Sarcopenic Obesity:
the challenge ahead

Prof Mauro Zamboni
Department of Medicine-Geriatric Division
University of Verona-Italy

Annual Congress German Society of Nutritional Medicine
Nurnberg, June 14-18 -2012
In healthy humans bone and muscle grow in parallel to body weight.

This harmony may be lost in older subjects.
Influence of Age on body composition

Longitudinal studies have shown that fat mass increases with aging peaking at about 60-75 years

Longitudinal Body Composition Changes in Old Men and Women: Interrelationships With Worsening Disability

Francesco Fantin,¹ Vincenzo Di Francesco,¹ Giorgia Fontana,¹ Alessandra Zivelonghi,¹ Luisa Bissoli,¹ Elena Zoico,¹ Andrea Rossi,¹ Rocco Micciolo,² Ottavio Bosello,¹ and Mauro Zamboni¹

Changes in FM, FFM and appendicular FFM: 5.5 years follow-up in stable weight men and women 70 years at the beginning of the study.
Sarcopenic Obesity

Age related body composition changes

Epidemic Obesity in older ages
## Prevalence of Obesity and Overweight for Adults Aged 20 Years or Older

<table>
<thead>
<tr>
<th>Categories by Age</th>
<th>% of Adults (95% Confidence Interval)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Allb</td>
</tr>
<tr>
<td>BMI ≥30</td>
<td></td>
</tr>
<tr>
<td>All, age, y</td>
<td></td>
</tr>
<tr>
<td>≥20</td>
<td>(33.9 (31.7-36.1), 32.8 (29.4-36.1), 44.1 (39.9-48.3), 37.9 (32.3-43.4), 39.3 (32.0-46.6))</td>
</tr>
<tr>
<td>≥20d</td>
<td>(33.8 (31.6-36.0), 32.4 (28.9-35.9), 44.1 (40.0-48.2), 38.7 (33.5-43.9), 40.4 (34.2-46.6))</td>
</tr>
<tr>
<td>Men, age, y</td>
<td></td>
</tr>
<tr>
<td>≥20d</td>
<td>(32.2 (29.5-35.0), 31.9 (28.1-35.7), 37.3 (32.3-42.4), 34.3 (28.2-40.3), 35.9 (26.3-44.4))</td>
</tr>
<tr>
<td>20-39</td>
<td>27.5 (23.8-31.2)</td>
</tr>
<tr>
<td>40-59</td>
<td>34.3 (29.8-38.8)</td>
</tr>
<tr>
<td>≥60</td>
<td>37.1 (33.1-41.0)</td>
</tr>
<tr>
<td>Women, age, y</td>
<td></td>
</tr>
<tr>
<td>≥20d</td>
<td>(35.5 (33.2-37.7), 34.0 (29.0-39.1), 38.2 (33.8-42.6))</td>
</tr>
<tr>
<td>20-39</td>
<td>34.0 (29.0-39.1)</td>
</tr>
<tr>
<td>40-59</td>
<td>38.2 (33.8-42.6)</td>
</tr>
<tr>
<td>≥60</td>
<td>33.6 (30.2-36.9)</td>
</tr>
<tr>
<td>BMI ≥25</td>
<td></td>
</tr>
<tr>
<td>All, age, y</td>
<td></td>
</tr>
<tr>
<td>≥20</td>
<td>(68.3 (66.6-70.0))</td>
</tr>
<tr>
<td>≥20d</td>
<td>(68.0 (66.3-69.8))</td>
</tr>
<tr>
<td>Men, age, y</td>
<td></td>
</tr>
<tr>
<td>≥20d</td>
<td>(72.3 (70.4-74.1), 63.5 (60.8-66.2))</td>
</tr>
<tr>
<td>20-39</td>
<td>63.5 (60.8-66.2)</td>
</tr>
<tr>
<td>40-59</td>
<td>77.8 (74.0-81.7)</td>
</tr>
<tr>
<td>≥60</td>
<td>78.4 (74.8-81.9)</td>
</tr>
<tr>
<td>Women, age, y</td>
<td></td>
</tr>
<tr>
<td>≥20d</td>
<td>(64.1 (61.3-66.9), 61.2 (56.7-65.7))</td>
</tr>
<tr>
<td>20-39</td>
<td>61.2 (56.7-65.7)</td>
</tr>
<tr>
<td>40-59</td>
<td>68.6 (64.4-72.7)</td>
</tr>
<tr>
<td>≥60</td>
<td>68.6 (64.4-72.7)</td>
</tr>
</tbody>
</table>

Abbreviation: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared).

aBased on data from the National Health and Nutrition Examination Survey (NHANES) 2007-2008.

bIncludes racial and ethnic groups not shown separately.

cIncludes Mexican Americans.

dAge adjusted by the direct method to the year 2000 Census population using the age groups 20-39 years, 40-59 years, and 60 years or older.

The prevalence of overweight and obesity increases with age.
operational definition of Sarcopenic Obesity

Combines those of sarcopenia and obesity
“Sarcopenia is a term that denotes the decline in muscle mass that occurs with healthy aging.”

Rosemberg 1989

**Definition of Sarcopenia**

by using muscle mass index

- **appendicular FFM (Kg)/h (mt)**
  - Baumgartner et al, 1998

- **total FFM (Kg)/body weight (kg)**
  - Janssen et al, 2002

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**Distribution in Young Adults**

- **Normal**
- **at Risk for Sarcopenia**
- **Severe Sarcopenia**

Skeletal Muscle Mass
**Definition of Sarcopenic Obesity**

Body composition in healthy aging: the New Mexico Elder Health Survey and the New Mexico Aging Process Study

- **Sarcopenic obesity**
  - Muscle mass/ height squared less than -2SD below the young adult reference mean
  - with % Fat > 27 in men and 38 in women
  - or BMI > 30

- **Normal**
- **Obese**

Baumgartner, 2000
Comparison of different sarcopenic obesity definitions and prevalence

<table>
<thead>
<tr>
<th>Definition of sarcopenic obesity</th>
<th>n</th>
<th>Mean age (SD)</th>
<th>Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baumgartner (58)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sarcopenia: skeletal muscle mass ≤2 SD below mean of young population or &lt;7.26 kg m⁻² in men and &lt;5.45 kg m⁻² in women.</td>
<td>M: 430</td>
<td>M: 60 and over</td>
<td>M: 4.4%</td>
</tr>
<tr>
<td>Obesity: percentage body fat greater than median or &gt;27% in men and 38% in women.</td>
<td>F: 401</td>
<td>F: 60 and over</td>
<td>F: 3.0%</td>
</tr>
</tbody>
</table>

*F, female; M, male; SD, standard deviation.*

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Gomez-Cabello a et al. Obesity Rev 2011

the New Mexico Elder Health Survey

and the New Mexico Aging Process Study
definition of Sarcopenic Obesity
potential problems

↓

*muscle mass index* may be misleading
*in subjects with high BMI*
Prevalence of Sarcopenia by method: ratio aLM and height squared and residual obtained from regression of aLM on height, fat mass, sex

Health Aging Body Composition Study: 2984 subjects aged 70-79

Newman et al, 2003
high BMI may induce under-estimation of Sarcopenia

high BMI and high FFM

Mobility limitation
Probably Sarcopenic

high BMI and high FFM
No mobility limitation
No Sarcopenic
Comparison of different sarcopenic obesity definitions and prevalence

<table>
<thead>
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</tr>
<tr>
<td>Davison et al. (33)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sarcopenia: two lower quintiles of muscle mass (&lt;9.12 kg m⁻² in men and &lt;6.53 kg m⁻² in women).</td>
<td>M: 1391</td>
<td>M: 76.3 (1.7)</td>
<td>M: 9.6%</td>
</tr>
<tr>
<td>Obesity: two highest quintiles of fat mass (&gt;37.16% in men and &gt;40.01% in women).</td>
<td>F: 1591</td>
<td>F: 77.3 (2.2)</td>
<td>F: 7.4%</td>
</tr>
<tr>
<td>Zoico et al. (51)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sarcopenia: two lower quintiles of muscle mass (&lt;5.7 kg m⁻²).</td>
<td>F: 167</td>
<td>F: 71.7 (2.4)</td>
<td>F: 12.4%</td>
</tr>
<tr>
<td>Obesity: two highest quintiles of fat mass (&gt;42.9%).</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gomez-Cabello et al. (current study)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sarcopenia: two lower quintiles of muscle mass (&lt;8.61 kg m⁻² in men and &lt;6.19 kg m⁻² in women).</td>
<td>M: 678</td>
<td>M: 72.4 (5.5)</td>
<td>M: 17.7%</td>
</tr>
<tr>
<td>Obesity: two highest quintiles of fat mass (&gt;30.33% in men and &gt;40.9% in women).</td>
<td>F: 2198</td>
<td>F: 72.1 (5.2)</td>
<td>F: 14.0%</td>
</tr>
</tbody>
</table>

F, female; M, male; SD, standard deviation.

Gomez-Cabello a et al. Obesity Rev 2011
## Prevalence of Sarcopenic Obesity

**cross-sectional study: 3136 subjects older than 65 years**

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Normal (%)</th>
<th>High fat (%)</th>
<th>Low muscle (%)</th>
<th>Sarcopenic obesity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Men (years)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>65 to 69</td>
<td>671</td>
<td>39.5</td>
<td>22.2</td>
<td>20.6</td>
<td>17.7</td>
</tr>
<tr>
<td>70 to 74</td>
<td>212</td>
<td>37.3</td>
<td>22.2</td>
<td>17.9</td>
<td>22.6</td>
</tr>
<tr>
<td>≥75</td>
<td>218</td>
<td>36.2</td>
<td>17.4</td>
<td>22.9</td>
<td>23.4</td>
</tr>
<tr>
<td><strong>Women (years)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>65 to 69</td>
<td>2188</td>
<td>35.1</td>
<td>25.7</td>
<td>25.1</td>
<td>14.0</td>
</tr>
<tr>
<td>70 to 74</td>
<td>801</td>
<td>39.2</td>
<td>29.5</td>
<td>21.2</td>
<td>10.1*</td>
</tr>
<tr>
<td>≥75</td>
<td>696</td>
<td>31.2</td>
<td>20.4</td>
<td>28.3</td>
<td>20.1</td>
</tr>
<tr>
<td><strong>Overall (years)</strong></td>
<td>2859</td>
<td>36.2</td>
<td>24.9</td>
<td>24.1</td>
<td>14.9</td>
</tr>
<tr>
<td>65 to 69</td>
<td>1042</td>
<td>40.4</td>
<td>28.8</td>
<td>21.1</td>
<td>9.7</td>
</tr>
<tr>
<td>70 to 74</td>
<td>903</td>
<td>35.1</td>
<td>25.6</td>
<td>24.5</td>
<td>14.8</td>
</tr>
<tr>
<td>≥75</td>
<td>914</td>
<td>32.4</td>
<td>19.7</td>
<td>27.0</td>
<td>20.9</td>
</tr>
</tbody>
</table>

Statistically significant ($P < 0.05$) differences between groups; *65–69 vs. ≥75.

Gomez-Cabello a et al. Obesity Rev 2011
definition of Sarcopenic Obesity
potential problems

\[ \downarrow \]

*muscle mass and muscle strength do not decline in parallel*
3-year changes in muscle mass and strength in older adults

Loss of leg lean mass (hatched bar) and muscle strength (black bar) in older adults. Results from the Health, ABC Study.


* Gender difference: p < .01, † Racial difference: p < .05
Results from the Health, Aging and Body Composition Study

Muscle quality (strength/muscle mass) in subjects without diabetes, with diabetes with duration <6 years and with duration >6 years

P values for Linearity:
< 0.001  0.001
< 0.001  0.001

A

Leg muscle quality (Nm/kg)

Men  Women

*†

B

Arm muscle quality (kg/kg)

Men  Women

* *

p<0.05 compared with subjects without diabetes
†p<0.05 compared with diabetic subjects with duration <6 years

Park SW et al. Diabetes 2006; 55:1813-8
Prevalence of Sarcopenic Obesity using definitions based on BMI and hand grip strength

epidemiological studies with mean age 75 years gives a prevalence of Sarcopenic Obesity ranging between 4-9%

<table>
<thead>
<tr>
<th>Study</th>
<th>Mean age (SD)</th>
<th>Impaired strength</th>
<th>Not impaired muscle strength</th>
<th>Impaired vs. not impaired strength</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Obese</td>
<td>Not obese</td>
<td>Obese</td>
<td>Not obese</td>
</tr>
<tr>
<td>BLSA (N = 1026)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age-adjusted prevalence (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>male / female</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health 2000 Survey (N = 1413)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age-adjusted prevalence (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>male / female</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>InCHIANTI (N = 856)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age-adjusted prevalence (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>male / female</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LASA (N = 1189)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age-adjusted prevalence (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>male / female</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Stenholm Curr Opin Clin Nutr Metab Care 2008
Which is the best index of obesity in older people?

- BMI > 30?
- Quantity of fat mass?
- Quality of fat?
Obesity should be identified as the degree of fat storage associated with elevated health risk.

The practical definition of Obesity is based on BMI

<table>
<thead>
<tr>
<th></th>
<th>BMI</th>
</tr>
</thead>
<tbody>
<tr>
<td>underweight</td>
<td>&lt; 18.5</td>
</tr>
<tr>
<td>normal weight</td>
<td>18.5-25</td>
</tr>
<tr>
<td>overweight</td>
<td>25-30</td>
</tr>
<tr>
<td>obesity</td>
<td>&gt; 30</td>
</tr>
<tr>
<td>morbid obesity</td>
<td>&gt;40</td>
</tr>
</tbody>
</table>

there is debate about the most appropriate indices and cut-off for overweight and obesity in the elderly
Visceral adipose tissue (VAT) and intermuscular adipose tissue (IMAT) increase with age.

Gallagher et al., 2004
Ectopic fat deposition changes muscle composition and declines muscle strength and function.

Thigh intermuscular fat in young and old subjects with the same BMI
Men 79 years old, BMI 35.2 kg/m²

Men 80 years old, BMI 26 kg/m²

Intermuscular fat by MRI

Intramuscular fat: Low Density Lean Tissue by CT

University of Verona

Obese sarcopenic subject

Normal weight subject
Abdominal subcutaneous fat
Inter-intra muscular fat
Hepatic and pancreatic fat
Subcutaneous gluteo-femoral fat

Epicardic fat, Intramyocardic fat
Abdominal subcutaneous fat
Abdominal visceral AT

If loss of muscle mass or strength
Sarcopenic obesity

Mauro Zamboni, Andrea Rossi, Elena Zoico, in “Sarcopenia” Editors A Cruz & J Morley, 2012 in press
Table 2

<table>
<thead>
<tr>
<th></th>
<th>Sarcopenic</th>
<th>Obese</th>
<th>Sarcopenic Obese</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>Low</td>
<td>High</td>
<td>Normal</td>
</tr>
<tr>
<td>Fat Mass</td>
<td>Low/normal</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>SMM</td>
<td>Low</td>
<td>Normal/high</td>
<td>Low</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>Low</td>
<td>High</td>
<td>Normal</td>
</tr>
<tr>
<td>Waist Circumference</td>
<td>Low/normal</td>
<td>High</td>
<td>Normal/high</td>
</tr>
</tbody>
</table>

**Abbreviations:** BMI, body mass index; SMM, skeletal muscle mass.

*Waters D & Baumgartner RN, 2011*

**Age related increase in body fat for normal males at constant BMI**

*Prentice AM & Jebb SA, 2001*
A biological connection between Sarcopenia and Obesity?

Muscle-Fat

a two-way cross-talk?
Does muscle loss cause fat gain?

AGING

↑ Fatigability

Muscle weakness

↓ Endurance capacity

Muscle wasting

↓ Physical activity

↓ Energy expenditure

↓ Obesity/abdominal fat

↓ Insulin resistance

Genetics

↓ Hypertension

↓ T2DM

↓ Dyslipidemia

↓ CVD

Nair KS, 2005
Does Fat gain cause Muscle loss?

Gustafson B et al. 2007
A mechanism driving to sarcopenic-obesity

Obesity
Weight gain

AGING

Muscle weakness
↓ Endurance capacity
↑ Fatigability
Muscle wasting

↓ Physical activity

↑ Total/abdominal fat

Macrophage recruitment

Energy expenditure
↓

Insulin resistance
↑

Insulin resistance

Muscle wasting
↓

Fatty infiltration

Lipid oxidation

Inflammation

Fatigability

Aging

↑ Fatigability

Endurance capacity

Leptin resistance

↑ Leptin

↑ TNF-alpha

↑ IL-6

↑ MCP-1

Inflammation

Obesity

Weight gain

Zamboni et al, 2008
Quantification of Intermuscular Adipose Tissue in the Erector Spinae Muscle by MRI: Agreement With Histological Evaluation

SAT: subcutaneous adipose tissue
M: muscle (multifidus)

Rossi et al. Obesity 2010 Mar 18
80 years
BMI 26 Kg/m²

79 years
BMI 35.2 Kg/m²

Rossi et al. Obesity 2010 Mar 18
Association between intermuscular adipose tissue area (IMAT), metabolic variables, indices of systemic and local inflammation in 20 elderly men.

Zoico E, Zamboni M et al. 2009
Adipose Tissue surrounding the Heart

Subcutaneous AT increases with obesity and aging.
Gene Expression in Subcutaneous vs Epicardial and PeriAortic Adipose Tissue

**Adiponectin**

SAT  EAT  AOAT

**MCP-1**

SAT  EAT  AOAT

**CD-3**

SAT  EAT  AOAT

*Bambace et al. Cardiovascular Pathology 2011*

* = p < 0.05
Fat deposition in the heart

Immunohistochemical Reaction
PLIN2

A = CAD (10 pz); B = non CAD (11 pz)

University of Verona, 2012
**Myocardial fatty infiltration**

Human atrium stained with hematoxylin and eosin; Magnification. A. 10x; B. 20x; Scale bar: A. = 200µm; B. = 100µm

Age $M \pm SD \ 69.55 \pm 7.50$ years

BMI $27.33 \pm 1.98 \text{ kg/m}^2$

University of Verona 2011
Myocardial fatty infiltration

University of Verona, 2011
**Grp-75 marker of mitochondrial stress**

*Immunohistochemical Reaction Grp75*

A = CAD (11 pz); B = non CAD (10 pz)

*University of Verona, 2012*
Grp-78 marker of endoplasmic reticulum stress

Immunohistochemical Reaction
Grp78
A = CAD (11 pz); B = non CAD (10 pz)

University of Verona, 2012
University of Verona, 2012

** p < 0.01
Myocardial lipid accumulation in patients with pressure-overloaded heart and metabolic syndrome

A. Heart specimens stained with hematoxylin and eosin

Patient with metabolic syndrome

Patient without metabolic syndrome

B. Heart specimens from patients with metabolic syndrome stained with hematoxylin and eosin

Ejection fraction >50%

Ejection fraction 50-30%

Ejection fraction <30%

R. Marfella et al, 2009
Does Fat gain cause Muscle loss?
A mechanism driving to sarcopenic-obesity

Zamboni et al, 2008
Chronological changes in metabolism and functions of cultured adipocytes (growth of 3T3-L1 adipocytes)

- Linear increase in TG accumulation
- Increase in aging markers

Zhu et al, Am J Physiol Endocrinol Metab 2004
Adipocyte aging is associated with a reduction in gene expression of the secretory proteins adiponectin and leptin.

Zhu et al, Am J Physiol Endocrinol Metab 2004
The effects of adipocyte aging on Adiponectin gene expression and protein secretion of 3T3-L1 adipocytes

Data are presented as means ± SD.

*p < 0.05

** = p < 0.01

*** = p < 0.001

(comparison between unstimulated and LPS treated adipocytes)

Zoico et al, Biogerontology 2010
The effect of FFAs and adiponectin on actin cleavage and protein degradation in C2C12 skeletal muscle cells

Wang et al, Endocrinology 2007
hypothesis explaining the involvement of metabolic disorders in changes in protein metabolism during obesity

- Whole-body protein metabolism is less sensitive to insulin action
- Metabolic disturbances associated with obesity could contribute to protein metabolism alterations

Obesity acts synergistically with sarcopenia to maximize the risk of physical disability
Associations between purely sarcopenic, purely obese, or sarcopenic-obese subjects and self-reported difficulties with physical function

<table>
<thead>
<tr>
<th>Physical function difficulty</th>
<th>Purely sarcopenic(^2) (n = 90)</th>
<th>Purely obese(^3) (n = 435)</th>
<th>Sarcopenic-obese (n = 36)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OR</td>
<td>95% CI</td>
<td>OR</td>
</tr>
<tr>
<td>Walking (n = 1252)</td>
<td>1.32</td>
<td>0.73, 2.38</td>
<td>1.38</td>
</tr>
<tr>
<td>Climbing stairs (n = 1258)</td>
<td>1.47</td>
<td>0.86, 2.51</td>
<td>1.79</td>
</tr>
<tr>
<td>Going down stairs (n = 1252)</td>
<td>0.98</td>
<td>0.54, 1.79</td>
<td>1.54</td>
</tr>
<tr>
<td>Rising from a chair or bed (n = 1259)</td>
<td>0.46</td>
<td>0.23, 0.93</td>
<td>1.09</td>
</tr>
<tr>
<td>Picking up object from floor (n = 1259)</td>
<td>1.12</td>
<td>0.63, 2.00</td>
<td>1.44</td>
</tr>
<tr>
<td>Lifting heavy objects or reaching an object (n = 1252)</td>
<td>1.03</td>
<td>0.61, 1.74</td>
<td>1.77</td>
</tr>
<tr>
<td>Moving difficulties (n = 1258)(^d)</td>
<td>1.10</td>
<td>0.60, 1.99</td>
<td>1.75</td>
</tr>
</tbody>
</table>

\(^1\) Healthy body composition served as the referent group [odds ratio (OR): 1.00] for the logistic regression analysis.

\(^2\) Women were classified as sarcopenic if their relative skeletal muscle mass was <2 SD below the mean of a sample of 229 healthy young (18–40 y) adults. For women, this cutoff was 5.45 kg/m\(^2\).

\(^3\) Women were classified as obese if their percentage of body fat was above the 60th percentile of the study sample.

\(^d\) Defined as ≥3 difficulties among the following physical functions: walking, climbing stairs, rising from a chair or a bed, picking up an object from the floor, and lifting heavy objects or reaching an object.

Rolland Y, 2009
Incident Disability by sarcopenic obesity status
(8 years follow-up in 451 old men)

Baumgartner et al, 2004
Incidence of Sarcopenia and Sarcopenic Obesity (7 year follow-up)

Rossi A et al, 2008
Relative Risk of Pulmonary decline by body composition changes (adjusted by sex and smoking)

Rossi A et al, 2008
Changes in walking speed between age 65-85 years according to combination of low muscle strength and obesity

Inchianti study
930 subjects
older than 65 years
6 year follow-up

Stenhols et al, 2009
Probability rate of a new mobility limitation according to combination of low muscle strength and obesity

Stenhols et al, 2009
Sarcopenia
reduced muscle mass and strength

Obesity
mainly visceral obesity

Lung Function

Physical Disability

Insulin resistance

Splanchnic ectopic fat deposition

Diabetes  Hypertension  Dyslipidemia

CVD

Zamboni et al, 2008  (mod)

consequences of Sarcopenic Obesity in the elderly

Sarcopenia

Physical Performance

Risk Falls

Bone Fractures

Physical Disability
Combined effect of midarm muscle and high waist circumference (WC) on mortality in men

Wannamethee et al, 2007
The concept of Sarcopenic Obesity could help us understand the complexity of the relation between obesity, mortality and morbidity in the elderly.

Better knowledge of the biological connection between sarcopenia and obesity is needed.

Better definition of sarcopenic obesity is warranted.
Visceral fat in young and old subjects with the same waist circumference
definition of Sarcopenic Obesity potential problems

Low BMI and low body weight may induce over estimation of sarcopenia

Definitition of sarcopenia just based on low muscle mass is likely sub-optimal.

low muscle mass with high physical performance
EWGSOP Working Definition of Sarcopenia

LOW MUSCLE MASS + LOW MUSCLE STRENGTH and/or LOW PHYSICAL PERFORMANCE = SEVERE SARCOPENIA

REPORT
Sarcopenia: European consensus on definition and diagnosis
Report of the European Working Group on Sarcopenia in Older People
ALFONSO J CRUZ JENToft, JEAN PIERRE BEYENS, JURGEN M. BAUER, YVES BORIE, TOMMY CEDERHOLM, FRANCESCO LANDI, FINBARR C. MARTIN, JEAN-PIERRE MICHEL, YVES ROLLAND, STEPHANE M. SCHNEIDER, EVA TOPINKOVA, MAURITS VANDEWOUDE, MAURO ZAMBONI
The fat frail sarcopenic subject