Presenter Disclosure Information

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Disclosed no conflict of interest
Normal-weight central obesity and cardiovascular mortality risk in the US population


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Commonly used BMI cutoff values to diagnose obesity have high specificity, but low sensitivity to identify adiposity, as they fail to identify half of the people with excess BF%.
Despite the good correlation between BMI and BF%, the diagnostic accuracy of BMI to diagnose obesity is limited, particularly in individuals in the intermediate BMI ranges.

**Abstract**

**Background**—Body mass index (BMI) is the most widely used measure to diagnose obesity. However, the diagnostic accuracy of BMI to detect excess in body adiposity is largely unknown.

**Methods**—A cross-sectional design of 13,601 subjects (age 20–79.9 years; 48% men) from the Third National Health and Nutrition Examination Survey. Bioelectrical impedance analysis was used to estimate body fat percent (BF %). We assessed the diagnostic performance of BMI using the World Health Organization reference standard for obesity of BF % > 25% in men and > 35% in women. We tested the correlation between BMI and both, BF % and lean mass by sex and age groups.

**Results**—BMI-defined obesity (≥ 30 kg/m²) was present in 21% of men and 31% of women, while BF %–defined obesity was present in 50% and 62%, respectively. A BMI ≥ 30 had a high specificity (95% in men and 99% in women), but a poor sensitivity (36% and 49 %, respectively) to detect BF %–defined obesity. The diagnostic performance of BMI diminished as age increased. BMI had a good correlation with BF % in men (R² = 0.44) and women (R² = 0.71), but also with lean mass (R² = 0.50 and 0.55, respectively).

**Conclusions**—Despite the good correlation between BMI and BF %, the diagnostic accuracy of BMI to diagnose obesity is limited, particularly for individuals in the intermediate BMI ranges. A BMI cut-off of ≥ 30 kg/m² has a good specificity but misses more than half of people with excess fat. These results help to explain the U and J-shape association between BMI and outcomes.
Central obesity was associated with mortality, whereas BMI was inversely associated with mortality.

In subjects with CAD, including those with normal and high BMI, central obesity but not BMI is directly associated with mortality.
OBJECTIVE

- We explored the relationship of different adiposity patterns with mortality risk in the US adult population.
- We hypothesized that people with normal BMI, but centrally obese, would have a higher cardiovascular mortality as compared with people who do not have a central fat distribution.

- Contains data for 33,994 persons aged 2 months and older
- Designed to assess health and nutritional status and provide a representative sample of the United States population
- Combine interview and physical examination data
- The interview includes demographic, socioeconomic, dietary and health related questions
- The examination component consists of medical, dental, physiologic measurements and laboratory tests

www.cdc.gov/nhanes
METHODS

• Our study included 12,785 subjects aged ≥18 years

• Baseline data were matched to the National Death Index to obtain mortality status

• The median follow up period was 14.3 years. There were 2,562 deaths, of which 1,138 were cardiovascular
Standard Obesity Definition

- BMI
  - Low = < 18.5 kg/m²
  - Normal = 18.5 - 24.9 kg/m²
  - Overweight = 25 - 29.9 kg/m²
  - Obese ≥ 30 kg/m²
Central Obesity Definition

Based on WHO criteria

Waist-to-hip ratio (WHR)

HIGH: \( \geq 0.85 \) in women
\( \geq 0.90 \) in men
Six patterns of adiposity

- **Overweight BMI**
  - Normal WHR
  - High WHR

- **Obese BMI**
  - Normal WHR
  - High WHR

- **Normal BMI**
  - Normal WHR
  - High WHR

Of all people with normal BMI, 47.8% had normal weight central obesity.

Normal Weight Central Obesity - Normal BMI, but high WHR

People with low BMI were excluded from this study.
Statistical analysis

- In order to determine the risk of mortality associated with the different patterns of adiposity, we created multivariate Cox proportional hazards models.
- We used normal BMI + normal waist-to-hip ratio as reference.
- All models were adjusted for potential confounders that have been shown to be associated with obesity and mortality.
Potential Confounders

- Age
- Gender
- Education
- Race
- Smoking status
- Dyslipidemia
- Baseline BMI

- COPD
- Diabetes
- Hypertension
- Heart failure
- Myocardial infarction
- Stroke
Statistical analysis

• All hazard ratio (HR) estimates were weighted and calculated after accounting for a complex survey design and sampling weights provided by the National Institute for Health Statistics

• People with COPD and cancer were excluded from analyses
Different Adiposity Patterns and All-Cause Mortality

Kaplan-Meier Survival Curve

- Normal BMI, normal WHR
- Normal BMI, high WHR
- Overweight BMI, normal WHR
- Overweight BMI, high WHR
- Obese BMI, normal WHR
- Obese BMI, high WHR

Normal Weight Central Obesity
Different Adiposity Patterns and Cardiovascular Mortality

Kaplan-Meier Survival Curve

Normal Weight Central Obesity

- Normal BMI, normal WHR
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Association Between Combinations of BMI and Central Obesity, and **All Cause Mortality**

<table>
<thead>
<tr>
<th>Weighted Hazard Ratio</th>
<th>Normal WHR</th>
<th>Hhigh WHR</th>
<th>Normal WHR</th>
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<th>Normal WHR</th>
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<tbody>
<tr>
<td>Age and Sex Adjusted HR</td>
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<td>Multivariate Adjusted HR</td>
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Association Between Combinations of BMI and Central Obesity, and **Cardiovascular Mortality**

![Graph showing the association between BMI and cardiovascular mortality](chart)

- **BMI by Age and Sex Adjusted HR**
- **Multivariate Adjusted HR**

- **Normal WHR** (Reference)
  - **HR=2.75**
  - **HR=2.34**

- **Overweight By BMI**
- **Obese By BMI**
Cardiovascular mortality risk stratified by age of participants

<table>
<thead>
<tr>
<th>Adiposity pattern</th>
<th>&lt;65 years old HR (95%CI)</th>
<th>≥65 years old HR (95%CI)</th>
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<tbody>
<tr>
<td>Normal BMI, high WHR</td>
<td>2.40 (1.24; 4.64)</td>
<td>1.71 (1.18; 2.47)</td>
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<tr>
<td>Overweight BMI, normal WHR</td>
<td>2.00 (0.82; 4.88)</td>
<td>1.33 (0.62; 2.86)</td>
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<tr>
<td>Overweight BMI, high WHR</td>
<td>1.70 (0.84; 3.44)</td>
<td>1.58 (0.95; 2.63)</td>
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<tr>
<td>Obese BMI, normal WHR</td>
<td>1.07 (0.13; 1.71)</td>
<td>2.58 (1.02; 6.56)</td>
</tr>
<tr>
<td>Obese BMI, high WHR</td>
<td>1.31 (0.60; 2.88)</td>
<td>2.52 (1.18; 5.40)</td>
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DISCUSSION
Possible causes

Why Normal Weight Central Obesity is related to high risk of cardiovascular diseases?

• Visceral fat accumulation
• Decreased amount of fat on hips and legs
• Decreased muscle mass in the legs
CONCLUSIONS

• The combination of central distribution of fat and normal weight by BMI (Normal Weight Central Obesity) yields the highest mortality risk.

• These findings have significant implications in clinical practice: Important to identify normal weight individuals with central obesity.

• Causes of central fat distribution are yet to be determined.
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THANK YOU
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<thead>
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<th>Adiposity pattern</th>
<th>White HR(95%CI)</th>
<th>African American HR(95%CI)</th>
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<tr>
<td>Normal BMI, high WHR</td>
<td>2.20(1.51;3.21)</td>
<td>2.03(1.12;3.67)</td>
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<tr>
<td>Overweight BMI, normal WHR</td>
<td>1.60(0.68;3.74)</td>
<td>2.74(1.24;6.04)</td>
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<td>Overweight BMI, high WHR</td>
<td>1.75(1.11;2.75)</td>
<td>1.93(0.98;3.79)</td>
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<td>Obese BMI, normal WHR</td>
<td>1.56(0.55;4.39)</td>
<td>4.04(1.47;11.14)</td>
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<tr>
<td>Obese BMI, high WHR</td>
<td>2.13(1.15;3.94)</td>
<td>3.11(1.37;7.02)</td>
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Relationship between Tertiles of Waist-to-Hip Ratio and All Cause Mortality
Relationship between Tertiles of Waist-to-HIp Ratio and Cardiovascular Mortality
Comparasion of metabolic syndrome components in different adiposity patterns

Only 2% of people with Normal Weight Central Obesity would be diagnosed as centrally obese based on ATP Central Obesity Criteria.