Using Functional Measures and AI to Predict Resilient Outcomes

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Physical Function & Physical Resiliency

- Resilient physical function
  - Meet or exceed pre-stressor levels
  - Absence of decline
- Trajectories of function
  - Loss, gain, recovery
- Ability to perform favorite activities
  - Quality of life
Measures of Physical Function

• Self-report of difficulty or dependency in daily activities
  • Mobility
  • Physical function
  • ADLs, IADLs

• Performance Measures
  • SPPB
    • Gait Speed
    • Chair Stands
    • Standing Balance
  • Grip Strength
  • Endurance Walking
LOWER-EXTREMITY FUNCTION IN PERSONS OVER THE AGE OF 70 YEARS AS A PREDICTOR OF SUBSEQUENT DISABILITY

Jack M. Guralnik, M.D., Ph.D., Luigi Ferrucci, M.D., Ph.D., Eleanor M. Simonsick, Ph.D., Marcel E. Salive, M.D., M.P.H., and Robert B. Wallace, M.D.

Table 2. Adjusted Relative Risk of Disability at Four Years of Follow-up, According to the Summary Performance Score at Base Line.*

<table>
<thead>
<tr>
<th>SUMMARY PERFORMANCE SCORE</th>
<th>NO. OF SUBJECTS†</th>
<th>DISABILITY IN ADL</th>
<th>MOBILITY-RELATED DISABILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NO. WITH DISABILITY</td>
<td>RR (95% CI)</td>
<td>NO. WITH DISABILITY†</td>
</tr>
<tr>
<td>4–6</td>
<td>112</td>
<td>32</td>
<td>4.2 (2.3–7.7)</td>
</tr>
<tr>
<td>7–9</td>
<td>487</td>
<td>50</td>
<td>1.6 (1.0–2.6)</td>
</tr>
<tr>
<td>10–12</td>
<td>522</td>
<td>29</td>
<td>1.0</td>
</tr>
</tbody>
</table>
Physical function in the context of physical resiliency:

**Individual improvement vs. population level trends**

Does low **function** mean low **resilience**?

Figure courtesy of Qian-Li Xue
Fatigability & Physical Resiliency

- Perception of fatigue in relation to a standardized task
- Standardizes fatigue in the research and clinical settings
- Commonly assessed using:
  - Pittsburgh Fatigability Scale
  - Standardized Treadmill Walk (e.g., 5 min at 1.5 mph/0.67 m/s)
  - Endurance walking task
- Associated with: physical function, inflammation, body composition, cognition, CVD, cancer, energy utilization
Fatigability & Physical Resiliency

• Meaningful to understanding endurance capacity, physical function, and quality of life
• Combines physical task with perception of difficulty
• Quantitative and qualitative aspects

Pittsburgh Fatigability Scale

<table>
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<tbody>
<tr>
<td>a. Leisurely walk for 30 minutes</td>
</tr>
<tr>
<td>b. Brisk or fast walk for 1 hour</td>
</tr>
<tr>
<td>c. Light household activity for 1 hour (cleaning, cooking, dusting, straightening up, baking, making beds, dishwashing, watering plants)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rating</th>
<th>Descriptor</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>No exertion at all</td>
</tr>
<tr>
<td>7</td>
<td>Extremely light</td>
</tr>
<tr>
<td>8</td>
<td>Very light</td>
</tr>
<tr>
<td>9</td>
<td>Light</td>
</tr>
<tr>
<td>10</td>
<td>Somewhat hard</td>
</tr>
<tr>
<td>11</td>
<td>Hard (heavy)</td>
</tr>
<tr>
<td>12</td>
<td>Very Hard</td>
</tr>
<tr>
<td>13</td>
<td>Extremely hard</td>
</tr>
</tbody>
</table>
Fatigability & Physical Resiliency

Tracking fatigability over time as a measure of physical resiliency

Marino F, et al, MSSE 2024
Artificial Intelligence & Physical Resiliency

• AI and digital technologies hold promise for improved monitoring and understanding of patient health
  • Wearable devices, voice assistants, robotics
  • Machine learning, computer vision, natural language processing
• Clinical measures and free-living measures
  • Gait technology (gait mats, motion capture systems)
  • In-home activities, medication adherence
• Dynamic/time-series ambulatory measures
  • Movement, sleep, heart rate & arrhythmias, continuous glucose, blood pressure, \( \text{SpO}_2 \), skin temperature
Mean Activity Counts by Time of Day

- Daily Avg:
  - 1,811k
  - 1,674k
  - 2,117k
  - 2,101k
  - 2,101k

- Days Since Intervention:
  - baseline
  - month 2
  - month 1
  - months 3-5
  - months 6+

Unpublished data
Summary & Considerations

• Physical function (traditional) and AI (novel) provide important insights into physical resiliency

• Need to Consider
  • Interplay with cognitive & sensory function
  • Combining patient perception with objective measurement
  • Combining traditional (in-lab/clinic) and real-world measures
  • How to gauge relative vs. absolute change
    • Individual vs. Population level
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