events and better survival [19, 20, 52]
- **< 1.05 ms⁻¹**: Cognitive decline within 5 years [30]
- **< 1.0 ms⁻¹**: Death and hospitalisation within 1 year [24]
- **< 0.8 ms⁻¹**: Mobility and ADL disability at 2 years; Mortality at 2 years and 3.8 years [36]
- **< 0.7 ms⁻¹**: Death, hospitalisation, institutionalisation, and falls [43]
- **< 0.6 ms⁻¹**: Functional or cognitive decline, institutionalisation, and mortality [24, 36]
- **< 0.42 ms⁻¹**: Functional dependence and severe walking disability [33, 51]
- **< 0.2 ms⁻¹**: Extremely frail [24]
- **< 0.15 ms⁻¹**: Institutionalisation, identifies highly dependent older people [50]

(Abellan van Kan 2009)
## Walking Speed and Function

<table>
<thead>
<tr>
<th>Walking speed</th>
<th>m/sec</th>
<th>mph</th>
<th>METS</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>.67</td>
<td>1.5</td>
<td>&lt; 2</td>
<td>1.5</td>
<td>self care</td>
</tr>
<tr>
<td>.89</td>
<td>2.0</td>
<td>2.5</td>
<td>self care</td>
<td>household activities</td>
</tr>
<tr>
<td>1.11</td>
<td>2.5</td>
<td>3.0</td>
<td>self care</td>
<td>carry groceries, light yard work</td>
</tr>
<tr>
<td>1.33</td>
<td>3.0</td>
<td>3.5</td>
<td>self care</td>
<td>climb several flights of stairs</td>
</tr>
</tbody>
</table>

N = 492 elders (Studenski, 2003)
Walking Speed is Predictive

Pooled Lifetimes by Gait Speed Category

OLS Model (Deer, 1994) for all 9 studies.

Percent Alive

Days to Death

Gait Speed (m/s): 0.0-0.4, 0.4-0.6, 0.6-0.8, 0.8-1.0, 1.0-1.2, 1.2-1.4, >1.4 m/s

0.4 m/s  4.6 m/s  .6-.8 m/s  .8-1.0 m/s  1.0-1.2 m/s  1.2-1.4 m/s  >1.4 m/s
Walking Speed is Predictive

Days to Death

Percent Alive

90-95%
70-82%
55-60%

Percent alive at 3000 days stratified by WS

3000 days = 8.5 years

0-0.4 m/s  0.4-0.6 m/s  0.6-0.8 m/s  0.8-1.0 m/s  1.0-1.2 m/s  1.2-1.4 m/s  >1.4 m/s
Improved at 1 year  31.6%
Transient improvement  41.2%
Never improved  49.3%

0.1m/s improvement in WS in 1 year

GAINS in Walking Speed Predicts 9 year mortality

Hardy 2007
GAINS in Walking speed predicts...

...9 year mortality

Improved at 1 year
Transient improvement
Never improved

0.1m/s improvement in WS in 1 year

Hardy 2007
Walking Speed Predicts…

…1 year health outcomes

% patient declines in one year stratified by WS

Decline from Baseline to 1 year

Studenski 2003
Abnormal Values

- Consider the contributing systems that can lead to an abnormal value - become areas to address in rehabilitation:

  - Balance
  - Muscle strength
  - Range of motion, flexibility
  - Need or appropriateness of mobility aid
  - Endurance
  - Cardiovascular fitness
  - Coordination
  - Cognition
  - Vision
  - Environment within which the person lives
Measurement of Walking Speed
Walking Speed is....

• Reliable (Richards 1995)

• Valid (Steffen 2002)

• Sensitive (van Iersel 2008)

• Specific (Harada 1995)

• Correlates with
  • Functional ability (Perry 1995)
  • Balance confidence (Mangione 2007)
Test-Re test Re test reliability coefficients reported in the literature range from:

0.929 (Evans 1997) to 0.97 (Stephens 1999)

- Variability related to:
  - Method used to measure
  - Distance measure
  - Diagnosis
  - Use of assistive device
  - Age
  - Anthropometrics (primarily leg length)
  - Self-selected or fast gait speed
Walking Speed: Predictive

- Walking speed has been used as a **predictor & outcome measure** across multiple diagnoses:
  
  - Older adults (Studenski 2003; Perera 2006)
  - Incomplete Spinal Cord Injury (Behrman 2005)
  - Frail Elderly (Purser 2005)
  - Hip Fracture (Palombaro 2006)
  - Pain & LBP (Lee 2007)
  - Children (Meyer-Heim 2007)
  - Stroke (Bowden 2008)
  - Parkinson’s Disease (Rochester 2009)
Feasibility of Use

Feasibility of Tests

1. Is the test safe?
2. Is it cost effective?
3. How easy is the test to administer?
4. How easily are the results of the test graded & interpreted?

Walking Speed

1. Safe
2. Adds no significant cost to an assessment
3. Easy to Administer
   • Requires no special equipment
   • Requires little additional time
     • Administered in about 2 minutes (Studenski 2003)
4. Easy to calculate (distance/time)
   • Easy to interpret based on published norms (Oberg 1993; Bohannon 1997; Steffen 2002; Lusardi 2003)
Assessment

- Walking speed can be quickly & accurately assessed in the majority of PT practice settings
- home care
- subacute & acute rehabilitation facilities
- long term care facilities
- out-patient offices
- schools
- community wellness/ screening activities (Bohannon 2009)
10 Meter Walk Test

- Reliable, inexpensive method (Perera 2006)
- 12 meter path
  - Central 10 meters being the timing area
4 Meter Walk Test

- Reliable
  - Recommended as most feasible
- 6 meter path
  - Central 4 meters being the timing area
# 4 Meter Walk Test

<table>
<thead>
<tr>
<th>Time to complete</th>
<th>= meters per second</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 seconds</td>
<td>1.3 m/s</td>
</tr>
<tr>
<td>4 seconds</td>
<td>1.0 m/s</td>
</tr>
<tr>
<td>5 seconds</td>
<td>0.8 m/s</td>
</tr>
<tr>
<td>6.7 seconds</td>
<td>0.6 m/s</td>
</tr>
</tbody>
</table>

[Diagram showing the 4 meter walk test with timing zones: Acceleration zone (1 meter), 4 meter Walk - Timed Section, Deceleration zone (1 meter).]
6 Minute Walk Test

• Most widely used long walk
  • widely accepted for congestive heart failure & COPD

• Recommended cutoff is 350 meters
  • equivalent to gait speed of around 1.0 m/s

• Possible that endurance is incorporated into usual walking speed
  • individuals self select their personal optimal walking speed (Studenski 2009)
Change In Walking Speed

True change vs. measurement error

- Different populations have different MDC’s (minimal detectable change scores)
- Most common is 0.1 m/s

Change of 0.1 m/s is predictor

- Gain of 0.1 m/s is predictor for well-being in those without normal WS (Purser 2005; Hardy, Perera 2007)
- Decrease in 0.1 m/s is linked with:
  - poorer health status
  - more disability
  - longer hospital stays
  - increased medical costs (Purser 2005)

Use a change of 0.1 m/s for patient goals
Interpretation of Walking Speed (WS)

Your patient, an 83 year old woman, is recovering from an acute stroke.

<table>
<thead>
<tr>
<th>Initial Examination</th>
<th>Reassessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>WS 0.79 m/s</td>
<td>WS 1.02 m/s</td>
</tr>
</tbody>
</table>

*IS THIS A MEANINGFUL CHANGE?*

Mean difference:

\[ \text{WS}_{\text{reassess}} - \text{WS}_{\text{initial}} = 0.23 \text{ m/s} \]

\[ \text{WS}_{\text{MDC}} = 0.10 \text{ m/s} \]
Interpretation of Walking Speed

• Not just a determination of a numerical value

• Important to also consider:
  • The absolute value
  • Change in functional status (Schmid et al 2007)
  • Changes in mobility aid use (Swenk et al 2011)

• The value needs to be consistent with physical demands required to be independent or return to previous living situation
In Summary
Take Home Points

Walking Speed IS THE Vital Sign for Function

- Red: < 0.6 m/s  **DANGER**
- Yellow: 0.6 to 1.0 m/s  **WARNING**
- Green: > 1.0 m/s  **COMMUNITY Ambulator**

- 4 meter test is feasible in most settings
  - **ALL** PT’s should test walking speed
  - on **ALL** patients
  - in **ALL** settings
Walking Speed has Strong Psychometric Properties

• Robust evidence for clinical use

• Easily measurable, clinically interpretable & a potentially modifiable risk factor (Hardy 2007 & Dickstein 2008)

• A change of 0.1 m/s is meaningful
References


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Bohannon R. Measurement of Gait Speed of Older Adults is Feasible and Informative in a Home-Care Setting. J Geriatr Phys Ther 2009;32(1).


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