

Obesity and Older Adults

EVIDENCE OVERVIEW
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Healthy weight for all

What determines underweight, overweight and obesity in older people and what are the associated health consequences? Scoping review

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Executive summary

Maintaining a healthy body weight is important for long-term physical and mental health. In Scotland, 78% of older adults aged 65 to 74 years have been classified as being overweight or having obesity. A small proportion of older adults in Scotland also present with underweight. These figures are concerning, as underweight, overweight and obesity can lead to a range of physical and mental health consequences for older adults.

This scoping review aims to identify, summarise, and report relevant evidence on abnormal body weight in older adults. In particular, the review attempts to address the following questions:

- What factors are associated with underweight, overweight and obesity in older adults?
- What are the physical and mental health consequences of underweight, overweight and obesity in older adults?

This review identified a number of factors that are associated with underweight, overweight and obesity in older people, including lifestyle factors, co-morbidities and other conditions, genetic factors, physiological factors, and personal factors.

The evidence identified in this review suggests clear links between underweight, overweight, and obesity and a number of physical and mental health outcomes. The evidence is stronger and more consistent for certain health outcomes, and evidence gaps remain in some areas. There was consistent evidence for associations between class III obesity and underweight and all-cause mortality. There was also consistent evidence for associations between overweight and obesity on cardiovascular disease mortality, high blood pressure, coronary heart disease, diabetes, stroke, chronic conditions, disability (including physical function, activities of daily living, pain, and arthritis), reduced quality of life, cognitive impairment and brain aging, and consistent associations between underweight and reduced physical function. There is less evidence for the impact of body weight on other health outcomes in older adults, including cancer, and some disease indicators. However, previous research in other age groups has demonstrated links between body weight and these outcomes. There was also less evidence for the impact of underweight (compared with evidence for overweight and obesity) on physical and mental health outcomes, with evidence gaps to address in future research.

It should be noted that the majority of the included studies were cross-sectional in design, meaning that the direction of effect cannot be established. For example, presence of disease may cause weight loss/gain or weight loss/gain may cause a particular disease. Whilst there were also a number of reviews and longitudinal cohort studies, some outcomes only had cross-sectional evidence available to draw conclusions. There are also issues associated with measurement of obesity and health outcomes, with different studies using different ways of measuring body weight, different cut-points, and different outcome measures for health outcomes.

These findings suggest that body weight in older adults is likely to have substantial impact on the National Health Service (NHS) and the health and care system. Creating environments to support people to maintain a healthy weight across the life course is important in order to avoid the consequences mentioned above when reaching an older age.

Introduction

The World Health Organization defines overweight and obesity as an abnormal and high accumulation of fat mass. Commonly it is measured through the Body Mass Index (BMI), which indicates the relationship between body weight and height. Whilst BMI cannot establish the amount of fat free mass and fat mass that comprise the total body weight, it is widely utilised to identify people whose weight is higher or lower to what is expected to be a normal weight for height (1).

Worldwide, the prevalence of obesity in adults is 13%, while overweight accounts for 39% (2). Within the countries of the Organisation for Economic Co-operation and Development (OECD), in 2015 the mean prevalence of obesity was 19.5%, and the highest prevalence belonged to the United States (38.2%), followed by the United Kingdom (in the 6th position) with a prevalence of 26.9% (3). In Scotland, a total of 65% of adults between the ages of 16 to 64 years, are classified as overweight or having obesity (4). Of particular concern, 78% of older adults in the UK aged between 65 and 74 years were overweight or had obesity (5).

Underweight, which is less common than overweight and obesity, is also a health concern in the United Kingdom. The Scottish Health Survey, in 2017, reported data for underweight for men and women aged 65 years and over. For men and women aged 65 to 74 years there was no reported data on underweight, and just 1% of women older than 75 years reported to be underweight (4).

Being either below or above a normal BMI ($\geq 18.5 - 24.9 \text{ kg/m}^2$) has been associated with both physical (e.g. cardiovascular disease, diabetes mellitus, etc.) and mental health consequences (e.g. depression/anxiety, dementia, etc.). Both underweight and overweight or obesity can be a cause and consequence of disease in adults and children (6).

In the UK, the British Medical Association considers older adults to be 65 years old or older, as proposed by the Office for National Statistics (7). Older adults are affected by changes in body weight and proportion of fat mass and fat free mass (e.g. muscle mass). A naturally occurring change in body composition, especially an increase in body fat, is expected with the aging process. However, the elderly can also present changes in body weight such as underweight, overweight and obesity due to different causes (8).

Malnutrition happens when a person does not have a diet with the right amount of nutrients and/or calories (9). The spectrum of malnutrition includes undernutrition (not getting enough nutrients) and over nutrition (having a higher intake of the nutrients needed) (10). Both situations can have an impact in health and well-being in older adults (11) (12). Moreover, aging brings a variety of changes of different nature having a direct impact on health: decreased mobility, hormonal imbalance, loss of skeletal muscle with gain of fat (i.e. sarcopenic obesity), moving to a retirement home, among others. These factors can all lead to a change in nutritional status and increased risk of developing chronic diseases, with associated morbidity/mortality implications (13).

The causes and effects of these changes in body weight have been researched due to the accelerated growth of this population and the increased need to develop adequate interventions, and to understand the role of weight and fat mass in health outcomes. The purpose of this scoping review is to identify and synthesise research on determinants and consequences of body weight in the elderly with physical and mental health outcomes.

Aims and objectives

This evidence review aims to identify, summarise, and report relevant evidence on obesity in older adults. In particular, the review attempts to address the following questions:

- What factors are associated with underweight, overweight and obesity in older adults?
- What are the physical and mental health consequences of underweight, overweight and obesity in older adults?

Methods

Design

Scoping review

Search strategy

Relevant databases were searched for articles published between 2009 to March 2019, including: Medline, Embase, PsychInfo, and the Cochrane libraries. Selected search terms for underweight, overweight, obesity, and physical and mental health outcomes were used (see Appendix 1). Screening was conducted in two stages, including title and abstract screening, and full text screening, by two independent reviewers who selected studies for inclusion using inclusion and exclusion criteria (Table 1). A third reviewer resolved any disagreements.

Table 1: Inclusion and exclusion criteria

Domain	Inclusion criteria	Exclusion criteria
<i>Study design</i>	All research design (e.g. quantitative, qualitative, mixed methods)	Protocols, or study outlines without results; dissertations (due to resource limitations)
<i>Population</i>	Adult humans, 65 years and over with either:	Non-human studies; participants below 65 years; participants taking

	- Underweight <18.5 kg/m ² ; or - Overweight ≥25 kg/m ² to <30 kg/m ² and/or obesity ≥30 kg/m ²	medication that induce weight loss or gain (e.g. antiepileptic's, antipsychotics); studies involving people with developmental or intellectual disabilities due to the unique nature of these populations.
<i>Interventions/ variables</i>	Studies reporting factors associated with underweight, overweight and obesity; studies reporting health consequences of underweight, overweight and obesity	Studies investigating anti-obesity drugs/agents (e.g. drug trials). Studies relating to eating disorders
<i>Outcomes</i>	Any mental or physical health outcomes	Outcomes do not relate to physical or mental health.
<i>Other variables</i>	Studies conducted within the last 10 years (to ensure 'currency'); English language paper available. Studies conducted in Scotland or similar countries (e.g. Europe, USA, Australia)	Studies conducted over 10yrs ago; non-English language papers, where a translation is not available.

Data extraction and quality appraisal

Data from each included study was extracted to a table, detailing date, population, geographical location, and findings. The evidence on 1) factors associated with underweight, overweight and obesity, 2) physical health consequences of underweight, overweight and obesity, and 3) mental health consequences of underweight, overweight and obesity are reported in the results section. The nature of the evidence for each health outcome, determined by the study design, was assessed according to the following hierarchy (see Table 2):

1. Systematic review (including meta-analysis) level evidence
2. Scoping and narrative review level evidence
3. Randomized Controlled Trial evidence
4. Longitudinal evidence
5. Cross-sectional evidence
6. Qualitative evidence

Table 2: Strength of evidence table (Higher to lower)

Study design	Some Characteristics	Evidence
Systematic reviews and meta-analysis level evidence	Focused clinical question, comprehensive sources and explicit search strategy, selection based on criterion, rigorous critical appraisal, and qualitative summary of results. Meta-analysis: quantitative approach for systematically combining results of previous research.	1
Scoping and narrative review level evidence	No systematically conducted. Summarizes a topic that is broad in scope.	2

Randomized Controlled Trial (RCT)	Control of various aspects of the research, and it is possible to identify causal links between interventions and outcomes of interest.	3
Cohort studies (Longitudinal)	Non-controlled environment and no intervention. Following through time, and it is possible to identify risk and protective factors.	4
Cross-sectional studies	Give information about a population at a given point in time to determine prevalence. They can infer correlations but not associations of causality.	5
Qualitative studies	Typically smaller sample sizes than quantitative research. Methodologies such as interviews, focus groups, ethnography, among others. Data can include texts, images or videos.	6

We have grouped the results according to different categories regarding physical and mental health outcomes. Each health outcome category presents the summary of the papers according their study design from where the results were extracted. Utilizing the previous table, conclusions could be made towards the strength of the evidence presented.

Results

Following removal of duplicates, 571 studies were identified for screening. Following title and abstract, then full text screening (220 studies), 116 papers were considered to meet all inclusion criteria (see Figure 1).

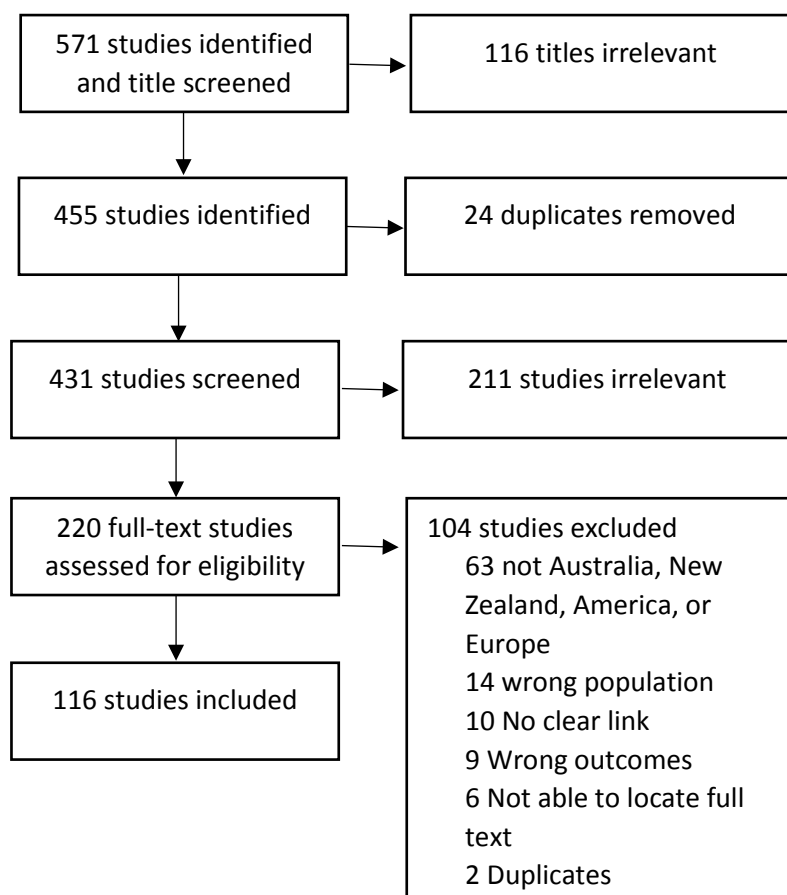


Figure 1 Study Flow Diagram

Factors associated with underweight, overweight and obesity in older adults

A total of 25 studies explored factors associated with underweight, overweight or obesity in older adults. Of these, five were reviews, four were longitudinal studies, 15 were cross-sectional studies, and one was a qualitative study.

A number of factors were identified as related to underweight, overweight and obesity in older adults including lifestyle factors, co-morbidities, genetic factors, physiological factors, and personal factors (see Table 3). Results are reported separately for 1) overweight ($\geq 25 - 29.9 \text{ kg/m}^2$) and obesity ($\geq 30 \text{ kg/m}^2$), and 2) underweight ($\text{BMI} < 18.5 \text{ kg/m}^2$).

Table 3: Factors associated with overweight and obesity in older adults

Type	Specific	Evidence	Strength of evidence
Lifestyle factors	Energy intake	Two narrative reviews noted that increased energy intake was associated with obesity in older adults (14, 15). Similarly, a cross-sectional study found that older adults with abdominal obesity were more likely to consume sweets two or more times per day, and were less likely to consume three or more servings of fruit per day (16).	2 Narrative reviews 1 Cross-sectional study
	Physical inactivity	Two narrative reviews found that low levels of physical activity are associated with obesity in older adults (14, 15), with one review noting that reduced physical activity accounts for 50% of the decrease in energy expenditure that occurs with aging (14). A longitudinal cohort study also found that low physical activity levels were associated with obesity in older adults (17) and a cross-sectional study found that low physical activity levels were associated with sarcopenic obesity (18). On the other hand, a longitudinal study found that regular practice of physical activity was not related with weight or waist circumference (19). A cross-sectional study found that adults with more regular activity rhythms had lower odds of being obese; and irregular activity rhythms were associated with metabolic syndrome (20).	2 Narrative reviews 2 Longitudinal studies 2 Cross-sectional study
	Sedentary behaviour	Two systematic reviews found that overweight and obesity in older adults are associated with sedentary behaviour (21, 22). A cross-sectional study also found that increasing BMI was associated with sedentary behaviour (23).	2 Systematic reviews 1 Cross-sectional study
	Tobacco consumption	One cross-sectional study found that tobacco consumption was associated with obesity (24). This was supported by a longitudinal cohort study of 2283 postmenopausal women, who found that weight gain was associated with smoking (25). A longitudinal study found that former smokers had higher weight and waist circumference than those who never smoked; however, those who were current smokers showed lower weight and waist circumference than those who never smoked (19).	1 Cross-sectional study 2 Longitudinal study
	Alcohol consumption	A longitudinal study found that individuals with moderate or high alcohol consumption were heavier than their counterparts (19).	1 longitudinal study
Co-morbidities or other conditions	Hypertension	A longitudinal cohort study found that not having hypertension was linked with weight gain in postmenopausal women (25).	1 Longitudinal study
	Mental health	In a cross-sectional study, anxiety was associated with a significant increased risk of central obesity, and depression was negatively associated with obesity (16).	1 Cross-sectional study
	Mobility	A cross-sectional study found that older adults with difficulty walking had higher rates of obesity (26).	1 Cross-sectional study
	Arthritis	One narrative review reported that arthritis causes physical immobility, resulting in reduced energy expenditure and high risk of weight gain (14).	1 Narrative review
	Metabolic syndrome	One narrative review reported that components of the metabolic syndrome are associated with obesity (14).	1 Narrative review
	Chronic conditions	A longitudinal study reported that the greater number of non-chronic diseases, the greater the likelihood to have a higher weight and waist circumference (23). This was supported by three cross-sectional studies (24) (27) (28).	3 Cross-sectional studies 1 Longitudinal study

	Oral health	Oral health status was found to be associated with obesity in a cross-sectional study, with people with more than 8 teeth being less likely to have obesity (28). Being edentulous was associated with obesity in two cross-sectional studies (24, 27).	3 Cross-sectional studies
	Eating disorders	A cross-sectional study found that cognitive restraint (conscious restriction of food intake) and emotional eating were significantly associated (positive) with obesity (29).	1 cross-sectional study
Genetic factors	FTO A allele (gene)	The FTO A allele did not significantly predict variance in BMI in a cross-sectional study in a sample of 355 overweight and obese men (30).	1 Cross-sectional study
Physiological factors	Changes in carbohydrate metabolism	One narrative review found that changes in carbohydrate metabolism are associated with obesity in older adults (15).	1 Narrative review
	Age-related physiologic mechanisms	One narrative review noted that age-related physiologic mechanisms are associated with obesity in older adults (14).	1 Narrative review
	Growth hormone & testosterone	One narrative review noted that declines in growth hormone and testosterone production are associated with obesity in older adults (14).	1 Narrative review
Personal factors	Age	A cross-sectional study found that BMI is negatively associated with age (23). Another cross-sectional study also found that younger age (<7 vs. >= 70 years) was associated with obesity (29).	2 Cross-sectional studies
	Residential location	One cross-sectional study found that residential location was linked with central obesity (24), and another cross-sectional study found that living in an urban area was associated with obesity (28). A systematic review found that perceptions of neighbourhood safety was not associated with obesity (31).	1 Systematic review 2 Cross-sectional studies
	Education	High education levels were associated with increasing body weight in men but not females in a longitudinal cohort study (19). Similarly, a cross-sectional study found that higher education (>= 8 vs. <8 years) was associated with obesity (29).	1 Longitudinal study 1 Cross-sectional study
	Gender	Two cross-sectional studies found that females were more likely to be obese than males (27, 28).	2 Cross-sectional studies
	Marital status	A longitudinal cohort study and two cross-sectional studies found that being married was associated with overweight and obesity (19, 23, 24).	1 Longitudinal study 2 Cross-sectional studies
	Income	A cross-sectional study found that higher income was associated with obesity (24).	1 Cross-sectional study
	Food insecurity	A narrative review also found that food insecurity was associated with obesity in older adults (32).	1 narrative review
	Number of teeth	A longitudinal study reported that a positive association between the number of present teeth and body cell mass index (which indicates a better nutritional status as it is muscular tissue) (33).	1 Longitudinal study

Factors associated with underweight in older adults

Identified studies mainly investigated factors associated with overweight and obesity. However, four studies (three cross-sectional; one qualitative study) looked at the factors associated with underweight in older adults. The cross-sectional studies found that factors associated with underweight included sarcopenia (34), being widowed (23), and having epilepsy (35).

The qualitative study identified a range of factors linked with underweight in older adults including factors relating to appetite and taste of food (poor appetite, feeling full, poor taste, not liking food in care homes), difficulties buying and cooking food (e.g. holding pans, opening bottles, going to the supermarket), decreased physical activity, mental health (e.g. mourning, forgetfulness, sadness, stress), hospitalisation and poor health (e.g. medication use, surgery, fatigue, diseases), ability to eat food (e.g. difficulty chewing, swallowing and dental problems), and social isolation, which was said to cause a lack of motivation to cook, and loneliness was related to poor appetite (36).

Physical health consequences of underweight, overweight and obesity in older adults

A total of 66 studies (13 reviews; 15 longitudinal studies; 38 cross-sectional studies) investigated physical health consequences of underweight, overweight and obesity in older adults. Results are reported separately for 1) overweight ($\geq 25 - 29.9 \text{ kg/m}^2$) and obesity ($\geq 30 \text{ kg/m}^2$), and 2) underweight ($\text{BMI} < 18.5 \text{ kg/m}^2$).

In older adults, overweight and obesity was associated with various health consequences, including all-cause mortality (for class III obesity), co-morbidities/other condition, disease indicators or risk factors, mobility and disability, and respiratory conditions. Overweight and obesity was associated with an increased risk of many of these health consequences, however some studies identified no associations or a protective effect. These results are presented in Table 4.

Table 4: Physical health consequences of overweight and obesity

Type	Specific	Evidence	Strength of evidence
Mortality	All-cause mortality	Two narrative reviews found that obesity in older adults is associated with increased risk of all-cause mortality (15, 37). This was supported by a cross-sectional study which found that the 4 th and 5 th highest BMI quintiles were associated with mortality (38) and a longitudinal cohort study (17). However, a scoping review found that overweight older adults had lower risk of mortality than older adults of other weight categories (39), and another review found that overweight was not associated with increased mortality and obesity was associated with a 10% increased risk of mortality (40). Longitudinal evidence also provided support for overweight and class I and II obesity having lower risk of all-cause mortality compared with underweight, normal weight and class III obese older adults (41) (42) (43) (44) (45).	3 Narrative reviews 1 scoping review 6 Longitudinal studies 1 cross-sectional study
	Cardiovascular disease mortality	A narrative review found that obesity increased the risk of death from cardiovascular disease (46). This was supported by a longitudinal	1 Narrative review

		cohort study, which found an increased cardiovascular disease mortality in the higher BMI range, with the effect most pronounced in men with a BMI $\geq 30\text{kg/m}^2$ (44), with another longitudinal study finding that moderate or severe obesity did not increase the risk of death amongst those with cardiovascular disease, but the risk of death was higher in the BMI group $\geq 40\text{kg/m}^2$ (47).	2 longitudinal studies
	Cancer mortality	One longitudinal cohort study found a U-shaped relationship between BMI and cancer mortality, suggesting that underweight and obese adults are most at risk of cancer mortality (44)	1 longitudinal study
Co-morbidities	Metabolic syndrome	A narrative review reported that high abdominal fat mass is indicative of metabolic syndrome (14), which was supported by a cross-sectional study that found associations between overweight and obesity and metabolic syndrome prevalence (48).	1 Narrative review 1 cross-sectional study
	High blood pressure	Two narrative reviews reported that obesity is correlated with high blood pressure (14, 49). This was supported by six cross-sectional studies, which also identified links between increasing BMI and blood pressure (50) (51) (48) (52) (53) (54) and one longitudinal study (55).	2 Narrative reviews 6 cross-sectional studies 1 longitudinal study
	Cardiovascular disease incidence	Two narrative reviews reported that obesity increases the risk of cardiovascular disease (14, 46). Three cross-sectional studies reported inconsistent findings, with one study reporting that overweight and obese older adults had a higher prevalence of cardiovascular disease incidence compared with normal weight adults (56) and two finding no association between BMI and cardiovascular disease (57, 58).	2 Narrative reviews 3 cross-sectional studies
	Coronary heart disease	A narrative review reported that obesity increases the risk of coronary heart disease in men but not in women (14), similarly a cross-sectional study found that obesity was associated with chronic heart failure in older adults (59). A longitudinal study found that obesity has a predictive effect for heart conditions (55).	1 narrative review 1 cross-sectional studies 1 longitudinal study
	Cancer	A narrative review and a longitudinal study found that obesity has a predictive effect for cancer (49, 55). A cross-sectional study found no association between BMI and cancer (57).	1 narrative review 1 cross-sectional study 1 longitudinal study
	Stroke	Two narrative reviews and a longitudinal study found that obesity has a predictive effect for stroke (46, 49, 55). However, a cross-sectional study found no association between BMI and stroke (57).	2 narrative reviews 1 cross-sectional study 1 longitudinal study
	Chronic conditions	A systematic review found that waist-to-height ratio is associated with non-communicable diseases (60). A longitudinal cohort study found that overweight and obese older adults had significantly more chronic conditions compared to normal weight adults, and had a much faster rate of chronic health conditions increase over time than normal weight adults (61). This was supported by two other longitudinal studies and one cross-sectional study (17, 62, 63). Two other cross-sectional studies found that higher BMI was associated with taking multiple medications (polypharmacy) (54, 64).	1 systematic review 3 longitudinal studies 3 cross-sectional studies
	Diabetes	Two cross-sectional studies and a longitudinal study reported an association between overweight and obesity and diabetes (55) (59) (57), and another cross-sectional study found that overweight and obesity was associated with hyperglycaemia (48). One cross-sectional study found no association between BMI and diabetes (58). Another cross-sectional study found that with those with both obesity and diabetes, the impact of obesity appears to outweigh that of diabetes (65). One RCT found that changes in insulin sensitivity index correlated	5 cross-sectional studies 1 longitudinal study 1 RCT

		significantly with changes in intrahepatic fat content but not with total body fat (66).	
Disease indicators	Self-reported health	A cross-sectional study found that older adults with obesity have lower self-reported health in rural regions compared to older adults with obesity in urban regions (67).	1 cross-sectional study
	Inflammation	A narrative review found that overweight and obesity was associated with increased levels of circulating pro-inflammatory cytokines TNF-, IL-6, and CRP, and noted that some studies have demonstrated a decrease in these cytokines with weight loss (68). Another narrative review found that obesity is associated with inflammation in older adults (37).	2 narrative reviews
	Kidney function	A longitudinal cohort study found that obesity was negatively associated with glomerular filtration rate (a measure of kidney function) (69).	1 longitudinal study
	Disease severity	A cross-sectional study of 76 adults found that disease severity was negatively associated with BMI (70).	1 cross-sectional study
	Sleep quality	A cross-sectional study found an association between obesity and poorer sleep quality (51)	1 cross-sectional study
	Blood lipids	Three cross-sectional studies found that overweight and obesity was associated with hypertriglyceridemia and dyslipidaemia compared with normal weight older adults (48, 53, 56), however another cross-sectional study found no association between BMI and lipid profile (58).	4 cross-sectional studies
	Nerve damage	A cross-sectional study found that abdominal obesity was associated with polyneuropathy (71).	1 cross-sectional study
	Lymphocytes	A cross-sectional study found that BMI was not associated with lymphocyte subsets (72).	1 cross-sectional study
	Wound healing	A clinical review reported that obesity increases the risk of wound healing problems including lymphedema and venous insufficiency (73).	1 Narrative review
	Vitamin D deficiency	A cross-sectional study found a significant correlation between vitamin D serum deficiency and obesity (58).	1 cross-sectional study
	Amyloid deposition	A cross-sectional study found a non-significant relationship between BMI and amyloid retention in overweight and obese older adults (74)	1 cross-sectional study
	Urinary incontinence	Obesity in older adults was weakly associated with urinary incontinence in a cross-sectional study (59)	1 cross-sectional study
	Mobility	Physical function	Two narrative reviews found that obesity is associated with declines in physical function (14) (15). Two longitudinal studies supported this, with one reporting that obesity significantly increased the risk of frailty in older adults (75) and another finding that years of physical functioning lost by age 85 years due to obesity was 6.1 years for men and 8.1 years for women (45). Six cross-sectional studies also found that obesity was associated with significantly lower physical function (67) (50) (76) (77) (78) (79), and one cross-sectional study found no significant differences in total functional performance scores between normal weight, overweight and obese groups; however noted that waist-to-hip ratio was significantly correlated with functional performance (70).
Activities of daily living		A longitudinal cohort study found that obesity at age 50 was associated with activities of daily living disability in elderly adults, and overweight was associated with an increased risk of activities of daily living disability. Amongst obese adults at age 50, weight gain (but not weight loss) was associated with increased risk of activities of daily living disability in elderly adults (80). A cross-sectional study found	2 longitudinal studies 2 cross-sectional study

		that adults with Alzheimer and a high waist circumference had lower scores on the ADL test (81). Finally, a longitudinal study found that central obesity was associated with all three disability outcomes in the instrumental activities of daily living (82), which was supported by a cross-sectional study (59).	
	Mobility	A clinical review reported that obesity was associated with 44% greater odds of mobility decline compared with normal weight older adults (33), which was supported by a cross-sectional study (83). Another cross-sectional study found no significant associations between BMI and falls (57).	1 Narrative review 2 cross-sectional studies
	Strength	Three cross-sectional studies found that higher body fat was associated with lower strength or skeletal muscle mass (18, 77, 84). However, one cross-sectional study found that participants with a higher body cell mass index were significantly more likely to have strong masseter muscle tension (85) and a longitudinal study found that central obesity was not associated with dynapenia (loss of strength) (17).	1 longitudinal study 4 cross-sectional studies
	Disability	Two reviews found that obesity was predictive of future disability (14, 39). This was supported by a longitudinal study, which found that obesity was an independent risk factor for developing functional disability in older adults (86), and three cross-sectional studies (87-89).	2 narrative review 1 longitudinal study 3 cross-sectional studies
	Pain	A cross-sectional study found that obesity and severe obesity was associated with chronic pain, with a dose response relationship between increasing BMI and increasing prevalence of chronic pain (90). This was supported by two further cross-sectional studies, which found associations between BMI and pain (91, 92).	3 cross-sectional studies
	Arthritis	Two narrative reviews reported that obesity is associated with arthritis and osteoporosis of weight-bearing joints (14, 49). Similarly, three cross-sectional studies and a longitudinal study reported associations between increasing BMI and prevalence of joint symptoms (93) and arthritis (57) (50) (55).	2 narrative reviews 3 cross-sectional studies 1 longitudinal study
	Osteoporosis	A cross-sectional study found no association between BMI and osteoporosis (57).	1 cross-sectional study
	Osteoarthritis	A cross-sectional study found that overweight and obese older adults had higher prevalence of osteoporosis compared with normal weight older adults (56).	1 cross-sectional study
Respiratory conditions	COPD	A cross-sectional study found that adults with previously undiagnosed COPD had higher waist circumference and more frequent abdominal obesity (94)	1 cross-sectional study
	Dyspnoea	A cross-sectional study of 76 older adults found that truncal fat predicted dyspnoea (70).	1 cross-sectional study
	Lung capacity	A cross-sectional study found that FEV1% was significantly higher in overweight and obese adults compared with normal weight adults (70). Obese older adults (and underweight) had higher prevalence of breathlessness compared with normal weight and overweight older adults (95).	2 cross-sectional studies
	Respiratory disorders	A cross-sectional study found that respiratory disorders were most common in morbidly obese (and underweight) older adults compared with other weight categories (50). Another cross-sectional study found no association between BMI and asthma or chronic lung disease (57). A longitudinal study found that asthma status was related to obesity but BMI status was not significantly associated (96).	1 longitudinal study 2 cross-sectional studies

Physical health consequences of underweight

A total of 15 studies (4 narrative reviews; six longitudinal studies; five cross-sectional studies) looked at the physical health outcomes associated with underweight in older adults.

A narrative review found that low BMI was an independent risk factor for increased risk of mortality (97), and two other narrative reviews also found an increased risk of death with the lowest BMI category (46, 49). A further narrative review concluded that low BMI may be linked to existing illnesses or conditions that cause this increased risk of mortality (40). Similarly, a longitudinal study of 4565 older adults found that underweight older adults (BMI < 18.5kg/m²) had at least 2-3 times greater risk of all-cause mortality than older adults with a normal weight (BMI 18.5 to 24.9kg/m²) (42). A longitudinal cohort study of 74,167 older adults reported that underweight adults had 45% greater mortality rates compared to normal weight subjects (43). Another longitudinal study found that underweight older adults with cardiovascular disease had increased risk of all-cause mortality compared with those without cardiovascular disease (47). A longitudinal cohort study found that chronic health conditions of underweight older adults did not differ from normal weight older adults, however, underweight older adults had a significantly slower rate of chronic health conditions increase over time than adults of normal weight (61).

A cross-sectional study found that underweight older adults (as well as those with obesity) had a higher prevalence of breathlessness compared with normal weight and overweight older adults (95). A cross-sectional study found that respiratory disorders were most common in underweight older adults (and those with morbid obesity) compared with other weight categories (50). Similarly, a narrative review reported that underweight was associated with loss of peripheral and respiratory muscle mass, increasing vulnerability to acute infectious diseases (40).

Six studies looked at the impact of underweight on physical function/mobility outcomes. A narrative review found that underweight increases the risk of disability and reduces mobility (49). Similarly, three cross-sectional studies found that underweight was associated with lower physical function/component scores (50) (67) (76), and in a longitudinal study, underweight was an independent risk factor for developing functional disability in older adults (86). A cross-sectional study found that risk of falling or trouble walking was more likely to be reported by underweight older adults (or those with obesity or morbid obesity), compared to normal weight older adults (50). However, a longitudinal cohort study found no association between baseline underweight (aged 50 years) and disability status in older adults (80).

Finally, a cross-sectional study found that underweight elderly participants had a 68% higher prevalence of anaemia, compared with normal body weight elderly individuals (98).

Mental health consequences of underweight, overweight and obesity in older adults

The following section presents the main results found in the review regarding the associations of underweight, overweight and obesity on mental health outcomes in older adults. The following are the categories into which the results were classified:

- Psychological wellbeing (e.g. quality of life, satisfaction with life)
- Cognitive performance/decline (training effects on memory, reasoning, verbal fluency)
- Dementia (e.g. Alzheimer's disease)
- Depression/anxiety
- Others (e.g. stress, sleep, delirium)

A total of 42 studies (11 reviews, 8 longitudinal studies, 22 cross-sectional studies and 1 randomized-controlled trial) investigated the relationship between obesity and mental health outcomes in older adults. Results are reported separately for 1) overweight ($\geq 25 - 29.9 \text{ kg/m}^2$) and obesity ($\geq 30 \text{ kg/m}^2$), and 2) underweight ($\text{BMI} < 18.5 \text{ kg/m}^2$).

Mental health consequences of overweight and obesity

In general, obesity was associated with lower psychological wellbeing, impacting on the overall quality of life of older adults.

Losing weight could have contradictory consequences. It can improve the mental component scores of the quality of life questionnaire, but it can also be a sign of underlying dementia and decrease cognitive performance, when it happens faster than normal. Cognitive performance has been reported to be lower in older adults who are overweight or have obesity. Additionally, when older adults with obesity received memory training, they reported lower training effects than the participants without obesity.

Regarding dementia, the evidence is also conflicting. Some authors mentioned that obesity was associated with brain aging being a risk factor for dementia, increasing the risk to develop Alzheimer's disease. On the other hand, some studies showed that obesity was negatively associated with dementia, or even it did not have any association. Also, the results could vary (increasing/lowering the risk) depending on the onset of obesity (mid-life vs late life). Another important outcome is depression, which was also found to be linked to overweight and obesity in older adults, and to have a dose-response relationship to levels of overweight and obesity.

Finally, obesity was also associated with greater levels of stress, but not with other nervous or emotional problems, or even with Parkinson's disease. Furthermore, losing weight in a controlled way, improved profile of mood states, and sleep duration and efficiency (see Table 5).

Table 5. Mental health consequences associated to overweight and obesity in older adults

Type	Specific	Evidence	Strength of evidence
Psychological wellbeing	Self-reported mental health status	Two cross-sectional studies showed found that being overweight or morbidly obese did not have a significant impact on the mental component of quality of life (50, 67). However, one of the studies showed that normal weight and obese individuals living in rural areas had lower mental wellbeing than their counterparts living in urban areas (67). A third cross-sectional study found that white adults had a significant trend showing worse self-rated mental health with increase in BMI, whereas black adults had better self-rated mental health with increase in BMI (99).	3 Cross-sectional studies
	Quality of life and life satisfaction	In a cross-sectional study, obesity was found to be significantly associated with lower quality of life and life satisfaction; and the association was greater in class II/III obesity than in class I (100). Another cross-sectional study found that adults with normal nutritional status were significantly connected with less frequent reporting worse quality of life (83). A longitudinal study found that men and women with a given BMI, each 6 cm increase in waist circumference was significantly associated with a lower quality of life in men and women. However, in women, for a given waist circumference, increased BMI was positively associated with better quality of life (101). Also, a narrative review found that sarcopenic obesity is associated with poor quality of life (15).	2 Cross-sectional studies 1 Longitudinal study 1 Narrative review
	Quality of life - Weight loss	An RCT with older adults and weight loss reported that losing weight improved the mental health composite of QOL scores at 3 months (102).	1 Randomized-controlled trial
Cognitive performance/decline	FTO gene	A cross-sectional study found that the presence of an allele of the FTO gene has a negative influence on human cognition, especially verbal fluency, when individuals are overweight or obese (30).	1 Cross-sectional study
	Cognitive impairment	A longitudinal study identified obesity as a risk factor for the development of mild cognitive impairment (103). A cross-sectional study also found a positive association between obesity and high waist circumference with severe cognitive impairment (104). Another two cross-sectional studies found that overweight and obesity (105, 106) were positively associated with poor cognitive performance. This was also reported in a scoping review (39). A cross-sectional study did not find any association between BMI and any of the domains of the Battery for Assessment of Neuropsychological Status (BRANS) (107).	1 Longitudinal study 4 Cross-sectional studies 1 Scoping review
	Weight change	A longitudinal study showed that women who lost weight had a lower cognitive function than women with stable weight or even those who gained weight. Those who lost >10% of weight had worse performance than those gaining <10% (25). A longitudinal study with 2802 participants found that older adults with obesity had a lower	1 Longitudinal study 1 Longitudinal study

	Training on memory, reasoning and speed of processing	training effect on memory; training effect of reasoning and speed of processing training did not differ by BMI class (108).	
	In patients with epilepsy	A cross-sectional study showed that overweight and obesity in epilepsy older adults did not have an association with cognitive performance (35).	1 Cross-sectional study
Dementia	Brain aging	A cross-sectional study suggest that obesity is associated with brain aging (a risk factor for dementia) (109). A narrative review also reported that obesity may contribute to global and regional brain atrophy (110). A cross-sectional study found that higher BMI was associated with lower brain volume in patients with mild cognitive impairment or Alzheimer's (111). Another cross-sectional study, reported a 1-1.5% average reduction of brain tissue with every unit increase in BMI in older adults (112). A cross-sectional study reported a significant positive relationship between total grey matter volume and BMI; no relationship was found for white matter volume and BMI (107). A cross-sectional study did not find an association of obesity with white matter hyper intensities volumes (113).	5 Cross-sectional studies 1 Narrative review
	Alzheimer's Disease	A scoping review (39) presented contradictory effects of overweight and obesity on the risk of Alzheimer's Disease. Some studies showed a protective effect of obesity towards dementia, but others showed an increased risk. However, a meta-analysis in this review showed that weight gain, central obesity and high fat mass increased risk of dementia. Two narrative reviews concluded that obesity is associated with an increased risk of Alzheimer's disease, especially when obesity started in mid-life (110, 114). A further longitudinal study showed that midlife obesity was associated with greater Alzheimer's disease-pattern neurodegeneration (115). Another narrative review found that for every unit increase in BMI at age 70, the risk of Alzheimer increased by 36% (46). Adding to this results, a forth narrative review mentioned that the pro-inflammatory state caused by obesity is related to vascular dysfunction in the brain increasing the risk of developing Alzheimer's disease (49). A cross-sectional study showed that obese patients with Alzheimer's disease had a bigger reduction in cognitive performance than overweight patients (81).	1 Scoping review 4 Narrative reviews 1 Longitudinal study 1 Cross-sectional study
	Late Onset Alzheimer's Disease	A cross sectional study showed that BMI and waist circumference were not associated with late onset Alzheimer's disease (LOAD). Whereas waist to hip ratio was positively associated with higher risk of LOAD (116).	1 Cross-sectional study
	Dementia	A systematic review presented consistent results of a positive relationship between overweight/obesity and dementia (including Alzheimer's disease and vascular dementia) (117).	1 Systematic review 4 Narrative review 1 Longitudinal study

		<p>A longitudinal study reported that abdominal obesity in adults older than 75 years was negatively associated with dementia, but not for adults between 65-75 years (118).</p> <p>Four narrative reviews found an association between elevated adiposity and weight in middle age, and higher risk of dementia (46, 114, 119, 120). One of the reviews mentioned that high BMI in older ages has conflicting results regarding association with dementia (46). Another of these reviews mentioned that overweight in late life was not related with dementia, and being obese showed a reduced risk of developing it (120).</p> <p>A longitudinal study with 423 adults showed that obesity increased the risk of incident motoric cognitive risk syndrome (pre-dementia syndrome) (121). Also, a meta-analysis concluded that obesity increases the risk of developing this syndrome (122).</p>	<p>1 Longitudinal study</p> <p>1 Meta-analysis</p>
Depression	<p>Depressive symptoms</p> <p>Anxiety/depression</p> <p>Neutrophil Gelatinase-associated lipocalin plasma levels</p>	<p>One cross-sectional study reported that older adults with obesity and diabetes (diabesity) had more depressive symptoms than those with neither diabetes nor obesity (79). Two cross sectional studies showed that obesity was significantly associated with higher degrees of symptoms of depression (87, 100). One of these, found that the association was greater in class II/III obesity than in class I (100). However, a narrative review reported that subjects with a higher BMI had lower prevalence of depressive symptoms when compared with subjects with lower BMI (115).</p> <p>A cross-sectional study did not find a significant association between obesity and depression/anxiety (29). However, a second cross-sectional study concluded that higher values of BMI were related to more problems of anxiety and depression (123).</p> <p>In a cross-sectional study, it was reported an association between greater waist circumference and severity of depression (124). Similar results were found by a longitudinal study reporting that women with increased waist circumference for a given BMI had higher odds of reporting depressive symptoms (101).</p> <p>Neutrophil Gelatinase-associated lipocalin (adipokine associated with late-life depression) plasma level were elevated in adults with a pathologically increased waist circumference in a cross-sectional study (124).</p>	<p>3 Cross-sectional studies</p> <p>1 Narrative review</p> <p>3 Cross-sectional studies</p> <p>1 Longitudinal study</p> <p>1 Cross-sectional study</p>

Others	Stress	A cross-sectional study showed that obesity was significantly associated with higher perceived stress by older adults (87).	1 Cross-sectional study
	Emotional/nervous problems or Parkinson's disease	One cross-sectional study did not find any significant association between overweight and obesity with emotional, nervous or psychiatric problems, or Parkinson's disease (57).	1 Cross-sectional study
	Mood – weight loss	An RCT with older adults and weight loss reported that those who lost weight showed improvements in the profile of mood states (total mood disturbance, depression, anger, fatigue and vigour) (102).	1 Randomized-controlled trial
	Sleep – weight loss	The same RCT reported that those who lost weight showed improvements in sleep duration and sleep efficiency (102).	1 Randomized-controlled trial
	Delirium	A cross-sectional study found that patients with malnutrition were more likely to develop delirium (97).	1 Cross-sectional study

Mental health outcomes related with underweight

Underweight in older adults represents a source of mental health-related consequences. Two cross-sectional studies showed that underweight individuals had lower mental component scores in a questionnaire measuring quality of life (50, 67). Regarding dementia, a prospective cohort study showed that being underweight in late life, but not in mid-life, was positively associated with dementia, increasing the risk by 60% (120). The authors attributed the differences in associations between BMI and dementia in mid- and late-life to the imprecise predictive value of BMI, and suggested that body fat might be a better predictor of the risk of developing dementia.

Also, a scoping review presented, in one of the studies, that having a low BMI or a faster decline in body weight may indicate underlying dementia (39). Similarly, a narrative review reported that losing weight is associated with dementia in older adults (40). Besides, a cross-sectional study found that demented patients with a BMI lower than 23 had cognitive dysfunction (97). Finally, a cross-sectional study showed that malnourished older adults with epilepsy had lower scores for cognitive measurements (35). However, in the same study those with lower body fat had better performance in the phonetic verbal fluency test and in the immediate memory performance test (35).

To conclude this section, body weight in older adults appears to impact mental health outcomes, however the results are sometimes conflicting. It can be concluded, that being overweight or having obesity in later life (65 years or over) decreases quality of life, and can increase the risk of developing certain disorders such as dementia (Alzheimer's disease and Vascular Dementia) and depression/anxiety. However, it is important to consider that the time point of the onset of obesity seems to be a determinant of the role that it is going to play when protecting or increasing the risk for certain conditions. Underweight appears to be associated with mental health, with much of the existing evidence exploring links between underweight and dementia. Also, weight change deserves a deeper exploration, given that the results can be conflicting.

Limitations

A number of limitations of the included studies and the review should be acknowledged when interpreting the findings. In particular, the majority of the included studies were cross-sectional in design which makes it impossible to attribute cause-and-effect. For example, for many health outcomes it is unclear whether obesity is causing the health outcome or whether the health outcome is the cause of the obesity. Longitudinal cohort studies provide greater insight into this, however it can still be challenging to fully understand the direction of effects as measurement of some outcomes, e.g. early onset dementia, is notably difficult.

Due to the broad, scoping nature of the search, and limiting the findings to countries with similar profiles to the UK, it is possible that some relevant evidence is missing and that inclusion of additional evidence may influence the conclusions of the review.

There were also inconsistencies in how individual studies determined underweight, overweight or obesity (i.e. body weight, body composition, waist circumference) and health outcomes, which could have impacted on the results and the interpretation of the findings.

Conclusions and recommendations

This scoping review has identified 116 studies (including reviews, longitudinal studies, cross-sectional studies, randomized controlled trials, and qualitative research) which has explored 1) the factors associated with underweight, overweight or obesity in older adults, and 2) the health consequences of underweight, overweight or obesity in older adults.

Various factors were found to be associated with underweight, overweight or obesity in older adults, including lifestyle factors, co-morbidities and other conditions, genetic factors, physiological factors, and personal factors.

Underweight, overweight or obesity was associated with a number of physical and mental health outcomes in older adults. However, for some health outcomes the evidence was inconsistent or limited to cross-sectional studies or few studies. In these instances, it is difficult to form conclusions about the links between body weight and health. The findings do, however, suggest that body weight does seem to be associated with several health outcomes for older adults. Consistent evidence was identified (>3 studies) for the association between underweight/class III obesity and all-cause mortality. There was also consistent evidence for associations between overweight and obesity on cardiovascular disease mortality, high blood pressure, coronary heart disease, diabetes, stroke, chronic conditions, disability (including physical function, activities of daily living, pain, and arthritis), reduced quality of life, cognitive impairment and brain aging, and consistent associations between underweight and reduced physical function. There are potential associations between underweight, overweight and obesity and other health outcomes, however reported findings are inconsistent or

there are a low number of studies (≤ 3 studies) to support conclusions. It is important to note that there are a number of factors which could confound the results. For example, onset of disease may be difficult to accurately measure and may confound the relationship between body weight change and health outcomes as it may be a health outcome (e.g. dementia) causing change in weight, rather than change in weight causing (the outcome) dementia.

Two scoping reviews provided some evidence for potential beneficial effects of weight loss in older adults, and identified the need for further research to understand the safety and efficacy of weight loss in older adults (125, 126). However, given the paucity of this evidence, adults should be encouraged to arrive to old age at a healthy weight, rather than to lose weight, to promote or maintain health status and physical function. In addition, the current obesogenic environment should be modified to support members of the population to maintain a healthy weight throughout the lifespan.

Appendices

Appendix 1: Example search terms (used in various combinations and adapted for different databases)

Combine (OR)	Combine (OR)	Combine (OR)
Obese Obesity Overweight Malnutrition Adiposity Fat mass Body weight Skinfold thickness Weight to height ratio BMI Body mass index Waist circumference Sarcopenic obesity Underweight Muscle mass wasting Sarcopenia Thinness Leanness	Mental health Mental illness Well-being Physical health Health Disease Chronic diseases Non-communicable diseases	Older adults Elderly Aged Aging
COMBINE (AND)		

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