The Obesity Paradox in the Elderly: Potential Mechanisms and Clinical Implications

Antigone Oreopoulos, MSc, PhD Candidate, School of Public Health, University of Alberta

Kamyar-Kalantar-Zadeh, MD, PhD, Arya Sharma, MD, PHD, Raj Padwal, MD, MSc Gregg C. Fonarow, MD

Oreopoulos et al, 2009

Objectives

- To understand:
  - the evidence on guidelines for overweight and obesity, and weight loss as they apply to the elderly
  - the benefits vs. risks of obesity in old age
  - the potential explanations for the obesity paradox
  - the Clinical Implications

Presenter Disclosure Information

Antigone Oreopoulos, MScPT, PhD Candidate

No relationships to disclose
The Relationship Between BMI and Outcomes in the Elderly

- Obesity is an independent risk factor for cardiovascular (CV) disease and all-cause mortality in the general population.
- It is a common presumption that elderly overweight and elderly obese individuals are at substantially increased risk for CV disease and mortality.
- Weight loss is recommended as a therapeutic goal to individuals who are overweight and obese by BMI, irrespective of age.

Definition of Obesity

- Current World Health Organization (WHO) and National Heart, Lung and Blood Institute (NHLBI) guidelines suggest to use BMI to define overweight and obesity, and recommend the same cutoff values of BMI in the elderly as in younger adults:
  - BMI under 18.5 kg/m² is considered underweight.
  - BMI between 18.5 and 25 kg/m² as normal weight.
  - BMI between 25 and 30 kg/m² as overweight.
  - BMI between 30 and 40 kg/m² as obese.
  - BMI 40 kg/m² and above as severely obese.

ACC/AHA Weight Management Recommendations

<table>
<thead>
<tr>
<th>Goals</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI: 18.5 to 24.9 kg/m²</td>
<td>Assess BMI and/or waist circumference on each visit and consistently encourage weight maintenance/reduction through an appropriate balance of physical activity, caloric intake, and formal behavioral programs when indicated. Class I Recommendation; Level of Evidence B.</td>
</tr>
<tr>
<td>Waist Circumference</td>
<td>If waist circumference (measured at the iliac crest) ≥35 inches in women and ≥40 inches in men, initiate lifestyle changes and consider treatment strategies for metabolic syndrome as indicated. Class I Recommendation; Level of Evidence B.</td>
</tr>
<tr>
<td>Women: &lt;35 inches/89 cm</td>
<td>The initial goal of weight loss therapy should be to reduce body weight by approximately 10% from baseline. With success, further weight loss can be attempted if indicated. Class I Recommendation; Level of Evidence B.</td>
</tr>
<tr>
<td>Men: &lt;40 inches/102 cm</td>
<td></td>
</tr>
</tbody>
</table>

Overweight is defined as BMI=25-30 kg/m². Obesity is defined as BMI >30 kg/m².


Obesity Trends* Among Canadian Adults

HPS, 1985

(*BMI ≥ 30, or ~30 lbs overweight for 5'4" woman)


No Data <10% 10%-14% 15-19% 20-25% 25%-
Obesity Trends* Among Canadian Adults

HPS, 1990

(*BMI ≥ 30, or ~30 lbs overweight for 5’4” woman)


Obesity Trends* Among Canadian Adults

NPHS, 1994

(*BMI ≥ 30, or ~30 lbs overweight for 5’4” woman)


Obesity Trends* Among Canadian Adults

NPHS, 1998

(*BMI ≥ 30, or ~30 lbs overweight for 5’4” woman)


Obesity Trends* Among Canadian Adults

CCHS, 2000

(*BMI ≥ 30, or ~30 lbs overweight for 5’4” woman)


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Geriatric Grand Rounds
Glenrose Rehabilitation Hospital, Edmonton, AB, Canada

June 23, 2009
Obesity Trends* Among Canadian Adults
CCHS, 2002
(*BMI ≥ 30, or ~ 30 lbs overweight for 5’4” woman)
[Map of Canada showing obesity trends]


Obesity Trends* Among Canadian Adults
CCHS, 2004
(*BMI ≥ 30, or ~ 30 lbs overweight for 5’4” woman)
[Map of Canada showing obesity trends]


Obesity Prevalence in Older Adults:
NHANES 1999-2000

<table>
<thead>
<tr>
<th>Age (Years)</th>
<th>Men (%)</th>
<th>Women (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40-49</td>
<td>26.0%</td>
<td>35.4%</td>
</tr>
<tr>
<td>50-59</td>
<td>26.3%</td>
<td>41.2%</td>
</tr>
<tr>
<td>60-69</td>
<td>32.2%</td>
<td>42.5%</td>
</tr>
<tr>
<td>70-79</td>
<td>28.9%</td>
<td>31.9%</td>
</tr>
<tr>
<td>≥ 80</td>
<td>9.6%</td>
<td>19.5%</td>
</tr>
</tbody>
</table>

- Those >65 years account for approx 12-13% of the population in Canada
- Expected to grow to approx 21% by the year 2025


INTERHEART: Nine Modifiable Risk Factors Account for ≥90% of First-MI Risk Worldwide

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>PAR (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smoking</td>
<td>36</td>
</tr>
<tr>
<td>Lack of Fruits/veg</td>
<td>14</td>
</tr>
<tr>
<td>Lack of Exercise</td>
<td>12</td>
</tr>
<tr>
<td>Alcohol</td>
<td>7</td>
</tr>
<tr>
<td>Hypertension</td>
<td>18</td>
</tr>
<tr>
<td>Diabetes</td>
<td>10</td>
</tr>
<tr>
<td>Abdominal obesity</td>
<td>20</td>
</tr>
<tr>
<td>Psychosocial</td>
<td>33</td>
</tr>
<tr>
<td>Lipids</td>
<td>50</td>
</tr>
<tr>
<td>All 9 risk factors</td>
<td>90</td>
</tr>
</tbody>
</table>

N=15,152 patients and 14,820 controls in 52 countries.
PAR=population attributable risk, adjusted for all risk factors.
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**Obesity**
- Insulin Resistance
- Autonomic Nervous System Dysfunction
- Hypertension
- Dyslipidemia
- Inflammation (CRP, cytokines)
- Diabetes
- Obstructive Sleep Apnea
- Left Ventricular Hypertrophy
- Diastolic Dysfunction
- Right Ventricular Dysfunction
- LV Enlargement
- Systolic Dysfunction
- Atherosclerosis
- Atrial Fibrillation

**CV Disease and Death**

**Body-Mass Index and Mortality in Men and Women by Age Groups**

12-year prospective cohort study of 1,213,829 individuals between the ages of 30 and 95 years.

82,372 deaths


**Increase in the Risk of CVD Mortality and All-Cause Mortality in Overweight and Obese Patients**

Data from 1 million men and women followed for 14 years with an average age of 57, who never smoked and had no history of disease at enrollment (CANCER PREVENTION STUDY II)

**Body Mass Index Is Inversely Related to Mortality in Older People**

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Risk Adjusted Hazard Ratio for BMI</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>All subjects (n=5,200)</td>
<td>0.88</td>
<td>0.84-0.93</td>
</tr>
<tr>
<td>65-74 (n=3,400)</td>
<td>0.88</td>
<td>0.81-0.95</td>
</tr>
<tr>
<td>≥75 (n=1,800)</td>
<td>0.86</td>
<td>0.80-0.92</td>
</tr>
<tr>
<td>Free of major disease (n=3,089)</td>
<td>0.93</td>
<td>0.85-1.01</td>
</tr>
</tbody>
</table>

Cardiovascular Health Study: 5200 Individuals Age 65 and above


Geriatric Grand Rounds
Glenrose Rehabilitation Hospital, Edmonton, AB, Canada
June 23, 2009
Overweight and obesity are not significant risk factors for all cause or cardiovascular mortality in the elderly. Excess body weight (overweight) may confer a modest survival benefit to the very elderly.

Reverse epidemiology: traditional cardiovascular risk factors, may, counterintuitively be protective and associated with greater survival in certain groups of people.

The Obesity Paradox in the Elderly

Overweight and obesity are not significant risk factors for all cause or cardiovascular mortality in the elderly.

Excess body weight (overweight) may confer a modest survival benefit to the very elderly.

Reverse epidemiology: traditional cardiovascular risk factors, may, counterintuitively be protective and associated with greater survival in certain groups of people.

**The Obesity Paradox is Present in Many Different Populations**
- Elderly
- Coronary Artery Disease and Heart Failure
- End Stage Renal Disease on Hemodialysis
- Rheumatoid Arthritis
- Chronic Obstructive Pulmonary Disease
- AIDS
- Malignancy

**BMI → ↑ Death in the General Population**

**BMI Associated Death Risk:**
- General Population

**BMI → ↓ Death in the Hemodialysis Population**

**BMI Associated Death Risk:**
- General Population versus Patients with Hemodialysis
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Obesity and All-cause Mortality in Patients with Known Coronary Artery Disease

Pathophysiology of Fat Accumulation with Age
- Energy intake does not change or declines with age
- Energy expenditure decreases with age
- Resting metabolic rate and thermic effect of food (rise in metabolic rate during digestion) declines with age
- Hormonal changes
  - reduced production of growth hormone and testosterone
  - decreased responsiveness to thyroid and leptin hormones
- These changes, combined with reduced physical activity, result in gradual fat accumulation

Body Fat Distribution and Structural Changes with Age
- Decline in height due to thinning of intervertebral discs and loss of vertebral body height
- Beginning in the third decade lean body mass (LBM) declines at a rate of 0.3 kg per year
- Fat is distributed differently with age – more accumulates in the abdomen
Is BMI a Valid Measure of Obesity in the Elderly?

- BMI assumes that variation in weight among individuals of the same height is due to fat mass.
- Does not differentiate between weight due to fat vs. lean muscle.
- Therefore, elderly persons may appear to have a stable “healthy” BMI despite excess fat and low muscle mass.

An Evidence-Based Assessment of Guidelines for Overweight and Obesity as They Apply to the Elderly (Cont’d)

- Meta-analysis of 32 studies (search date to Jun 2005)
  - Summary relative risk of all-cause mortality for an overweight BMI: 1.00 (95% Confidence Interval, 0.97–1.03)
  - Summary relative risk of all-cause mortality for an obese BMI was 1.10 (95% CI, 1.06–1.13)
- BMI in the overweight or obese range is not associated with a significantly increased risk of mortality in the elderly.

Is there an Optimal BMI for Older Adults?

- BMI associated with the lowest risk of death range was between 24 and 35 kg/m², with the majority in the range 27-30 kg/m².
- Older women may have a 2-5 kg/m² higher optimal range than older men.
- Optimal targets for BMI in the elderly have yet to be validated in a large prospective trial.
Potential Role of Lean Body Mass (LBM) in Explaining the Paradox

- After controlling for WC, increased BMI was protective against mortality, whereas after controlling for BMI, increased WC was associated with mortality.
- This suggests that in the elderly, BMI represents LBM whereas WC represents fat mass.
- Authors recommended using both measures in the clinical setting.

Obesity and Cardiovascular Mortality in the Elderly

- No consistent relationship between cardiovascular mortality and BMI.

What About Waist-to-Hip Ratio (WHR)?

- Similar to WC, studies have shown a linear positive relationship between WHR and all-cause mortality in older adults.
- In the clinical setting WC has the advantage over WHR of requiring only one measurement.

Independent Effects of Current and Midlife BMI on Mortality in the Elderly

- Mortality risk is increased in obese and non-obese older adults who were obese at midlife (approx age 50).
- This is NOT the case for newly obese older adults.

McTigue et al. Obesity 2006;14:1485-97
Janssen and Bacon, Obesity:16:2504, 2008
Potential Explanations for Age Differences in the Relationship of BMI and Mortality

- **BMI is invalid in older adults**
  - Age-dependent height decrease may induce a false BMI increase

- **The Survival Effect**
  - Overweight individuals who survive to old age have characteristics that protect them from adverse effects of being overweight/obese

- **Time discrepancy between competing risk factors**
  - Obesity-related consequences take years to develop; those who become obese in old age may die of non-obesity-related conditions first
  - May explain why newly obese elderly are not at higher risk of death but previously elderly obese are at higher risk

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Potential Explanations for Age Related Differences for BMI and Mortality (Con’t)

- **Reverse Causation**
  - Unintentional weight loss can affect BMI–mortality analyses if the weight loss occurs prior to the BMI measurement

- **Residual confounding**
  - Smoking, unintentional weight loss, social economic status, health insurance, adherence

- **Cohort Effect**
  - Occurs when a study compares different cohorts (or groups) of people that are not actually comparable i.e. different time periods with different lifestyles, environments, risk factors

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Benefits of Being Obese in Old Age: Obesity as Protective in the Elderly Potential Explanations

- **Mechanical Protective Effects of Obesity**
  - Less osteoporosis
  - Less traumatic events secondary to falls (more padding)

- **Protection from cognitive decline**
  - Being underweight is associated with cognitive decline in elderly adults
  - May be different for males and females

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Benefits of Being Obese in Old Age: Obesity as Protective in the Elderly Potential Explanations (Con’t)

- **Improved antioxidant defense**
  - Weight loss in the elderly is associated with reduced skeletal muscle oxidative metabolism
  - Could lead to oxidative stress and inflammation

- **Energy Reserve**
  - Obesity may protect against malnutrition and weight loss and disease in the elderly
“I’m not eating. I’m self-medicating.”

Risks of Being Obese in Old Age
- Diabetes
- Hypertension
- Hyperlipidemia
- Sleep Apnea
- Pulmonary Hypertension
- Osteoarthritis
- Long term medication use
- Some cancers

- Higher BMI values and increased morbidity
- BUT a neutral or inverse relationship between higher BMI and total and cardiovascular mortality
- This is contradictory and merits further study

More Risks of Being Obese in Old Age
- Obesity is linked to poorer health-related quality of life and functional decline
- Progressive decrease in mobility due to loss of LBM, strength, balance, and joint dysfunction
- Optimal BMI for maintenance of functional capacity may be above the ‘normal’ range
  - BMI 23-30 associated with the lowest rate of decline in physical function

The Impact of Obesity on Active Life Expectancy in Older American Men and Women
Health Transitions for Adults Aged 70 and Older, by Obesity Status: AHEAD 1993–1998

<table>
<thead>
<tr>
<th></th>
<th>Obese (n = 973)</th>
<th>Not Obese (n = 6,408)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remained active in 1998, %</td>
<td>41.5</td>
<td>50.5</td>
</tr>
<tr>
<td>Became disabled in 1998, %</td>
<td>16.7</td>
<td>12.7</td>
</tr>
<tr>
<td>Remained disabled in 1998, %</td>
<td>14.5</td>
<td>6.4</td>
</tr>
<tr>
<td>Died by 1998, %</td>
<td>20.5</td>
<td>26.4</td>
</tr>
</tbody>
</table>

Reynolds SL et al. The Gerontologist  2005; 45:438-444
Physical Inactivity and Low Levels of Physical Fitness in the Elderly

- Physical fitness, not BMI, is an independent risk factor for all-cause or cardiovascular mortality in the elderly
- Even modest levels of physical activity can attenuate age-related weight loss in older adults with chronic disease

Effect of Weight Loss in the Elderly

- Recent systematic review identified 16 studies on effect of weight loss interventions in subjects >60 years
  - Baseline BMI ≥27 kg/m², weight loss ≥3% or ≥2 kg, trial duration ≥6 mon
- Markers of inflammation (interleukin-6, C-reactive protein, and tumor necrosis factor) reduced and improvements in WC, blood pressure, serum levels of LDL cholesterol and fasting glucose
- One study found an average weight loss of 3.0 kg associated with a 30% reduction in a composite cardiovascular endpoint at 2.5 years follow-up
- In patients with osteoarthritis, significant improvements seen in the physical function components of the SF 36 and WOMAC

Loss of LBM Associated with weight loss

- Loss of LBM associated with weight loss reported in some trials
- However, this is a common finding in weight loss trials of any age group, but more of a concern in the elderly
- Best way to minimize loss of LBM is to couple the weight reduction intervention with resistance training exercise
- Resistance exercises beneficial for preserving bone density and for maintaining lean mass and muscular strength
- To date, no clinical trials have evaluated the effect of intentional weight loss on mortality in elderly individuals.

Effect of Weight Loss in the Elderly (Con’t)

- Increase in 6-min walk distance, decrease in stair climb time, and decrease in knee pain
- Two trials evaluated BMD changes after weight loss; significant reductions on total body BMD were observed, but no effect on regional BMD at common sites of fractures such as the hip or spine
Outcomes with Low BMI

- In every age group, underweight status is associated with substantially increased risk of mortality.
- In the elderly, underweight status by BMI poses a far greater threat than overweight or obese status.
- Involuntary weight loss is always abnormal and merits careful clinical evaluation for the underlying cause.

Conflicting Findings

- Intervention trials showing clinically important benefits of weight reduction:
  - improvements in osteoarthritis, physical function, and possibly diabetes and coronary heart disease
- Yet longitudinal studies suggest maintaining weight is favorable in older persons who become obese after 60

Associations between BMI, Abdominal Fat, and Intentional Weight Loss with Outcomes in the Elderly

<table>
<thead>
<tr>
<th></th>
<th>High BMI</th>
<th>High abdominal fat</th>
<th>Increased lean muscle</th>
<th>Effect of Intentional Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Cause Mortality</td>
<td>or neutral</td>
<td>or neutral</td>
<td>Unknown</td>
<td>Unknown</td>
</tr>
<tr>
<td>Cardiac Mortality</td>
<td>or neutral</td>
<td>or neutral</td>
<td>Unknown</td>
<td>Unknown</td>
</tr>
<tr>
<td>Cognitive function</td>
<td>or neutral (may be different for females)</td>
<td>or neutral (may be different for females)</td>
<td>Unknown</td>
<td>Unknown</td>
</tr>
<tr>
<td>Bone mineral density</td>
<td></td>
<td></td>
<td></td>
<td>slight</td>
</tr>
<tr>
<td>Physical function</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiovascular mortality (MI, stroke)</td>
<td></td>
<td></td>
<td>or neutral</td>
<td>Unknown</td>
</tr>
<tr>
<td>Cancer Incidence</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes mellitus/insulin resistance</td>
<td></td>
<td></td>
<td>or neutral</td>
<td>Unknown</td>
</tr>
<tr>
<td>Blood pressure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality of life</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long term medication use</td>
<td></td>
<td></td>
<td>Unknown</td>
<td>Potential for antihypertensives</td>
</tr>
</tbody>
</table>

Oreopoulos, Kalantar-Zadeh, Sharma and Fonarow, 2009 (accepted)

Which Patients do we Recommend Weight Loss to?

- Currently not enough evidence to base recommendations for weight loss in obese elderly persons
- Decisions about whether or not to advise weight loss must be individualized, with particular attention to the patient’s weight history and co-existing medical conditions
Clinical Implications (1)

- The current targets for ‘normal’ BMI derived from epidemiologic studies of younger and middle-aged populations do not appear to apply to the elderly.
- BMI should be used in conjunction with indices of body composition, such as WC (an index of body fat) and/or mid arm muscle circumference (an index of muscle mass).
- The ideal BMI target in the elderly may be closer to 25 – 35 kg/m² (lower range for males and upper range for females).

Clinical Implications (2)

- Increased weight or a high BMI in advanced age may provide benefits such as protection from bone loss and fractures, malnutrition and cognitive decline.
- Obesity, especially abdominal obesity, in older age may confer adverse health risks such as metabolic syndrome, diabetes, and cancer risk.
- Physical activity and physical fitness are important determinants of mortality risk in the elderly, independent of obesity, and may attenuate age-related weight loss.

Clinical Implications (3)

- Physical fitness and functional independence may be a more productive focus than weight loss in older adults with obesity.
- In the elderly, underweight status by BMI poses far greater threat than being overweight or obese.
- Unintentional weight loss is never normal and requires clinical investigation for the underlying cause.

Obesity Paradox Conclusions

- The challenge in easily measuring fat and fat distribution in the clinic makes it difficult to determine the most valid, practical definition of 'obesity' in the elderly.
- In contrast to younger patients overweight and obese BMI does not appear to confer increased risk of mortality in the elderly, but are related to comorbidities/disability.
- More research is needed to determine optimal BMI in the elderly and guide therapeutic recommendations.
Acknowledgements

- Dr. Gregg Fonarow, MD, FACC
  - David Geffen School of Medicine at UCLA
- Dr. Kamyar Kalantar-Zadeh, MD, MPH, PhD
  - Lac Harbor-UCLA Medical Center
- Dr. Arya Sharma, MD, PhD
  - University of Alberta
  - [www.drsharma.ca](http://www.drsharma.ca)
- Dr. Raj Padwal, MD, MSc
  - University of Alberta

THANK YOU

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Any Questions/Comments?
Table: Summary of studies with large sample sizes (>1000 subjects), mean follow-up time of at least 5 years and mean age of ≥65 indicating a reverse epidemiology of obesity in older adults

<table>
<thead>
<tr>
<th>Reference</th>
<th>Sample Size</th>
<th>Mean Age and range</th>
<th>Follow-up period (years)</th>
<th>Findings and Source of Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Losonzcy et al (19), 1995 USA</td>
<td>2449 men, 3938 women</td>
<td>≥70</td>
<td>5</td>
<td>Inverse BMI-mortality association, lowest mortality at BMI 26.3-28.3 in men and ≥29.2 in women; data from the Established Populations for Epidemiologic Studies of the Elderly</td>
</tr>
<tr>
<td>Allison et al (10), 1997 USA</td>
<td>2769 men, 4491 women</td>
<td>77 (70-99)</td>
<td>6</td>
<td>U-shaped BMI-mortality association, lowest mortality risk at BMI 27-30 for men and 30-35 for women; data from the Longitudinal study of Aging</td>
</tr>
<tr>
<td>Wassertheil-Smoller et al (7), 2000 USA</td>
<td>3975 men and women</td>
<td>71</td>
<td>5</td>
<td>No relationship between death or stroke and BMI in the placebo group, a U- or J-shaped BMI-mortality association in the treatment group. Lowest risk of death for men at BMI of 26.0 and for women at BMI of 29.6 in the treatment group; data from the Systolic Hypertension in the Elderly Program (SHEP) trial</td>
</tr>
<tr>
<td>Dey et al (9), 2001 Sweden</td>
<td>1225 men, 1403 women</td>
<td>70</td>
<td>15</td>
<td>U-shaped BMI-mortality association, lowest mortality risk at BMI 27-29 for men and 25-27 for women, weight loss increased mortality; cohort study in Sweden</td>
</tr>
<tr>
<td>Grabowski et al (18), 2001 USA</td>
<td>2860 men, 4667 women</td>
<td>77 (≥70)</td>
<td>8</td>
<td>Inverse association between BMI and mortality, lowest mortality risk in subjects with obesity (BMI &gt;28.5) compared to subjects with normal BMI (19.5-28.4); data from the Longitudinal Study of Aging</td>
</tr>
<tr>
<td>Janssen et al (22), 2005 Canada</td>
<td>2262 men, 2938 women</td>
<td>(65-90+)</td>
<td>9</td>
<td>Inverse relationship between BMI and mortality after adjustment of WC, linear positive relationship between WC and mortality after adjustment of BMI; participants of the Cardiovascular Health Study</td>
</tr>
<tr>
<td>Price et al (25), 2006 UK</td>
<td>7892 men, 13667 women</td>
<td>80 (≥75)</td>
<td>5.9</td>
<td>Inverse association between BMI and mortality, linear positive association between WHR and mortality; data from 53 family practices in United Kingdom</td>
</tr>
<tr>
<td>Corrada et al (16), 2006 USA</td>
<td>8609 women, 4842 men</td>
<td>73 (44-101)</td>
<td>23</td>
<td>U-shaped BMI-mortality association among persons &gt;80, lowest mortality risk at BMI 25 - 29.9 in persons &gt;80; data from the Leisure World Cohort Study in California</td>
</tr>
<tr>
<td>Dolan et al (12), 2007 USA</td>
<td>8029 women</td>
<td>72 (65-77)</td>
<td>8</td>
<td>U-shaped BMI-mortality and WC-mortality associations, lowest mortality risk at BMI 23.4 -29.8; data from Community-based study in Baltimore, Maryland</td>
</tr>
<tr>
<td>Mazza et al (49), 2007 Italy</td>
<td>1275 men, 1982 women</td>
<td>74 (65-95)</td>
<td>12</td>
<td>Inverse association between BMI and mortality; participants from the Cardiovascular Study in the Elderly (CASTEL)</td>
</tr>
</tbody>
</table>
Table: Associations between BMI, Abdominal Fat, and Intentional Weight Loss with Outcomes in the Elderly

<table>
<thead>
<tr>
<th>Outcome</th>
<th>High BMI</th>
<th>High abdominal fat</th>
<th>Increased lean muscle</th>
<th>Effect of Intentional Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Cause Mortality</td>
<td>↓ or neutral</td>
<td>↑</td>
<td>↓</td>
<td>Unknown</td>
</tr>
<tr>
<td>Cardiovascular Mortality</td>
<td>↓ or neutral</td>
<td>↑ or neutral</td>
<td>Unknown</td>
<td>Unknown</td>
</tr>
<tr>
<td>Cardiovascular morbidity (MI or stroke)</td>
<td>↑</td>
<td>↑</td>
<td>neutral</td>
<td>↓</td>
</tr>
<tr>
<td>Cancer incidence</td>
<td>↑</td>
<td>↑</td>
<td>↓ or neutral</td>
<td>Unknown</td>
</tr>
<tr>
<td>Diabetes mellitus/insulin sensitivity</td>
<td>↑</td>
<td>↑</td>
<td>neutral</td>
<td>↓</td>
</tr>
<tr>
<td>Blood pressure</td>
<td>↓</td>
<td>↑</td>
<td>Unknown</td>
<td>↓</td>
</tr>
<tr>
<td>Physical function</td>
<td>↓ but higher than 'normal'</td>
<td>↓</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>Quality of life</td>
<td>↓</td>
<td>↓</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>Cognitive function</td>
<td>↑ or neutral (may be different for females)</td>
<td>↑ or neutral (may be different for females)</td>
<td>Unknown</td>
<td>Unknown</td>
</tr>
<tr>
<td>Long term medication use</td>
<td>↑</td>
<td>↑</td>
<td>Unknown</td>
<td>Potential ↓ for anti-hypertensives</td>
</tr>
<tr>
<td>Bone mineral density</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>slight ↓</td>
</tr>
<tr>
<td>Dyslipidemia</td>
<td>↑</td>
<td>↑</td>
<td>Unknown</td>
<td>↓</td>
</tr>
</tbody>
</table>

↓: decreased; ↑: increased
Association Between BMI and Mortality after Age 65


Effect of Obesity on Functional Status and Quality of Life in the Elderly


Relationship Between Physical Fitness, Obesity and Mortality in the Elderly


Effect of Intentional Weight Loss on Mortality in the Elderly


