SIG Symposium
IMPROVING PREVENTIVE SCREENING FOR SARCOPENIA

Exploring muscle mass measurements that predict functional outcomes

Gulistan Bahat, MD
Istanbul Medical School
Division of Geriatrics
EUGMS Congress 2017-Nice, September 21
CONFLICT OF INTEREST DISCLOSURE

• I have no potential conflict of interest to report.
OBJECTIVE
Background

Low muscle mass (LMM) definition

- differs among the consensus groups in regard to “muscle mass adjustment method”
Adjusting skeletal muscle mass (SMM)

- Height
- Weight
- Body mass index (BMI)
Adjusting by Height*

• First and most used adjustment method*
• $\text{SMM/height}^2$†
  – kg/m$^2$
• Young mean-2SD

†Appendicular SMM by DXA
Adjusting by Weight*

- SMM/ body weight – %
- Young mean-2SD

†Total SMM by BIA
Adjusting by BMI*

- **SMM/ BMI**
  - kg/(kg/m²)
- Young mean-2SD (BMIa)
- SMM threshold that best predict the low grip strength (BMIb) (FNIH)

†Appendicular SMM by DXA
Prevalence of sarcopenia

Association of sarcopenia with adverse health outcomes

differ among different definitions
Which LMM adjustment method reveals better efficacy in relation to functional outcomes?
Association of SMMI with sarcopenia related outcomes

- Hand grip strength
- Usual gait speed (UGS)
- Activities of daily living (ADL)
- Instrumental ADL (IADL)
- Frailty
Prevalence by different adjustment methods

- Low muscle mass
- Sarcopenia
MATERIALS AND METHODS
• Participants
  – Community-dwelling
  – 60-99 years of age
  – Outpatient clinic of a university hospital
Body composition

- bioimpedance analysis (BIA) (Tanita-BC532)

LMM was evaluated according to our national data

- SMM index (SMMI) by height*
  - females < 7.4 kg/m², males < 9.2 kg/m²
- SMMI by weight
  - females < 33.6, males < 37.4
- SMMI by BMIa
  - females < 0.823 males < 1.049
- SMMI by BMIb
  - females < 0.677 kg/BMI males < 1.017 kg/BMI

• Muscle strength
  – hand grip strength (Jamar hydraulic hand dynamometer)
• Usual gait speed (UGS) (4m)
• Activities of daily living (ADL)
  – Katz*
• Instrumental ADL (IADL)
  – Lawton**

• Frailty
  – FRAIL scale

FRAIL scale

- Fatigue
- Resistance (ability to climb one flight of stairs)
- Ambulation (ability to walk one block)
- Illnesses (Greater than 5)
- Loss of Weight (>5%)

0 = robust / 1-2 = pre-frail / ≥ 3 = frail
Statistical analysis

- Descriptive data: % or mean, SD or median
- Correlation analyses (Pearson or Spearman Rho)
- Independent sample t test or Mann Whitney-U
RESULTS
• n= 1307
  – 421 male (32.2%)
  – 886 female (67.8%)
• Age: 78.5 (5.7)
Prevalences

**Low Muscle Mass**
- 2.1% (H)
- 47.2% (W)
- 63.4% (BMIa)
- 21% (BMIb)

**Low Grip Strength**
- 39.4%

**Low Gait Speed**
- 36.1%

**Sarcopenia**
- 1.3% (H)
- 23.9% (W)
- 35.2% (BMIa)
- 13.2% (BMIb)

Low Muscle Performance
- 54.5%
Association of SMMI with sarcopenia related outcomes

- Hand grip strength
- Usual gait speed (UGS)
- Activities of daily living (ADL)
- Instrumental ADL (IADL)
- Frailty
Hand grip strength correlated with all SMMIs (p<0.001)

- Height: r=0.286
- Weight: r=0.298
- BMI: r=0.548
Association of SMMI with sarcopenia related outcomes

Usual Gait Speed

- Height (p=0.267)
- Weight (r=0.08, p=0.009)
- BMI (r=0.22, p<0.001)
Association of SMMI with sarcopenia related outcomes

ADL

- Height (p=0.71)
- Weight (r=0.08, p=0.008)
- BMI (r=0.17, p<0.001)
Association of SMMI with sarcopenia related outcomes

IADL

Height (p=0.49)

Weight (r=-0.06, p=0.04)

BMI (r=0.07, p=0.03)
Association of SMMI with sarcopenia related outcomes

- Height (p=0.61)
- Weight (r= -0.06, p=0.04)
- BMI (r= -0.18, p<0.001)
### Association of SMMI with sarcopenia related outcomes

<table>
<thead>
<tr>
<th>SMMI adjusted by</th>
<th>Height (kg/m²)</th>
<th>Weight (%)</th>
<th>BMI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td>p=0.007</td>
<td>p=0.001</td>
<td>p=0.02</td>
</tr>
<tr>
<td></td>
<td>r=-0.075</td>
<td>r=0.221*</td>
<td>r=0.086</td>
</tr>
<tr>
<td><strong>BMI</strong></td>
<td>p&lt;0.001</td>
<td>p&lt;0.001</td>
<td>p&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>r=0.628</td>
<td>r=-0.752*</td>
<td>r=0.633</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Hand grip strength</strong></th>
<th>p&lt;0.001</th>
<th>p&lt;0.001</th>
<th>p&lt;0.001</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>r=0.286</td>
<td>r=0.298</td>
<td>r=0.548*</td>
</tr>
</tbody>
</table>

| **Usual gait speed**  | p=0.267 | p=0.009 | p<0.001* |
|                       | r=0.033 | r=0.077 | r=0.223 |

| **ADL**               | p=0.71  | p=0.008 | p<0.001* |
|                       | r=0.08  | r=0.17  | r=0.666 |

| **IADL**              | p=0.49  | p=0.045 | p=0.026* |
|                       | r=-0.059 | r=0.066 | r=-0.18 |

| **Frail score**       | p=0.61  | p=0.04  | p<0.001 |
|                       | r=-0.063 | r=-0.18 |       |

*BMI: body mass index*
Sarcopenia diagnoses defined by different SMMI vs Functional Outcomes

Sarcopenia-SMMI-Height
- ADL (p=0.002)

Sarcopenia-SMMI-Weight
- Hand grip strength (p<0.001)

Sarcopenia-SMMI- BMIa or BMIb
- All functional measures (p<0.001)
## Association of sarcopenia diagnoses defined by different SMMI vs Functional Outcomes

<table>
<thead>
<tr>
<th>Sarcopenia</th>
<th></th>
<th></th>
<th></th>
<th>BMIa</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>H</td>
<td>W</td>
<td></td>
<td>p&lt;0.001</td>
<td>p&lt;0.001</td>
</tr>
<tr>
<td>LMM adjusted by</td>
<td></td>
<td></td>
<td></td>
<td>(27.8 vs 20.6)</td>
<td>(29 vs 20.5)</td>
</tr>
<tr>
<td><strong>Hand grip strength</strong></td>
<td>p=0.3</td>
<td>p&lt;0.001</td>
<td></td>
<td>p&lt;0.001</td>
<td>p&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>(17.2 vs 16.1)</td>
<td></td>
<td></td>
<td>(17.4 vs 16.8)</td>
<td>(17.3 vs 16.7)</td>
</tr>
<tr>
<td><strong>Usual gait speed</strong></td>
<td>p=0.4</td>
<td>p=0.16</td>
<td></td>
<td>p&lt;0.001*</td>
<td>p&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>(1 vs 0.64)</td>
<td></td>
<td></td>
<td>(0.91 vs 0.66)</td>
<td></td>
</tr>
<tr>
<td><strong>ADL</strong></td>
<td>p=0.002</td>
<td>p=0.78</td>
<td></td>
<td>p&lt;0.001</td>
<td>p&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>(21.7 vs 18.8)</td>
<td></td>
<td></td>
<td>(21.1 vs 18.5)</td>
<td></td>
</tr>
<tr>
<td><strong>IADL</strong></td>
<td>p=0.22</td>
<td>p=0.08</td>
<td></td>
<td>p&lt;0.001</td>
<td>p&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>(0.8 vs 1.6)</td>
<td></td>
<td></td>
<td>(1 vs 1.6)</td>
<td></td>
</tr>
<tr>
<td><strong>Frailty score</strong></td>
<td>p=0.106</td>
<td>p=0.51</td>
<td></td>
<td>p&lt;0.001</td>
<td>p&lt;0.001</td>
</tr>
</tbody>
</table>

*: assessed by FRAIL score

ADL: activities of daily living, IADL: instrumental activities of daily living
DISCUSSION
Best matches for muscle mass adjustment sarcopenia functional:

A Comparison of Muscle Function, Mass, and Quality in Liver Transplant Candidates: Results From the Functional Assessment in Liver Transplantation Study.

Sarcopenia, sarcopenic obesity and mortality in older adults: results from the National Health and Nutrition Examination Survey III.

Association between sarcopenia and higher-level functional capacity in daily living in community-dwelling elderly subjects in Japan.

Switch to our new best match sort order

Search results

Items: 1 to 20 of 23  Selected: 3
Skeletal muscle mass adjusted by height correlated better with muscular functions than that adjusted by body weight in defining sarcopenia

- Prevalence of sarcopenia
  - 3.3% (SMMI-height)**
    - 6.7% (male) vs 0.4% (female)(kg/m2)
  - 7.6% (SMMI-weight)**
    - 4% (male) vs 10.7% (female) (%)
- \(\kappa\) coefficient: 0.17 (Agreement)
  - 0.39 (male)
  - 0.03 (female)

**Young mean-2SD
Association of functionality between different SMMI adjustment methods

- SSMI (height) correlated with
  - Grip strength \( r = 0.171 \), gait speed \( r = 0.109 \)
- SSMI (weight) correlated with
  - Grip strength \( r = 0.105 \), gait speed \( r = 0.098 \)

Association of functionality between different SMMI adjustment methods

- SSMI (height) correlated with
  - Grip strength \( (r = 0.171) \), gait speed \( (r = 0.109) \)
- SSMI (weight) correlated with
  - grip strength \( (r = 0.105) \), gait speed \( (r = 0.098) \)

- SMMI-Height correlated better than SMMI-Weight
  - Grip strength
  - Gait speed
  - More muscular functions

Sarcopenia among patients receiving hemodialysis: weighing the evidence

Piyawan Kittiskulnam\textsuperscript{1,2}, Juan J. Carrero\textsuperscript{3}, Glenn M. Chertow\textsuperscript{4}, George A. Kaysen\textsuperscript{5}, Cynthia Delgado\textsuperscript{1} & Kirsten L. Johansen\textsuperscript{1*}

- SMMI- height, SMMI-weight (%), SMMI-BSA, SMMI-BMI
- Prevalence of LMM(8-32%)
  - SMMI- height
    - Lowest (esp. in F)
  - SMMI-BSA
    - highest
  - SMMI-weight, SMMI-BMI
    - classified more overweight and obese patients as LMM

*Kittiskulnam et al. J Cachexia Sarcopenia Muscle. [e-pub ahead of print].*
• Prevalence of LMM
  – 8.1% (SMMI-height)
  – 25.3% (SMMI-weight)
  – 32.4% (SMMI-BSA)
  – 25% (SMMI-BMI)

• Prevalence of LMM (M/F)
  – 12.2% vs 2.3%
  – 27.8% vs 21.7%
  – 37.3% vs 25.5%
  – 24.9% vs 25.1%

*Kittiskulnam J Cachexia Sarcopenia Muscle. [e-pub ahead of print].
Association of functionality between different SMMI adjustment methods

- Hand grip strength
- LMM
  - SMMI-height
  - SMMI-weight
- LMM
  - SMMI-BSA
    - OR: 1.9
  - SMMI-BMI
    - OR: 1.8

*Not associated with low hand grip strength*

*Associated with low hand grip strength*

*Kittiskulnam J Cachexia Sarcopenia Muscle. [e-pub ahead of print].*
Association of functionality between different SMMI adjustment methods

- Hand grip strength
- LMM
  - SMMI-height
  - SMMI-weight
- LMM

  - SMMI-BMI and SMMI-BSA correlated better than SMMI-Height and SMMI-Weight
  - Grip strength

- OR: 1.8

*Kittiskulnam J Cachexia Sarcopenia Muscle. [e-pub ahead of print].*
Association of functionality between different SMMI adjustment methods

- Gait speed
- Gait speed vs SMMI (correlation) (less robust)
  - SMMI-height (-)
  - SMMI-weight (+)
  - SMMI-BSA (+)
  - SMMI-BMI (+)

*Kittiskulnam et al. J Cachexia Sarcopenia Muscle. [e-pub ahead of print].
Association of functionality between different SMMI adjustment methods

- Gait Speed
- LMM
  - SMMI-Height
  - SMMI-BSA

- LMM
  - SMMI-Weight
    - OR: 2.1
  - SMMI-BMI
    - OR: 1.6

*Not associated with low gait speed*

*Associated with low gait speed*

*Kittiskulnam et al. J Cachexia Sarcopenia Muscle. [e-pub ahead of print]*
Association of functionality between different SMMI adjustment methods

- Gait Speed
- LMM
  - SMMI-height
  - SMMI-BSA

Not associated with low gait speed

- SMMI-BMI and SMMI-Weight correlated better than SMMI-Height and SMMI-BSA
  - OR: 1.6

*Kittiskulnam et al. J Cachexia Sarcopenia Muscle. [e-pub ahead of print]
Association of functionality between different SMMI adjustment methods

- Gait Speed
- LMM
  - SMMI-height
  - SMMI-BSA

- LMM
  - SMMI-weight

- SMMI-BMI seems most valid
- Hand grip strength and gait speed
  - OR: 1.6

*Kittiskulnam et al. J Cachexia Sarcopenia Muscle. [e-pub ahead of print]*
Prevalence of sarcopenia and its association with functional and nutritional status among male residents in a nursing home in Turkey

GULISTAN BAHAT¹, BULENT SAKA¹, FATIH TUFAN¹, SIBEL AKIN¹, SÜLEYMAN SIVRIKAYA², NURULLAH YUCEL², NILGUN ERTEN¹, & MEHMET A. KARAN¹
Low skeletal muscle mass index is associated with function and nutritional status in residents in a Turkish nursing home

Asli Tufan¹, Gülistan Bahat², Hilal Ozkaya³, Didem Taşcioğlu², Fatih Tufan², Bülent Saka², Sibel Akin⁴, and Mehmet Akif Karan²

¹Department of Internal Medicine, Division of Geriatrics, Marmara University Hospital, Istanbul, Turkey, ²Istanbul Medical School, Department of Internal Medicine, Division of Geriatrics, Istanbul University, Istanbul, Turkey, ³Department of Health and Social Services, Kayışdağ Darülacéeze Ministry, Istanbul Metropolitan Municipality, Istanbul, Turkey, and ⁴Department of Internal Medicine, Division of Geriatrics, Erciyes University Hospital, Kayseri, Turkey

prevalence rates. In our 2010 study, before the recommendation of EWGSOP, where we used the definition of LMM with kg/body surface area index, we detected the prevalence as

---

**Materials and methods**

**Subjects and measurements**

Male residents aged >60 years in a nursing home in Istanbul, Turkey, who were not bed-ridden were included in our study cross-sectionally. Participants were enrolled on September 2009. Male residents aged ≥70 years were also assessed as a subgroup. Height and weight were measured then body mass index (BMI) was calculated as weight (kilograms) divided by squared (meters$^2$).

Body composition was assessed with bio impedance analysis (BIA) using a Tanita BC 532 model body analysis monitor [12]. The EWGSOP denoted BIA as the most valid, reliable and feasible method of measuring muscle mass in daily practice. Whole-body bioelectrical impedance analysis measurements were undertaken in a standardised manner, all being in erect position, within the same examination room early in the morning after the subjects completed a minimum 6-h fast and before any significant physical activity. Fat-free mass was measured using BIA and SMM was calculated using the following equation: SMM (kg) = 0.566*FFM (fat-free mass). The skeletal muscle mass index (SMMI) was calculated as skeletal muscle mass (kg)/height$^2$ [13].
In our previous study in 2010, no significant association between LMM and functional status was found [10]. In contrast, in the present study, ADL scores were statistically significant between residents having low muscle mass and normal muscle mass in >70 years subgroup and at significance border in >60 years group. This shows that the EWGSOP definition of LMM correlates well with functional status using the national normative cut offs. Also, this
In our previous study in 2010, no significant association

- SMMI-Height associated better than the SMMI-BSA
- ADL/IADL

...normal muscle mass in >70 years subgroup and at significance border in >60 years group. This shows that the EWGSOP definition of LMM correlates well with functional status using the national normative cut offs. Also, this
Sarcopenia Defined by Combining Height- and Weight-Adjusted Skeletal Muscle Indices is Closely Associated With Poor Physical Performance

Nai-Hsin Meng, Chia-Ing Li, Chiu-Shong Liu, Wen-Yuan Lin, Chih-Hsueh Lin,

- SMMI-Height or SMMI-Weight
- Prevalence
  - 5.7% (SMMI-Height)
  - 9.7% (SMMI-Weight)

Association of functionality between different SMMI adjustment methods

- Falls
  - SMMI-Weight Sarcopenia (+)
  - SMMI-Height Sarcopenia (-)

Association of functionality between different SMMI adjustment methods

• Falls
  – SMMI-Weight Sarcopenia (+)
  – SMMI-Height Sarcopenia (-)

- SMMI-Weight is better associated than SMMI-Height for Falls

Age-related skeletal muscle mass loss and physical performance in Taiwan: Implications to diagnostic strategy of sarcopenia in Asia

Li-Kuo Liu,¹,⁴ Wei-Ju Lee,¹,⁵ Chien-Liang Liu,¹,⁴ Liang-Yu Chen,¹,²,⁴ Ming-Hsien Lin,¹,⁴ Li-Ning Peng,¹,²,⁴ and Liang-Kung Chen¹,³,⁴
Association of functionality between different SMMI adjustment methods

• Gait speed
  – SMMI-weight less associated than SMMI-height (M)
  – No association (F)

• Handgrip strength
  – SMMI (height) (M,F)
  – None with SMMI-weight

Association of functionality between different SMMI adjustment methods

- Gait speed
  - SMMI-weight less associated than SMMI-height (M)
  - No association (F)

- SMMI-Height is better associated better than SMMI-Weight
  - Grip strength
  - Gait speed

Functional Impact of Relative Versus Absolute Sarcopenia in Healthy Older Women

Marcos Estrada, MD,* Alison Kleppinger, MS,* James O. Judge, MD,* Stephen J. Walsh, ScD,† and George A. Kuchel, MD*
Gait speed

- SMMI-weight more associated than SMMI-height

Leg press (strength-power)

- SMMI-height more associated than SMMI-weight

Association of functionality between different SMMI adjustment methods

- Gait speed
  - SMMI-weight more associated than SMMI-height
- Leg press (strength-power)
- SMMI-height more associated than SMMI-weight

- SMMI-Weight is better associated than SMMI-Height
- Gait speed
- SMMI-Height is better associated than SMMI-Weight
- Leg strength
- Leg power

SUMMARY OF EXISTING LITERATURE
SMMI-Height Better

- SMMI-Height correlated better than SMMI-Weight*
  - Grip strength
  - Gait speed
  - More muscular functions

- SMMI-Height is better associated better than SMMI-Weight**
  - Grip strength
  - Gait speed

- SMMI-Height is better associated than SMMI-Weight***
  - Leg strength
  - Leg power

- SMMI-Height associated better than the SMMI-BSA****
  - ADL/IADL

SMMI-Weight Better

- SMMI-Weight is better associated than SMMI-Height*
  - Gait speed

- SMMI-Weight correlated better than SMMI-Height and SMMI-BSA **
  - Gait speed

- SMMI-Weight is better associated than SMMI-Height
  - for Falls***

** Kittiskulnam et al. J Cachexia Sarcopenia Muscle. [e-pub ahead of print]
**SMMI-BMI better**

- SMMI-BMI correlated better than SMMI-Height and SMMI-Weight*
  - Grip strength
  - Gait speed
  - More muscular functions

- SMMI-BMI correlated better than SMMI-Height and SMMI-BSA*
  - Gait speed

*Kittiskulnam J Cachexia Sarcopenia Muscle. [e-pub ahead of print].
CONCLUSIONS
Prevalences of “Low muscle mass” and “Sarcopenia” change significantly between SMM adjustment methods

“Muscle mass adjustment with BMI” seems to have better relation with “functionality”
Strengths and Limitations

**Strengths**
- Large no of participants
- Older adults
- National cut-off values

**Limitations**
- Cross sectional
- Longitudinal analyses to be performed
THANK YOU!
• The most appropriate method of indexing muscle mass remains unknown
• Recent evidence suggests that LMM indexed to “body size” has more robust associations with poor physical performance than criteria adjusted “only for” “height” or “body weight”*†‡

† Meng NH, Li CI, Liu CS, et al. Sarcopenia defined by combining heightand weight-adjusted skeletal muscle indices is closely associated with
Sarcopenia in patients with chronic kidney disease not yet on dialysis: Analysis of the prevalence and associated factors*

• Prevalence of sarcopenia (via 2 different definitions)
  – 11.9% (EWGSOP) (kg/m²)**
  – 28.7% (FNIH) (kg/BMI)

• Not specifically looked for association of functionality between different SMMMI adjustment methods

** Young mean-2SD
- **Prevalence of LMM**
  - 8.1% (SMMI-height)
  - 25.3% (SMMI-weight)
  - 32.4% (SMMI-BSA)
  - 25% (SMMI-BMI)

- **Prevalence of LMM (m/f)**
  - 12.2% vs 2.3%
  - 27.8% vs 21.7%
  - 37.3% vs 25.5%
  - 24.9% vs 25.1%
Table 1 | Patient characteristics

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Total (N = 645)</th>
<th>Men (N = 378)</th>
<th>Women (N = 267)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, yr</td>
<td>56.7 (14.5)</td>
<td>55.5 (14.3)</td>
<td>58.5 (14.5)</td>
<td>0.01</td>
</tr>
<tr>
<td>Black, %</td>
<td>61.5</td>
<td>59.0</td>
<td>65.2</td>
<td>0.11</td>
</tr>
<tr>
<td>Diabetes, %</td>
<td>43.9</td>
<td>39.4</td>
<td>50.2</td>
<td>0.01</td>
</tr>
<tr>
<td>CAD, %</td>
<td>8.8</td>
<td>10.3</td>
<td>6.7</td>
<td>0.11</td>
</tr>
<tr>
<td>CHF, %</td>
<td>18.8</td>
<td>19.6</td>
<td>17.6</td>
<td>0.53</td>
</tr>
<tr>
<td>Dialysis vintage, yr</td>
<td>2.8 (1.3–5.4)</td>
<td>2.6 (1.2–5.2)</td>
<td>2.9 (1.4–5.9)</td>
<td>0.20</td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td>28.1 (6.9)</td>
<td>27.4 (6.4)</td>
<td>29.2 (7.6)</td>
<td>0.001</td>
</tr>
<tr>
<td>BSA, m²</td>
<td>1.9 (0.3)</td>
<td>1.9 (0.2)</td>
<td>1.8 (0.2)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Body fat, %</td>
<td>29.9 (10.2)</td>
<td>25.5 (9.2)</td>
<td>36.1 (8.2)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Total muscle mass, kg</td>
<td>26.6 (6.5)</td>
<td>29.0 (6.0)</td>
<td>23.1 (5.6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Hand grip strength, kg</td>
<td>26.4 (10.6)</td>
<td>31.5 (10.2)</td>
<td>19.2 (5.9)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Gait speed, m/s</td>
<td>0.9 (0.3)</td>
<td>1.0 (0.3)</td>
<td>0.9 (0.3)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Serum creatinine, mg/dl</td>
<td>8.4 (2.7)</td>
<td>8.9 (2.9)</td>
<td>7.6 (2.3)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Serum albumin, g/dl</td>
<td>4.0 (0.4)</td>
<td>4.0 (0.4)</td>
<td>4.0 (0.3)</td>
<td>0.09</td>
</tr>
<tr>
<td>Serum prealbumin, g/dl</td>
<td>29.9 (7.3)</td>
<td>30.2 (7.7)</td>
<td>29.4 (6.6)</td>
<td>0.14</td>
</tr>
</tbody>
</table>

**Prevalence of low muscle mass** by each indexing method, %

- Muscle mass/height squared: 8.1, 12.2, 2.3, <0.001
- Muscle mass/BW (x100): 25.3, 27.8, 21.7, 0.08
- Muscle mass/BSA: 32.4, 37.3, 25.5, 0.002
- Muscle mass/BMI: 25.0, 24.9, 25.1, 0.95

**Prevalence of low muscle strength** (%)

- 29.9, 30.6, 28.8, 0.03

**Prevalence of slow gait speed** (%)

- 34.5, 24.7, 48.3, <0.001

BMI, body mass index; BSA, body surface area; BW, body weight; CAD, coronary artery disease; CHF, congestive heart failure.

Data are presented as mean (SD) and median (25th to 75th).

*P < 0.05: considered significantly different between men and women.

*Presence of low muscle mass defined as muscle mass ≥2 SDs below normal mean of young adults. The mean 2-SD values for men and women are 7.89 and 6.05 kg/m² for muscle mass/height squared, 32.68% and 27.85% for muscle mass/body weight (%), 14.31 kg/m² and 11.64 kg/m² for muscle mass/BSA, and 0.97 and 0.72 m² for muscle mass/BMI.

*Defined as hand grip strength <26 and <16 kg in men and women, respectively.

*Defined as gait speed ≤0.8 m/s.
• ** young mean-2SD (for all)
Sarcopenia and its individual criteria are associated, in part, with mortality among patients on hemodialysis

Piyawan Kittiskulnam\textsuperscript{1,2}, Glenn M. Chertow\textsuperscript{3}, Juan J. Carrero\textsuperscript{4}, Cynthia Delgado\textsuperscript{1}, George A. Kaysen\textsuperscript{5} and Kirsten L. Johansen\textsuperscript{1}

- SMMI-height\textsuperscript{2}; SMMI-weight, SMMI-BSA, SMMI-BMI **
- Prevalence of sarcopenia
  - 3.9\% (SMMI-height)
  - 11.4\% (SMMI-weight)
  - 15.7\% (SMMI-BSA)
  - 14\% (SMMI-BMI)

** young mean-2SD (for all)
• Association of mortality between different SMMMI adjustment methods

• Unadjusted analyses
  – LMM by all indexing methods was associated with significantly higher mortality compared with normal muscle mass
    • lowest HR: (SMMI- weight) (HR: 1.75)
    • highest HR: (SMMI-height) (HR: 2.71)

• Adjusted analyses
  – Borderline statistical significance
    • SMMI-height (HR: 2.03, 95% CI 1.00–4.10, p= 0.05)
    • SMMI-BMI (HR: 1.70,p= 0.08)

Table 2 | Characteristics of sarcopenic patients (low muscle mass groups according to each indexing method and weakness) and deaths during follow-up

<table>
<thead>
<tr>
<th>Variables</th>
<th>Low muscle mass by height squared and weakness</th>
<th>Low muscle mass by BW and weakness</th>
<th>Low muscle mass by BSA and weakness</th>
<th>Low muscle mass by BMI and weakness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black, %</td>
<td>62.5</td>
<td>36.0</td>
<td>0.01</td>
<td>66.0</td>
</tr>
<tr>
<td>Male, %</td>
<td>57.4</td>
<td>84.0</td>
<td>0.01</td>
<td>58.1</td>
</tr>
<tr>
<td>Diabetes, %</td>
<td>43.5</td>
<td>56.0</td>
<td>0.22</td>
<td>41.9</td>
</tr>
<tr>
<td>Age, yr</td>
<td>55.9 ± 14.1</td>
<td>75.9 ± 9.9</td>
<td>&lt;0.001</td>
<td>54.3 ± 13.3</td>
</tr>
<tr>
<td>Muscle metric (units vary)</td>
<td>9.5 ± 1.9</td>
<td>7.1 ± 0.7</td>
<td>&lt;0.001</td>
<td>33.7 ± 4.2</td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td>28.4 ± 7.0</td>
<td>21.8 ± 2.0</td>
<td>&lt;0.001</td>
<td>28.0 ± 7.0</td>
</tr>
<tr>
<td>Fat, %</td>
<td>30.0 ± 10.2</td>
<td>259 ± 10.7</td>
<td>0.045</td>
<td>29.1 ± 10.4</td>
</tr>
<tr>
<td>Serum creatinine, g/dl</td>
<td>8.5 ± 2.7</td>
<td>6.6 ± 2.2</td>
<td>0.001</td>
<td>8.6 ± 2.7</td>
</tr>
<tr>
<td>Serum albumin, g/dl</td>
<td>4.0 ± 0.4</td>
<td>3.8 ± 0.3</td>
<td>0.03</td>
<td>4.0 ± 0.4</td>
</tr>
<tr>
<td>Death during follow-up, %</td>
<td>69 (11.2)</td>
<td>&lt;10 (&lt;0.0)</td>
<td>&lt;0.001</td>
<td>61 (10.7)</td>
</tr>
<tr>
<td>Death rate (per 100 patient-yr)</td>
<td>5.9 (4.6-7.4)</td>
<td>24.7 (12.8-47.4)</td>
<td>&lt;0.001</td>
<td>5.6 (4.4-7.2)</td>
</tr>
</tbody>
</table>

Data are presented as mean ± SD, N (%), and 95% confidence interval.
• (Adjusted analyses)
• LMM (SMMI-H)+slowness (HR: 2.92, p=0.01)
• LMM (SMMI-BMI)+slowness (HR: 2.51, p=0.002)

• *Kittiskulnam J Cachexia Sarcopenia Muscle. [e-pub ahead of print].
<table>
<thead>
<tr>
<th>Parameters</th>
<th>Total (n = 645)</th>
<th>Men (n = 378)</th>
<th>Women (n = 267)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years</td>
<td>56.7 (14.5)</td>
<td>55.5 (14.3)</td>
<td>58.5 (14.5)</td>
<td>0.01</td>
</tr>
<tr>
<td>Black, %</td>
<td>61.5</td>
<td>59.0</td>
<td>65.2</td>
<td>0.11</td>
</tr>
<tr>
<td>Diabetes, %</td>
<td>43.9</td>
<td>39.4</td>
<td>50.2</td>
<td>0.01</td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td>28.1 (6.9)</td>
<td>27.4 (6.4)</td>
<td>29.2 (7.6)</td>
<td>0.001</td>
</tr>
<tr>
<td>BSA, m²</td>
<td>1.9 (0.3)</td>
<td>1.9 (0.2)</td>
<td>1.8 (0.2)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Dialysis vintage, years</td>
<td>2.8 (1.3–5.4)</td>
<td>2.6 (1.2–5.2)</td>
<td>2.9 (1.4–5.9)</td>
<td>0.36</td>
</tr>
<tr>
<td>Serum creatinine, mg/dL</td>
<td>8.4 (2.7)</td>
<td>8.9 (2.9)</td>
<td>7.6 (2.3)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Serum albumin, g/dL</td>
<td>4.0 (0.4)</td>
<td>4.0 (0.4)</td>
<td>4.0 (0.3)</td>
<td>0.08</td>
</tr>
<tr>
<td>Prevalence of low muscle mass* by each index, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muscle mass/height^2</td>
<td>8.1</td>
<td>12.2</td>
<td>2.3</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Muscle mass/body weight (×100)</td>
<td>25.3</td>
<td>27.8</td>
<td>21.7</td>
<td>0.08</td>
</tr>
<tr>
<td>Muscle mass/BSA</td>
<td>32.4</td>
<td>37.3</td>
<td>25.5</td>
<td>0.002</td>
</tr>
<tr>
<td>Muscle mass/BMI</td>
<td>25.0</td>
<td>24.9</td>
<td>25.1</td>
<td>0.95</td>
</tr>
<tr>
<td>Prevalence of low muscle mass and low muscle strength** by each index, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muscle mass/height^2</td>
<td>3.9</td>
<td>5.6</td>
<td>1.5</td>
<td>0.01</td>
</tr>
<tr>
<td>Muscle mass/body weight (×100)</td>
<td>11.4</td>
<td>12.0</td>
<td>10.5</td>
<td>0.56</td>
</tr>
<tr>
<td>Muscle mass/BSA</td>
<td>15.9</td>
<td>18.6</td>
<td>12.0</td>
<td>0.02</td>
</tr>
<tr>
<td>Muscle mass/BMI</td>
<td>14.0</td>
<td>14.1</td>
<td>13.9</td>
<td>0.93</td>
</tr>
</tbody>
</table>

BMI, body mass index; BSA, body surface area
Data are presented as mean ± SD and median (25th to 75th).
P < 0.05 consider significantly different between men and women.
*Presence of low muscle mass defined as muscle mass ≥2SD below normal mean of young adults. The mean-2SD values for men and women are 7.89 and 6.05 kg/m² for muscle mass/height^2, 32.68 and 27.85% for muscle mass/body weight (%), 14.31 and 11.64 kg/m² for muscle mass/BSA, 0.97 and 0.72 m² for muscle mass/BMI, respectively.
**Presence of low muscle strength defined as handgrip strength <26 and <16 kg in men and women, respectively.
### Table 3: Linear and logistic regression analysis of the association of low muscle mass indexed by each metric with muscle strength and physical performance

<table>
<thead>
<tr>
<th>Measure of low muscle mass</th>
<th>Unadjusted $P$</th>
<th>Adjusted* $P$</th>
<th>Unadjusted</th>
<th>$P$</th>
<th>Adjusted* $P$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Handgrip strength</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muscle/height $^2$</td>
<td>1.29 [-4.33, 1.75]</td>
<td>0.40</td>
<td>-2.72 [-5.08, -0.36]</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>Muscle/body weight (×100)</td>
<td>-2.78 [-4.66, -0.91]</td>
<td>0.004</td>
<td>0.45 [-1.17, 2.07]</td>
<td>0.59</td>
<td></td>
</tr>
<tr>
<td>Muscle/BSA</td>
<td>-4.52 [-6.24, -2.80]$^*$</td>
<td>&lt;0.001</td>
<td>-3.24 [-4.83, -1.65]</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Muscle/BMI</td>
<td>-6.84 [-8.66, -5.02]$^*$</td>
<td>&lt;0.001</td>
<td>-2.59 [-4.26, -0.93]</td>
<td>0.002</td>
<td></td>
</tr>
<tr>
<td><strong>Gait speed</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muscle/height $^2$</td>
<td>-0.13 [-0.21, -0.05]</td>
<td>0.003</td>
<td>-0.08 [-0.16, 0.00]</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>Muscle/body weight (×100)</td>
<td>-0.17 [-0.22, -0.12]</td>
<td>0.004</td>
<td>-0.09 [-0.15, -0.04]</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>Muscle/BSA</td>
<td>-0.08 [-0.13, -0.03]</td>
<td>0.001</td>
<td>0.03 [-0.02, 0.08]</td>
<td>0.28</td>
<td></td>
</tr>
<tr>
<td>Muscle/BMI</td>
<td>-0.13 [-0.19, -0.08]</td>
<td>0.001</td>
<td>-0.07 [-0.13, -0.02]</td>
<td>0.01</td>
<td></td>
</tr>
</tbody>
</table>

Cl, confidence intervals; OR, odds ratio

Reference group is low muscle mass group by each metric.

*Significant difference between men and women ($P < 0.05$). Difference in handgrip strength was $-7.93 [-9.93, -5.93]$ in men and $-3.16 [-4.75, -1.58]$ kg in women for muscle/BSA.

For muscle/BMI, difference in handgrip strength was $-8.88 [-11.10, -6.65]$ and $-3.94 [-5.51, -2.37]$ kg in men and women, respectively.

*Adjusted for age, race, sex, and diabetes.

†Low grip strength defined as $<16$ kg for women and $<26$ kg for men; low gait speed defined as $<0.8$ m/s.

*Kittiskulnam J Cachexia Sarcopenia Muscle. [e-pub ahead of print].
Table 3: Linear and logistic regression analysis of the association of low muscle mass indexed by each metric with muscle strength and physical performance.

<table>
<thead>
<tr>
<th>Measure of low muscle mass</th>
<th>Difference [95% CI] in handgrip strength (kg) or gait speed (m/s)</th>
<th>OR [95% CI] for having low handgrip strength or slow gait speed†</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unadjusted $P$</td>
<td>Adjusted* $P$</td>
</tr>
<tr>
<td>Handgrip strength</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muscle/height$^2$</td>
<td>$-2.79$ [−4.33, 1.75]</td>
<td>0.40</td>
</tr>
<tr>
<td>Muscle/body weight (×100)</td>
<td>−2.78 [−4.66, −0.91]</td>
<td>0.004</td>
</tr>
<tr>
<td>Muscle/BSA</td>
<td>−4.52 [−6.24, −2.80]</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Muscle/BMI</td>
<td>−6.84 [−8.66, −5.02]</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Gait speed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muscle/height$^2$</td>
<td>$-0.13$ [−0.21, −0.05]</td>
<td>0.003</td>
</tr>
<tr>
<td>Muscle/body weight (×100)</td>
<td>−0.17 [−0.22, −0.12]</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Muscle/BSA</td>
<td>−0.08 [−0.13, −0.03]</td>
<td>0.001</td>
</tr>
<tr>
<td>Muscle/BMI</td>
<td>−0.13 [−0.19, −0.08]</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Cl’s, confident intervals; OR, odds ratio
Reference group is low muscle mass group by each metric.

*Significant difference between men and women ($P < 0.05$). Difference in handgrip strength was −7.93 [−9.93, −5.93] in men and −3.16 [−4.75, −1.58] kg in women for muscle/BSA.

†For muscle/BMI, difference in handgrip strength was −8.88 [−11.10, −6.65] and −3.94 [−5.51, −2.37] kg in men and women, respectively.

*Adjusted for age, race, sex, and diabetes.

†Low grip strength defined as <16 kg for women and <26 kg for men; low gait speed defined as ≤0.8 m/s.
• Low LMM(SMMI-BMI)
  – associated with increased likelihood for incident mobility impairment
• NOT THE LOW SMM!!!
Differences among skeletal muscle mass indices derived from height-, weight-, and body mass index-adjusted models in assessing sarcopenia

Kyoung Min Kim, Hak Chul Jang, and Soo Lim

- Review
- Differences among SMMI (height, weight, BMI)
- Prevalence (LMM)
  - 9.3% (M), 0.2% (F) (SMMI-height)
  - ~10% (M-F) (SMMI-weight)
  - 26.8% (M), 27.9% (F) (SMMI-BMI)
• Prevalence of sarcopenia
  – For a range of cut-offs of SMMI (height) from different operational definitions
    • 2.3 to 28.0 (DXA)
    • 7.1-98.0% (BIA)
• Association (cross-sectional) of SMMI (height) based sarcopenia with falls
  – Limited
  – Only in EWGSOP and AWGS definitions, in women
• Association of death with SMMI with death
• Death
  – SMMI-Height less than SMMI-BMI

• *Kittiskulnam J Cachexia Sarcopenia Muscle. [e-pub ahead of print].
• Definition of FNIH LMM

• Cutpoints of LMM that discriminate weakness (<26kg-16kg)
  – <0.789-0.512

Grip strength was correlated with SMMI ($p < 0.001$)
- SMMI-height ($r = 0.31$)
- SMMI-weight ($r = 0.43$)
- SMMI-BSA ($r = 0.56$)
- SMMI-BMI ($r = 0.64$)

Difference in grip strength among patients with low vs. normal muscle mass
- Most prominent by SMMI-BMI
  - 6.84 kg, $P < 0.001$

*Kittiskulnam J Cachexia Sarcopenia Muscle. [e-pub ahead of print].*
• Sarcopenic participants
  – SMMI-Height
  – SMMI-Weight
  – SMMI-Height or SMMI-Weight ("combined sarcopenia")

Comparison of height- and weight-adjusted sarcopenia in a Taiwanese metropolitan older population

Nai-Hsin Meng,1,2 Chia-Ing Li,2,3 Chiu-Shong Liu,2,4 Chih-Hsueh Lin,2,4,5 Wen-Yuan Lin,2,4 Chin-Kai Chang,1,2 Tsai-Chung Li6 and Cheng-Chieh Lin2,4,7

- Gait speed
  - Others
    - timed up-and-go
    - six-minute walk
    - single-leg stance
    - timed chair stands
    - Flexibility

- Grip strength
  - Others
    - elbow flexors
    - knee extensors
    - knee flexors

Association of functionality between different SMMI adjustment methods

• Grip Strength
  – Sarcopenia (SMMI-H)
  – Sarcopenia (SMMI-W)
  – Sarcopenia (SMMI-C) (SMMI-H or SMMI-W)

• Gait Speed
  – Sarcopenia (SMMI-H)
  – Sarcopenia (SMMI-W)
  – Sarcopenia (SMMI-C)

Association of functionality between different SMMI adjustment methods

- Other Functional Measures
- Sarcopenia (SMMI-H or SMMI-W)
  - Lower performance in all muscle strengths and all physical performance tests

Table 3  Comparison of Physical Performance and Muscle Strength Between Subjects With and Without Sarcopenia

<table>
<thead>
<tr>
<th>Variable</th>
<th>Without H-Sarcopenia (n = 889)</th>
<th>With H-Sarcopenia (n = 49)</th>
<th>Without W-Sarcopenia (n = 769)</th>
<th>With W-Sarcopenia (n = 88)</th>
<th>Without C-Sarcopenia (n = 734)</th>
<th>With C-Sarcopenia (n = 123)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexibility (cm)</td>
<td>20.84 ± 0.73</td>
<td>16.33 ± 1.93</td>
<td>20.81 ± 0.73</td>
<td>18.18 ± 1.50</td>
<td>21.05 ± 0.74</td>
<td>17.75 ± 1.28</td>
<td>.009</td>
</tr>
<tr>
<td>Six-min walk test (m)</td>
<td>409.58 ± 5.75</td>
<td>351.18 ± 14.44</td>
<td>412.17 ± 5.74</td>
<td>351.45 ± 11.19</td>
<td>415.58 ± 5.78</td>
<td>354.57 ± 9.51</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Walking speed (m/s)</td>
<td>0.75 ± 0.01</td>
<td>0.64 ± 0.03</td>
<td>0.76 ± 0.01</td>
<td>0.61 ± 0.02</td>
<td>0.76 ± 0.01</td>
<td>0.63 ± 0.02</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Timed up-and-go test (s)</td>
<td>9.74 ± 0.29</td>
<td>12.33 ± 0.71</td>
<td>9.60 ± 0.29</td>
<td>12.37 ± 0.55</td>
<td>9.47 ± 0.29</td>
<td>12.14 ± 0.47</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Timed chair stands (s)</td>
<td>6.18 ± 0.18</td>
<td>6.86 ± 0.44</td>
<td>6.11 ± 0.18</td>
<td>7.12 ± 0.34</td>
<td>6.07 ± 0.18</td>
<td>7.01 ± 0.29</td>
<td>.001</td>
</tr>
<tr>
<td>Single leg stance (s)</td>
<td>4.56 ± 0.30</td>
<td>3.85 ± 0.76</td>
<td>4.63 ± 0.30</td>
<td>3.57 ± 0.59</td>
<td>4.68 ± 0.31</td>
<td>3.66 ± 0.51</td>
<td>.040</td>
</tr>
<tr>
<td>Grip strength (N)</td>
<td>256.07 ± 3.05</td>
<td>215.21 ± 7.54</td>
<td>255.82 ± 3.10</td>
<td>231.39 ± 5.92</td>
<td>258.18 ± 3.11</td>
<td>227.70 ± 5.07</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Elbow flexor strength (N)</td>
<td>184.61 ± 3.32</td>
<td>141.74 ± 8.21</td>
<td>181.12 ± 3.41</td>
<td>180.35 ± 6.57</td>
<td>183.63 ± 3.44</td>
<td>169.21 ± 5.63</td>
<td>.010</td>
</tr>
<tr>
<td>Knee extensor strength (N)</td>
<td>206.52 ± 4.11</td>
<td>154.85 ± 10.07</td>
<td>203.71 ± 4.21</td>
<td>191.10 ± 8.06</td>
<td>206.79 ± 4.24</td>
<td>180.92 ± 6.91</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Knee flexor strength (N)</td>
<td>153.12 ± 3.04</td>
<td>105.84 ± 7.43</td>
<td>150.45 ± 3.13</td>
<td>139.69 ± 6.00</td>
<td>153.40 ± 3.14</td>
<td>129.58 ± 5.12</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Leg press (N)</td>
<td>519.39 ± 13.52</td>
<td>277.77 ± 35.76</td>
<td>510.70 ± 14.06</td>
<td>450.11 ± 26.88</td>
<td>523.20 ± 14.00</td>
<td>403.69 ± 23.23</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Grip strength/weight (N/kg)</td>
<td>4.17 ± 0.05</td>
<td>4.34 ± 0.13</td>
<td>4.28 ± 0.05</td>
<td>3.50 ± 0.10</td>
<td>4.26 ± 0.06</td>
<td>3.81 ± 0.09</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Elbow flexor strength/weight</td>
<td>3.01 ± 0.06</td>
<td>2.86 ± 0.14</td>
<td>3.03 ± 0.06</td>
<td>2.71 ± 0.11</td>
<td>3.04 ± 0.06</td>
<td>2.80 ± 0.09</td>
<td>&lt;.010</td>
</tr>
<tr>
<td>Knee extensor strength/weight</td>
<td>3.37 ± 0.07</td>
<td>3.12 ± 0.16</td>
<td>3.42 ± 0.07</td>
<td>2.86 ± 0.13</td>
<td>3.42 ± 0.07</td>
<td>2.98 ± 0.11</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Knee flexor strength/weight</td>
<td>2.49 ± 0.05</td>
<td>2.14 ± 0.12</td>
<td>2.51 ± 0.05</td>
<td>2.09 ± 0.09</td>
<td>2.53 ± 0.05</td>
<td>2.13 ± 0.08</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Leg press/weight (N/kg)</td>
<td>8.39 ± 0.21</td>
<td>5.82 ± 0.57</td>
<td>8.43 ± 0.22</td>
<td>6.75 ± 0.42</td>
<td>8.55 ± 0.22</td>
<td>6.55 ± 0.36</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Note: General linear modeling was used to estimate the least-square means, adjusted for age, sex, exercise, education, hypertension, diabetes, and cataracts. Bold values indicate p < .05.
Abbreviations: LSM ± SE = least-square means ± standard error.
Combining height- and weight-adjusted SMI
associated with more functional measures