Obesity Paradox during Aging

Ian M. Chapman
Division of Medicine, University of Adelaide, Adelaide, Australia

Abstract
Although obesity in young people is a risk factor for morbidity and mortality, the effect of obesity in the elderly is much more complex. For example, the body weight associated with maximal survival increases with increasing age. Even more striking is the ‘obesity paradox’ in the elderly, in which overweight is associated with increased risk for cardiovascular disease but decreased mortality from these diseases. Thus, although intentional weight loss by obese older people is probably safe, and likely to be beneficial if they have obesity-related morbidities, caution should be exercised in recommending weight loss to overweight older people on the basis of body weight alone. Methods of achieving weight loss in older adults are the same as in younger adults. Weight loss diets should be combined with an exercise program, if possible, to preserve muscle mass, as dieting results in loss of muscle as well as fat, and older people have reduced skeletal muscle mass compared to younger adults. Weight-loss drugs have not been extensively studied in older people and there is the potential for drug side effects and interactions. Weight loss surgery appears to be safe and effective, although it probably produces less weight loss than in younger adults. Little is yet known about the outcomes of such surgery in people over 65 years.

Prevalence of Overweight and Obesity among Older People

In most developed countries large numbers of older people are overweight. In recent surveys, approximately 71% of Americans 60 years or older and 60% of those 65 years or older were overweight (BMI ≥25), while approximately 32% of those 60 years or older and 20% of those 65 years or older were obese (BMI ≥30) [1, 2]. Similarly, 29% of 55- to 64-year-olds in England were obese [3], while 43% of Australians over 65 were overweight and 25% of 65- to 74-year-olds and 14.4% over 75 years were obese [4]. Not only is obesity common in older people, but it is becoming more common, in line with the increasing rate in younger adults. The prevalence of obesity among people in the USA over 60 years increased from 20 to 32% between 1988–1994 and 1999–2000 [5], and among those over 70 years from 11.4 to 15.5% between 1991 and
2000 [6]. There have been similar increases in other countries [4], including non-western countries. The combined prevalence of overweight and obesity in China more than doubled between 1991 and 1999–2000, from 13 to 27%, with the greatest increases occurring in those older than 65 years [7].

**Changes in Body Weight and Body Composition with Increasing Age**

An understanding of the causes and consequences of obesity in older people is aided by an understanding of the changes in appetite, food intake, energy expenditure and body composition that occur normally with aging.

**Changes in Appetite and Food Intake with Increasing Age**

Adults generally become less hungry and eat less as they get older, even if healthy [8]. This physiological, age-related reduction in appetite and energy intake is multifactorial and has been termed ‘the anorexia of aging’ [9]. Average daily energy intake decreases by about 30% between 20 and 80 years [8]. Most of this decrease in energy intake is probably a response to the decline in energy expenditure that also occurs with aging. Changes in body weight and body composition reflect the balance of these two declines. Body weight tends to increase through early adult life into middle age, indicating a more rapid decline in energy expenditure than in food intake during this time. In contrast, body weight tends to decrease in older people due to a faster decline in food intake than in energy expenditure in later life.

**Changes in Body Weight with Increasing Age**

On average, people in westernized countries gain weight until they are about 50–60 years old, remain weight stable for a while and then tend to lose weight [10]. Although some of the decline in body weight after age 50–60 years apparent in cross-sectional studies is due to the premature death of obese people, declining body weight among older people has also been demonstrated in longitudinal studies. In a 2-year, United States, prospective study, community-dwelling men over 65 years lost on average 0.5% of their body weight per year and 13.1% of the group had a weight loss of 4% per annum or more [11]. As a result of weight loss in old age, and the premature death of obese people at younger ages, the prevalence of overweight and obesity, as defined by standard BMI criteria (BMI >25 and ≥30, respectively) peaks around age 55–65 years. It then remains fairly stable until about age 70–75 years, before decreasing [4].

A substantial minority of older people have quite marked weight changes over time [11, 12]. In one study of home-dwelling people over 65 years in the USA [12],
30% had a greater than 5% change in their body weight over 3 years, with 17% losing more than 5% of their initial body weight and 13% gaining 5% or more. There is evidence that body weight category interacts with changes in body weight to affect health. Adverse effects particularly occur in already underweight people who lose weight and in already overweight people who gain weight [13].

Changes in Body Composition with Increasing Age

Enlargement and Redistribution of Fat Stores
With aging there is usually a steady increase in fat stores and decrease in fat-free mass, the latter mainly due to loss of skeletal muscle. Consequently, at any given weight or body mass index, older people have, on average, substantially more body fat than young adults. In one study, the mean body fat percentage of 75-year-old men weighing 80 kg was 29%, compared to 15% in 20-year-old men of the same weight [14] (fig. 1). The increase in body fat with aging is multifactorial in origin, with decreased physical activity being a cause, as well as contributions from reduced growth hormone secretion, declining sex hormone action and reduced resting metabolic rate and thermic effect of food.

Older adults not only have more body fat than young adults, but their fat is distributed differently. A greater proportion of body fat in older than young people is intrahepatic, intramuscular, and intra-abdominal (versus subcutaneous) [15, 16], changes that in both young and older adults are associated with increased insulin resistance [16]. In one study, intramuscular fat stores were 50% greater, intrahepatic stores four times greater, and intravenous fat mass nearly doubled.

Fig. 1. The age-related increase in BMI associated with 20% increased risk of death relative to people with a BMI of 21 (lowest risk group). Data from the American Cancer Society’s Cancer Prevention Study demonstrating a decline in the relative risk of death with increasing body weight with increasing age among 324,135 men and women followed for 12 years. Data not available for women over 75 years. Adapted from Stevens et al. [48].
times greater and insulin resistance two times greater in older (65–74 years) than young adults (20–32 years) [16]. In younger adults such changes to body fat stores and increases in insulin resistance are associated with adverse metabolic outcomes, including increased rates of diabetes mellitus and cardiovascular disease. While it might, therefore, be predicted that the age-related changes in body fat stores would lead to bad metabolic outcomes in older people, this is not proven. Indeed, given that the body weight compatible with longest survival increases with increasing age (see below), and much if not all of the increase in body weight is due to increased fat stores, it may be that advancing age in some way blunts the harmful effects of increasing body fat.

Loss of Skeletal Muscle (Sarcopenia)
Aging is associated with a decrease in muscle mass and strength, with a loss of up to 3 kg of lean body mass per decade after age 50 years. After age 60 years, loss of body weight is disproportionately of lean body tissue, predominantly skeletal muscle. The causes of age-related skeletal muscle loss are multiple and not fully understood, but probably similar to those leading to fat gain, including reduced exercise and anabolic hormone action. When excessive, this loss of skeletal muscle leads to sarcopenia (from the Greek meaning ‘poverty of flesh’). Sarcopenia has been defined in various ways, including as a skeletal mass more than 2 SDs below the young adult sex-specific mean [17]. The prevalence of sarcopenia in older people varies according to the population studied and diagnostic criteria used, but is in the range of 6–15% in people over 65 years [17]. The prevalence of sarcopenia increases dramatically as the ‘young-old’ age, and is up to four times higher in those over 85 years than in those 70–75 years [18].

The reduction of skeletal muscle mass and strength in sarcopenia is so severe that it is often associated with marked functional impairment. The presence of sarcopenia is an independent predictor of poor gait, balance, falls, and fractures. In the NHANES III study, for example, older people with marked sarcopenia (less than 5.75 kg skeletal muscle/m²) were 3.3 times (women) to 4.7 times (men) more likely to have physical disability than those with low-risk skeletal muscle mass (more than 6.75 kg/m²) [19].

Sarcopenic Obesity
In young adults, obesity tends to be associated with increased skeletal muscle, acquired to support the extra weight. In contrast, in older people, excess weight, to the point of obesity, can co-exist with muscle loss and even sarcopenia. Hence, the existence of sarcopenic obesity, or the ‘skinny fat’ elderly, who have high levels of body fat but do not look overweight as they have lost much of their lean tissue. This combination in people with sarcopenic obesity of an excess of (possibly) metabolically bad fat tissue and a deficiency of beneficial muscle is associated with particularly adverse effects [20]. In one prospective study of elderly people followed for up to 8 years, those with
sarcopenic obesity (skeletal muscle mass more than 2 SDs below young adult mean AND percentage body fat above the 60th percentile) at baseline were 2–3 times more likely to develop disabilities in activities of daily living than were lean sarcopenic, nonsarcopenic obese or normal body composition subjects [21]. The age-related loss of skeletal muscle and its adverse effects probably helps explain the consistently demonstrated benefits of exercise programs in elderly people, particularly those that increase muscle mass and function.

**Causes of Overweight and Obesity in Older People**

As indicated above, epidemiological studies show that over the last few decades people have not usually gained weight during old age. It follows from this that the high and increasing proportion of overweight and obesity in older people observed over recent decades is mainly due to the high and increasing proportion of adults who reach old age already overweight. The causes of obesity in the elderly are therefore largely those of obesity in younger adults. These are complex, multifactorial and relate to changing environmental factors which have made it easier for people to consume more energy than they expend [22]. They have been extensively reviewed elsewhere and will not be addressed further in this chapter.

Older people are often not weight stable and a substantial minority of older people have quite marked weight changes over time [11, 12]. There are therefore some people who only become overweight or whose weight increases dramatically in later life. This can be due to medical illnesses, which restrict mobility and hence alter the food intake-energy expenditure balance in favor of the former. Most common among these is musculoskeletal disease, such as osteoarthritis of the lower limbs or back, while cardiac failure and depression are also important causes, as is increased food intake due to corticosteroid use.

**Consequences of Obesity in Older People**

As in younger adults, obesity in older adults is associated with absolute and relative increases in both mortality and morbidity. Obesity-related co-morbidities are summarized in table 1. Most of these conditions become more common and severe with increasing age even in those who are not overweight, but their adverse effects are exacerbated by excess weight.

Several apparent paradoxes related to obesity in older people will be considered below. Firstly, obesity in older people appears to be associated with the same if not greater morbidities and reduction of quality of life as in younger adults, but the association of excess weight with increased mortality is substantially weaker than in younger people. In the very old there may, indeed, be no association between excess
Obesity Paradox 25

body weight and reduced life expectancy, except perhaps in the extremely obese. Secondly, the effects of weight loss by ‘overweight’ older people are not well defined and may be adverse, even if weight loss is intentional. For example, even though obesity is associated with increased cardiovascular disease, obesity also reduces the mortality rate from such diseases (see below).

**Morbidity, Function and Quality of Life**

As in younger adults, obesity in older people is associated with increased rates of cataracts, mechanical urinary and bladder problems, sleep apnea and other respiratory problems (reviewed in [10]), vascular disease, hypertension and type 2 diabetes mellitus [23]. After the age of 65 years, over 60% of people have symptomatic osteoarthritis, commonly affecting the hip and knee, and this is a major cause of disability. Excess weight hastens the development of osteoarthritis of the knee and possibly other joints [24, 25], exacerbates the symptoms of lower limb osteoarthritis, and makes surgical treatment more hazardous.

Functional capacity and mobility are significantly reduced in obese compared to lean older adults [26]. The association of obesity and functional disability is particularly strong in older adults, in whom it is associated with reduced muscle mass and strength and hence with physical frailty [20]. Obese older people have increased

<table>
<thead>
<tr>
<th>Table 1. Obesity-related comorbidities in older people</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced mobility</td>
</tr>
<tr>
<td>Reduced quality of life</td>
</tr>
<tr>
<td>Type 2 diabetes mellitus</td>
</tr>
<tr>
<td>Hypertension</td>
</tr>
<tr>
<td>Cardiovascular disease</td>
</tr>
<tr>
<td>Sleep apnea</td>
</tr>
<tr>
<td>Increased rate of malignancies</td>
</tr>
<tr>
<td>Breast</td>
</tr>
<tr>
<td>Colon</td>
</tr>
<tr>
<td>Prostate</td>
</tr>
<tr>
<td>Uterus</td>
</tr>
<tr>
<td>Fatty liver</td>
</tr>
<tr>
<td>Thromboembolic disease</td>
</tr>
</tbody>
</table>
difficulties performing activities of daily living, including dressing and getting in and out of bed [27, 28]. Compared to their nonobese counterparts, obese older people are less likely to be pain free, have greater limitations of physical function, and are more likely to be homebound. Obesity is predictive of a greater rate of future disability, declines in functional status [10], particularly when associated with loss of skeletal mass [21], and an increased admission rate to nursing homes [29]. Among women age 65 years or more in the Nurses Health Study, a weight gain of 20 lb (≈9 kg) or more over 4 years was associated with a reduction in reported physical functioning [13]. Increased fat mass appears to be the factor specifically responsible for obesity-related disability [26].

Obesity is associated with a reduced quality of life [30], due to multiple factors, including associated joint pain [31]. There have been reports that overweight women have a greater disease burden and greater reduction in quality of life than overweight men [27, 32]. Obesity has been linked with depression, but study results are conflicting [33–35]. There is evidence for link between obesity and the later development of Alzheimer type dementia, but evidence for this is not clear cut, and may be confused by the associated conditions of diabetes and hypertension, both of which are linked to dementia [36].

Obesity, particularly central obesity, is a risk factor for and component of the metabolic syndrome. It is associated with and predisposes to hypertension, dyslipidemia and cardiovascular disease among adults of all ages. There is an increased rate of vascular disease, particularly ischemic heart disease, congestive cardiac failure and cerebrovascular disease in overweight people, including older people [37].

The Obesity Paradox in the Elderly

Although obesity is a risk factor for the development of vascular disease, it is now well established that when obese people develop these vascular diseases they have better outcomes than their normal weight counterparts. This has been termed the ‘obesity paradox’, and applies for people with hypertension, coronary artery disease, congestive cardiac failure, peripheral arterial disease and those referred for exercise testing [38–42]. Studies have consistently shown reductions in mortality of up to 40% in people with heart failure who are obese, compared to individuals without elevated BMIs [38]. In one study of over 108,927 subjects with de-compensated heart failure, mortality decreased by 10% for every 5-unit increase in BMI [43]. This paradox has attracted considerable interest, and a number of potential mechanisms for the protective effects of body fat and increased BMI have been proposed. These include greater metabolic reserve, protective effects of certain fat-derived factors such as cytokines and of higher blood pressure, reduced activation of the sympathetic nervous system, and lower circulating concentrations of natriuretic peptides [38].
Preservation of Bone Mass

A beneficial effect of obesity in older people is its association with increased bone density. This combines with cushioning of falls provided by the extra fat stores, particularly around the hips ('endogenous' hip protectors) to reduce fracture rates in older people [44]. Most studies show that when overweight adults of any age intentionally lose weight they also lose bone [10, 45]. Substantial unintentional weight loss in older people is associated with an increased risk of hip fracture [46]. This is probably due to a combination of reduced bone mass and the effects of whatever illness caused the weight loss, for example by increasing the likelihood of falls. Although it is reasonable to assume that there is at least some increase in fracture risk due to the weight loss-associated bone loss, in overweight older people who intentionally lose weight, this has not been established.

Mortality

The harmful effects of overweight/obesity on life expectancy are weaker in older than young adults (see below). Nevertheless, the relative risk of mortality is increased at high BMIs until about the age of 75 years, and because of the greater background death rate in older people the absolute increase in death rate attributable to obesity is substantial; 25% of the excess deaths attributed to obesity in a NHANES analysis occurred in people over 70 years [5]. The causes of increased mortality are essentially the same as those in younger adults: diabetes, hypertension, sleep apnea, cardiovascular disease and an increased risk with obesity of developing certain cancers, including breast, uterus, colon and prostate.

The relative increase in the risk of death associated with being obese compared to being normal weight is not as great in older as in young adults. An assessment of 13 observational, prospective studies in which nonhospitalized people over 65 years were followed for at least 3 years [47], found an association between mortality and increased BMI in only a few, and then only above a BMI of 27–28.5, with little or no increase in mortality at any BMI for people over 75 years. Where an optimum BMI could be identified it was usually in the range 27–30. Consistent with this, in the large, prospective, American Cancer Society’s Cancer Prevention Study, involving over 300,000 adults, the BMI associated with a 20% relative increase in mortality above the optimum BMI of 21 rose steadily with age, from 23.8 at 30–44 years to 30.5 at 75–84 years [48] (fig. 1). In the same study, the relative risk of death associated with every increment of 1.0 in BMI decreased significantly with increasing age between age 30 years and ≥85 years, such that there was no significant increase in relative risk of death above age 75 years. Similarly, a combined analysis of the American NHANES I-III (1974–2000) study results found no significant increase in mortality with any degree of overweight in people over 70 years, and an increased death rate