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SHORT REPORT

Body composition and mortality risk in later life

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Abstract

Background: body mass index is used widely to define overweight and obesity. Both high and low body mass indices are associated with increased mortality risk during middle age, but the relationship is less clear in later life. Thus, studies on the relationships between other aspects of body composition and mortality among older subjects are needed.
Objective: to investigate associations between different aspects of body composition and mortality in older people.
Methods: the study population comprised 921 participants aged ≥65 years who underwent dual-energy X-ray (DXA) absorptiometric examination at the Sports Medicine Unit, Umeå University. The main reason for admission was clinical suspicion of osteoporosis. Total, abdominal and gynoid fat masses and lean body mass were measured by DXA absorptiometry at baseline, and the cohort was followed (mean duration, 9.2 years) for mortality events.
Results: during follow-up, 397 participants died. Lean mass was associated negatively with mortality in men and women ($P < 0.001$). Total fat mass showed a U-shaped association with mortality in men ($P < 0.01$) and a negative association in women ($P < 0.01$). A higher ratio of abdominal to gynoid fat mass increased mortality risk in women ($P = 0.04$), but not in men ($P = 0.91$).
Conclusions: lean mass is associated strongly with survival in older subjects. Greater fat mass is protective in older women, whereas very low or very high fat mass increases the risk of death in men. Further research is needed to better understand the mechanisms underlying these associations.

Keywords: *fat mass, fat distribution, lean mass, mortality, dual-energy X-ray absorptiometry (DXA), older people*

Introduction

Overweight and obesity are major health issues in modern society. Numerous reports have detailed the hazards of excess weight in young and middle-aged subjects, but accumulating evidence has suggested that the association between excess weight and mortality is weaker in later life.

Anthropometric methods are commonly used to study the association between body composition and mortality risk. In this study, we aimed to further the understanding of these relationships in older individuals by quantifying lean mass, fat mass and fat distribution more precisely using dual-energy X-ray absorptiometry (DXA), then following the cohort for subsequent mortality events.

Methods

Participants

Since 1991, a total of 921 individuals (728 women, 193 men) aged ≥65 years have undergone full-body DXA scans at Umeå University, Sweden and were all included in the present study. During 2005–06, the most common causes for these measurements were previous fractures (38.0%), a general fear of osteoporosis (26.6%) and previous or present corticosteroid therapy (25.5%).

Body composition measurements

Fat and lean masses were measured using DXA (GE Lunar, Waukesha, WI, USA). Abdominal and gynoid fat masses were determined from total-body scans. For a more

detailed description, please see previous publications [1, 2]. DXA has been validated previously in adults and older individuals and is a reliable and valid method for measuring body composition [3, 4].

Identification and classification of deaths

Information on deaths in the cohort was collected from the central register of deaths in Sweden.

Statistical analyses

Differences between two groups were calculated using Student's *t*-test for independent samples. Relationships between lean and fat mass measurements and the risk of death were determined using Cox regression models adjusted for age. U-shaped trends were assessed by adding the square of the variable to the model.

The time of enrolment was defined as the day of the first body scan. The study endpoint was the event of death or the study end date of 1 June 2009. All statistical tests were two sided, and the SPSS software (ver. 17.0; SPSS Inc., Chicago, IL, USA) was used for statistical analyses. $P \leq 0.05$ was considered significant.

Results

The study cohort consisted of 921 subjects; baseline characteristics and causes of death are shown in Table 1. The most common causes of death were cardiovascular disease (41%), respiratory disease (14%) and cancer (13%).

The correlation coefficient between body mass index (BMI) and lean mass was 0.48 in women and 0.60 in men. Total fat mass correlated closely with gynoid fat mass ($r = 0.95$), abdominal fat mass ($r = 0.85$) and BMI ($r = 0.85$), but not with lean mass ($r = 0.02$) or fat distribution [abdominal: gynoid fat mass ratio ($r = -0.19$)].

The associations between lean and fat masses and mortality are presented in Table 2. In women, lean mass, BMI and total and gynoid fat masses showed negative linear associations with mortality [hazard ratios (HRs) = 0.81–0.85, $P < 0.01$ for all]. Abdominal fat mass displayed a U-shaped trend, with high risks among both lean and abdominally obese subjects ($P < 0.05$). The distribution of central versus peripheral fat mass, indicated by the ratio of abdominal to gynoid fat mass, showed a positive linear association (HR = 1.13, $P = 0.04$) with mortality.

In men, high lean mass was associated negatively with the risk of death (HR = 0.69, $P = 0.001$). BMI and abdominal, total and gynoid fat masses were associated with mortality by a U-shaped trend ($P < 0.01$ for all).

To further evaluate trends in risk, subjects were split into quartiles of each measurement. We found indications of a threshold effect of lean mass in men and women. Subjects in the quartile with the least lean mass had a higher risk of mortality compared with those in other quartiles (HR = 1.48–2.15, $P = 0.14$–0.001), whereas differences in risk among the other quartiles were small.

In secondary analyses, we adjusted the model for BMI. In women, the associations were slightly attenuated but only changed the degree of significance for total fat mass (HR = 0.96, $P = 0.730$). In men, the BMI adjustment did not change the significance of any result.

Table 1. Characteristics of the cohort and causes of mortality

		Women ($n = 728$)	Men ($n = 193$)
No. of deaths		290	107
	Range	Mean (standard deviation)	
Age (years)	65–89	72.7 (5.2)	71.5 (4.9)**
Follow-up time (years)	0–18	9.6 (4.0)	7.8 (3.8)***
Weight (kg)	34–118	64.9 (11.3)	76.7 (10.8)***
Height (m)	1.38–1.96	1.60 (0.06)	1.73 (0.07)***
Body mass index (kg/m^2)	14.5–43.9	25.4 (4.2)	25.5 (3.2)
Total fat (kg)	4.0–64.7	26.2 (8.1)	21.5 (6.7)***
Abdominal fat (kg)	0.2–2.8	1.6 (0.5)	1.7 (0.4)
Gynoid fat (kg)	0.5–6.4	2.6 (0.8)	1.9 (0.6)***
Abdominal:gynoid fat (kg)	0.31–1.46	0.62 (0.12)	0.92 (0.15)***
Lean mass (kg)	22.8–75.4	38.9 (4.9)	55.3 (6.8)***
Cause of death[a]		*n* (%)	
Cardiovascular disease		90 (39.6)	37 (43.0)
Respiratory disease		32 (14.1)	12 (14.0)
Cancer		28 (12.3)	12 (14.0)
Urogenital disease		13 (5.7)	6 (7.0)
Infection		8 (3.5)	3 (3.5)
Bowel disease		9 (4.0)	1 (1.2)
Neurologic disease		7 (3.1)	0 (0.0)
Other		40 (17.6)	15 (17.4)

[a]Information available for 79% of all deaths.
**$P < 0.01$, ***$P < 0.001$.

Table 2. Trends and risk of mortality per standard deviation of body composition parameter in women and men

	P for U-shaped trend	HR for linear trend	*P* for linear trend
Women			
Body mass index	0.114	0.84	0.003
Abdominal fat mass	0.018	–	–
Total fat mass	0.179	0.85	0.009
Gynoid fat mass	0.214	0.82	0.001
Abdominal:gynoid fat mass	0.104	1.13	0.044
Lean mass	0.512	0.81	<0.001
Men			
Body mass index	<0.001	–	–
Abdominal fat mass	<0.001	–	–
Total fat mass	<0.001	–	–
Gynoid fat mass	0.002	–	–
Abdominal: gynoid fat mass	0.382	1.01	0.910
Lean mass	0.480	0.69	0.001

HR, hazard ratio.

When the effects of lean and fat masses were analysed in the same model, lean mass remained a strong predictor, while the effects of fat masses were weakened slightly (data not shown).

To control for the possible confounding effects of pre-existing diseases, we re-examined the cohort after excluding those who died during the first 2 years of follow-up. This exclusion did not significantly alter the results.

Discussion

We investigated associations between different aspects of body composition and the risk of mortality in an older population. In both men and women, lean body mass was associated inversely with mortality (HR = 0.69–0.81, $P < 0.01$), with indications of a threshold effect. Subjects with the least lean mass had a higher risk of mortality, but the benefit of high versus average lean mass was small.

Regular exercise is associated with higher lean body mass and is associated negatively with hypertension, high cholesterol level, type II diabetes and overall mortality [5]. Thus, an increased mortality risk associated with low lean mass could be due to low levels of physical activity.

Even in physically active individuals, muscle mass shows an age-related decline [6]. Possible mechanisms include hormonal changes, low-grade inflammation and poor nutrition [6]. A clear relationship exists between loss of muscle mass and loss of independence, which contributes to falls, fractures and hospitalisations [7]. Healthy adults show a functional overcapacity in most biological systems, but these margins attenuate with ageing [8]. The loss of function in one system, such as the musculoskeletal system, is often related to a decreased capacity in other systems. Therefore, low muscle mass might be an indicator of an overall decline in biological function.

Except for abdominal fat mass, all fat measurements were associated with a decreased risk of mortality in women; however, the distribution of fat, as indicated by the ratio of abdominal to gynoid fat mass, was associated with an increased risk of mortality in women. Price *et al.* [9] found negative associations between BMI and waist circumference and overall mortality, and a higher waist- to-hip ratio (WHR) moderately increased mortality. Our results are in agreement with these findings.

As the association between BMI and mortality is weaker in older people than in younger subjects [10–12], the role of BMI as a screening tool in older subjects has been questioned [9]. Several studies have concluded that the WHR is a better proxy for predicting disease and mortality in these individuals [9, 10]. However, we found a relatively weak association between the ratio of abdominal to gynoid fat mass and mortality. Results from this and other studies instead suggest that lean body mass is a better predictor of mortality in older subjects [13, 14].

Overweight and obesity are associated with increased risks of mortality in younger adults. However, in our and other studies of older people, high levels of body fat were associated with increased survival. Body fat is an energy buffer that might extend life expectancy in individuals with chronic or long-term diseases, possibly outweighing other negative effects of fatness. However, despite having tried to exclude early mortality events in this study, the seemingly protective effect of fat mass may be attributed to confounding factors of pre-existing disease.

This study had some limitations. First, the study sample was not population based, but consisted of subjects admitted for DXA examination, increasing the risk of selection bias. However, the anthropometric measurements of our subjects did not differ from those of a large population-based cohort from the same area [15]. Also, because this study was conducted on patients, a higher prevalence and incidence of disease can be expected. However, this is more likely to weaken the associations between the assessed body composition indices and mortality due to potential competing risks from other diseases.

The main strength of the present study is the use of precise and direct measurement by DXA. DXA estimation of lean and fat masses has been validated and correlates highly with values determined by other reference methods [3, 4]. Assessments of regional fat have also been found to correlate closely with those measured by computed tomography [16].

In summary, increased lean body mass decreases the risk of death in both men and women aged ≥65 years. In men, different estimates of obesity showed a U-shaped relationship with the risk of death, with both high and low estimates of body fat increasing the risk of death. In women, a high amount of fat was generally protective, with the exception of a high ratio of abdominal to gynoid fat mass, which increased the risk of death.

Key points

- High lean mass is associated with longer life expectancy.
- Low body fat is associated with decreased life expectancy.
- Fat distribution is a weak predictor of mortality risk in older people.

Conflict of interest

None declared.

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Ethics

The study was approved by the regional ethics board in Umeå.

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