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Evidence base for the key concepts of healthy eating for older adults in the UK

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Introduction

The Older People Specialist Group of the BDA is working to develop a resource to guide healthy eating in older age. This is because the healthy eating messages for the general population are not appropriate, due to the additional factors which influence health and eating with ageing.

Six topics were identified as important to include in the new resource:

- Healthy body weight,
- Importance of Nutrient Density,
- Importance of Hydration,
- Importance of Vitamin D,
- Importance of activity (alongside nutrition),
- Joy in Eating

Each of these areas needed an evidence base to support any advice provided in the new resource.

This report summarises the evidence available in the literature to underpin the patient facing resource. Each area has been searched, the findings summarised and references listed. The search strategy used is specified with the criteria for inclusion of articles in the literature summary. The topic areas were adapted as the work developed to align with the available information.

The report is designed to allow the searches to be reproducible (search terms and databases specified) but the searches are not exhaustive or comprehensive. This is not a systematic review. The searches were limited to retrieving systematic reviews or other narrative reviews to use the available resources efficiently. Other original articles may be included were appropriate.

This report provides the evidence base for this new patient facing resource and can be up dated in the future using the same methodology.

Literature Review

Review framework and methods

Review framework

The work presented in this report outlines the process used to capture relevant evidence to underpin the proposed health promotion guide. A systemic approach was adopted using a well known framework (Arksey and O'Malley, 2005) for scoping reviews. This approach involves five stages:

1. Identifying the research question and objectives
2. Identifying relevant studies
3. Study selection
4. Charting the data
5. Collating, summarising and reporting the results

Various adaptations to the process were adopted in order to capture sufficient information to support the development of the proposed healthy eating guide, yet complete the work within the resources available.

Research question & objectives

The research question is: "What evidence exists to inform a healthy eating guide for older adults?".

The objectives of the review were to identify the evidence supporting five essential concepts for healthy eating in older adults, which include:

1. Nutrient dense diet,
2. Healthy body weight,
3. Vitamin D requirements
4. Physical activity enhanced by protein intake
5. Enjoyment of eating

Statements relating to each of these concepts were developed then used to build each search strategy and inform the choice of key words.

Inclusion criteria

The following criteria guided our literature searches.

Types of participants

Studies were sought that included healthy older adults (above 65 years old). Studies with older adults with potential risks of metabolic and other diseases were included. However, studies with adults with a diagnosed disease were excluded, because these people will require adjustment to healthy eating advice to manage their condition.

Phenomena of interest

Searches were developed for each of the five areas of interest (nutrient dense diet, healthy body weight, vitamin D requirements, protein for muscles function and enjoyment of eating).

Context

Due to resource constraints this review only focused on recent evidence relevant for public health advice. The timeframe was limited to the last 10 years (2012-2021). In two cases (physical activity and enjoyment of eating) the number of final studies was unmanageable and so limits were reduced to the previous 5 years (2017-2021).

Sources of evidence

The main source of evidence sought for each concept were any type of systematic review. These are studies where researchers have conducted comprehensive and systematic searches of the literature, appraised quality of evidence, and possibly used meta-analysis to combine results of more than one study. If systematic reviews were not available, narrative reviews or expert opinion articles were sought to obtain summarised information about the topic area. Only one topic warranted the use of original research (nutrient density).

Identifying relevant studies

A search strategy was developed for each concept of interest and applied to two or more relevant medical, healthcare or social science databases (these are specified below). Given the linguistic and resource limitations of the review team, only studies reported in English were considered.

Databases

Systematic searches of the following electronic databases (outlined Table 1) were conducted between April and September 2021.

Table 1: Electronic databases used throughout the searches

Database (in the order search was conducted)	
1	The Cochrane Library The Cochrane Database of Systematic Reviews
2	MEDLINE (Ovid)
3	EMBASE (Europe)
4 (only for enjoyment of eating)	PsychInfo

Search terms

The terms used to search the databases consisted of MeSH (or thesaurus) headings and keywords that related to the research question, concept and inclusion criteria. The terms were searched in singly and combined using Boolean operators to identify relevant literature as shown in Table 2.

The final search strategy for each concept is shown in Appendix 1. Additional inclusion and exclusion criteria (shown in Table 3) were set on the database searches to enhance specificity.

Table 2: Search terms & MeSH headings used in database searches

1st Filter	AND	2nd Filter	AND	3rd Filter	AND	4th filter
Older adult* OR elderly* OR above 65, geriatr*, senior, aged		Nutrient dens* OR micronutrient*, nutrient rich*, dens* food Optimal levels of protein, calcium, folate, vitamin B-12 / eating habit* OR dietary allowance* OR diet therapy or practice guideline Deficiency or supplementation of vitamin D colecalciferol Protein meal OR snack, high biological value, nutrient distribution AND physical activity OR muscle mass OR strength Body mass index OR BMI OR weight, overweight, obes*, weight loss, thinness AND mortality, morbidity prevention, activities of daily living, risk factors (AND ethnic minorities) **Subgroup a** eating. Food habits, Choice, Preference, eating behaviour, dietary exposure, foodway*, feeding behaviour/ food preferences/ (eat* or meal* or nutrition) ((shop* or eat* or consum* or food* or feed* or diet*) adj3 (behave* or habit* or strateg* or decid* or decis* or pattern* or choice* or preference*)).mp. culinary practi*.mp. meals/ DIET/ “DIET, FOOD, AND NUTRITION”/ **Subgroup b** pleasure/ (Pleasur* or pleasant* or fun of enjoy* or epicur* or hedon*).tw. (Delight, happ*, joy* satisfact*, treat*).tw.		English language and 2012-2021 (until July or September)		Reviews

* = Truncation symbol indicates databases searched for word ending variants

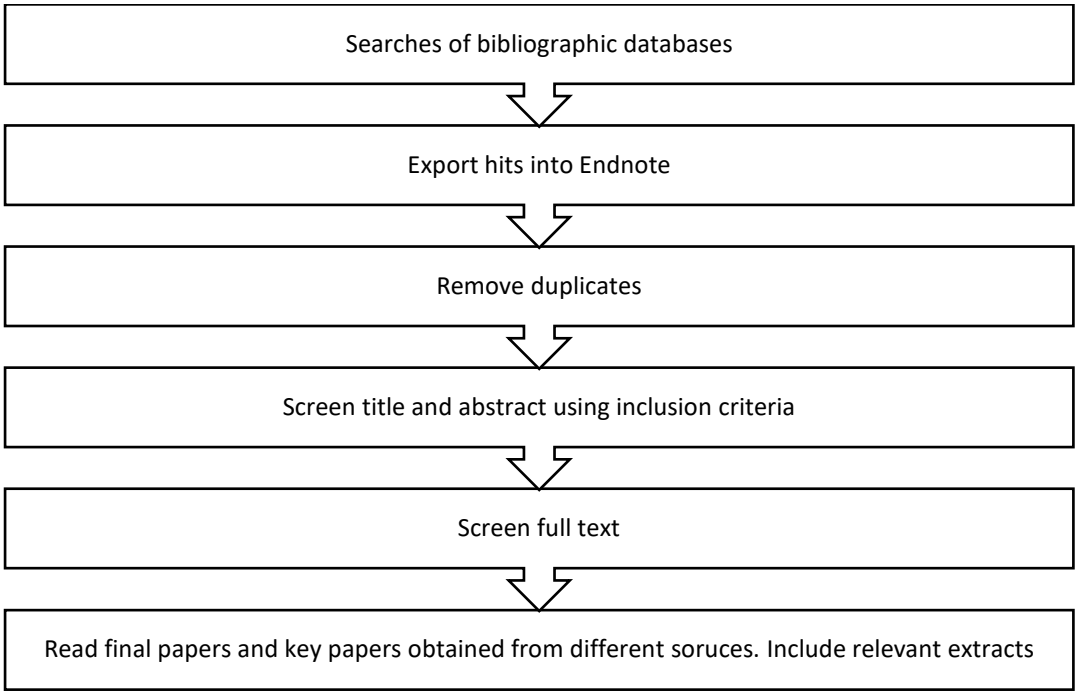
Table 3: Inclusion and exclusion criteria set on database searches

Inclusion	Exclusion
Written in English language	Magazines
Full text	Infants, adults only studies
Academic journals	Foreign language
Human studies only	Anything before 2012
International literature	Unpublished literature
Literature reviews	Qualitative
From specific years (2012-2021)	Quantitative
	Grey literature
	Dissertation abstracts
	Conference proceedings
	Children
	Adolescence

Process for study selection

A systematic process for the identification and selection of relevant studies for each area of the review was conducted as shown in Figure 1. This sequential approach allowed for more information about studies to be elicited before making a decision as to whether they were eligible for inclusion or exclusion in the review.

Figure 1 Flow diagram of study selection



The inclusion and exclusion criteria were agreed based on the focus of the review and statements. These criteria were used to screen by title, abstract and full text. To

ensure transparency, studies excluded at the abstract and full text screening stages were documented with a justification of why they did not meet inclusion criteria (see PRISMA for every area).

Bibliographic management

EndNote bibliographic database was used for collecting and managing data during this review. Endnote files are available.

Assessment of methodological quality

Assessment of methodological quality was not undertaken; this was outside the remit and resources of the project. The rationale for the use of reviews (ideally systematic reviews) was that the evidence had been assessed for quality as part of the original review methodology.

Charting, collating, summarising and reporting the results

Reporting of study selection

Study selection was documented and presented on a PRISMA flow diagram for each concept.

Collating and summarising data

Data from included sources of evidence was extracted using key word finder and reading the relevant sections for the key concept. For instance, for vitamin D there were several papers that mentioned other key nutrients for older adults. Nevertheless, the focus was extracting data from vitamin D only. Quotes were extracted and only occasionally paraphrasing was used. Each piece of information included author and year and the whole citation was included in the reference list.

Results

The five concepts are presented in the following sections with this structure:

- Concept for healthy eating on older adults
- Proposed statements to be used in the healthy eating guide
- Method (describes paper number from preliminary selection to full text)
- Findings or paper extracts grouped per statement
- Highlights or summary and conclusion
- References

Each search strategy and PRISMA statement appear at the end of the document in the appendices or when describing the method, respectively.

Vitamin D

Statements

These were divided into two areas (supplements and sunlight) for ease of searching and increased chances of obtaining relevant hits.

Vitamin D supplements

1. You cannot meet Vitamin D requirements through food alone (and therefore taking a supplement is healthy and one of the most effective ways of meeting your needs)
2. You should purchase an over the counter vitamin D supplement (generic brands may be more cost effective than branded products)
3. You should take a vitamin D supplements between the months September to March
4. Vitamin D3 supplement is preferable to Vitamin D2 as it is more readily absorbed. Vitamin D2 may be more acceptable to people who are Vegan

Sunlight and vitamin D

1. Between late March to September, you can make vitamin D from sunlight as long as you are exposing enough of your skin for at least 10 minutes a day (ensuring safe sun exposure)

2. If you do not expose your skin to sunlight, you should take a vitamin D supplement all year round

Method

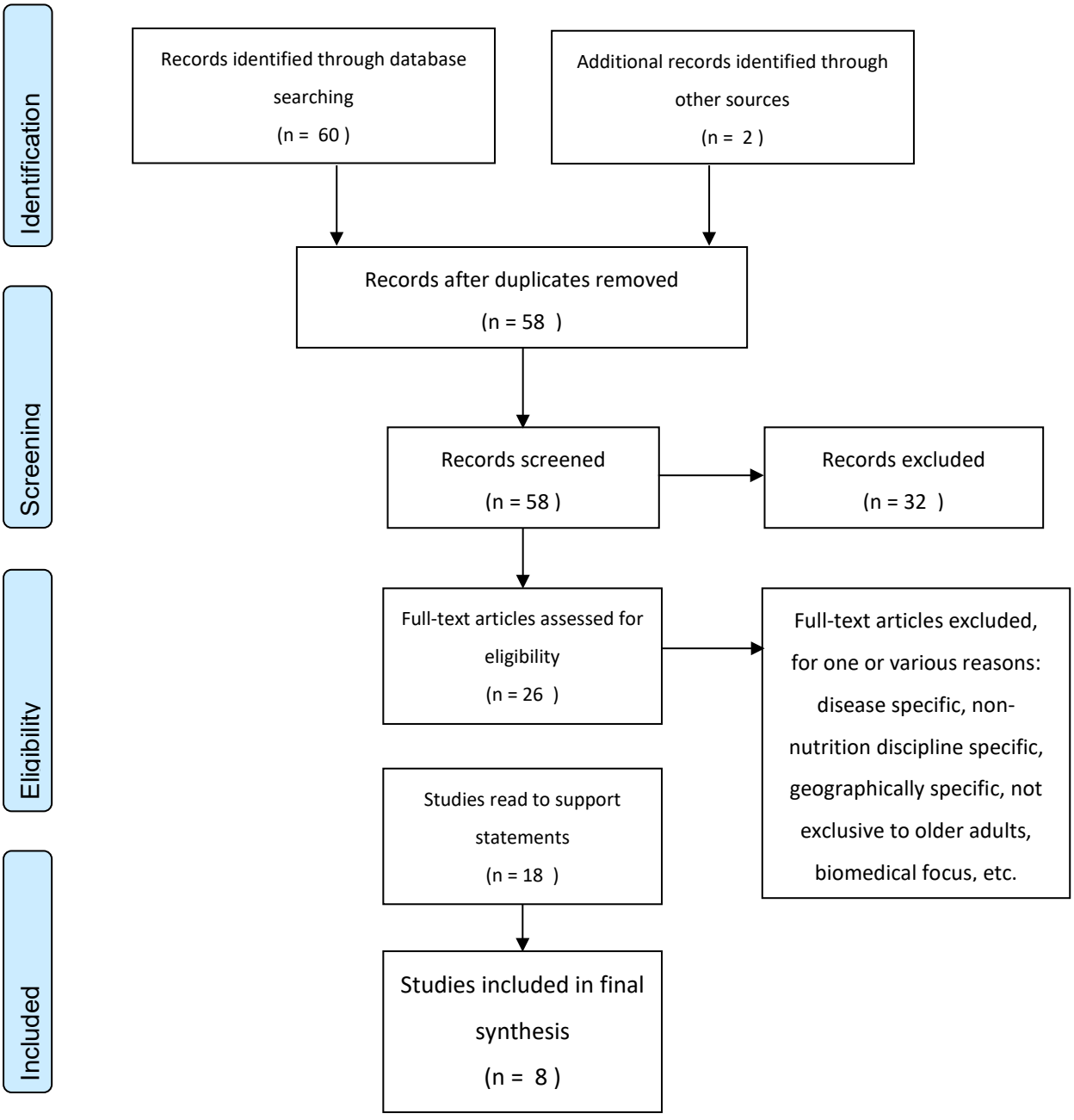
A systematic search was conducted in three specialised databases: OVID Medline, EMBASE and COCHRANE.

In Appendix 1, we present the search strategy for all databases so this can be reproduced at a later date or for other purposes.

In figure 2 we show the graphic representation of how we arrived at the final selection of papers that needed to be read to extract relevant supportive information. The paper obtained from other sources came from email alerts on nutrition and COVID-19, as well as from the SACN, which was shared by the BDA team.

After screening by title and abstract, the most relevant articles were read and only eight papers contained relevant information to back up the provided statements. Quotes were extracted or paraphrasing was done where necessary. The collated information supporting each statement is presented next.

Figure 2 PRISMA for Vitamin D



Findings

You cannot meet Vitamin D requirements through food alone (and therefore taking a supplement is healthy and one of the most effective ways of meeting your needs)

- Only few foods provide a valuable source a vitamin D (Yong, 2021)

- Dietary ocean fish has the highest concentration to provide vitamin D, rather than meat (Grant, Al Anouti and Moukayed, 2020).
- Women might be more exposed to vit D deficiency perhaps because they eat less meat than men. However fortifying food with vitamin D does not eliminate the need to measure its concentrations as some people will not consume adequate amounts of fortified food for many reasons. Some reasons are socioeconomic factors, or having a milk intolerance, for example in African descendants. (Grant, Al Anouti and Moukayed, 2020)
- As most foods have a low natural content of vitamin D (apart from oily fish), the dietary intake of vitamin D is low in most countries, except in those where oily fish is consumed in high quantities (Bouillon, 2017)
- When the level of vitamin D fortification is insufficient, large volumes of such food need to be consumed. Unfortunately, irrespective of whether the food fortification with vitamin D is mandatory or voluntary, insufficient fortification of food with vitamin D is a common occurrence in many countries (Wimalawansa, Razzaque and Al-Daghri, 2018).
- The dietary contribution to the desirable plasma levels of 25(OH)D is considerably lower in Italy than in US, due to the composition of diet (with less animal fats) and to the lack of appropriate fortification and supplementation of foods (Cesareo *et al.*, 2018).
- Vitamin D supplementation is necessary to achieve the desired serum vitamin D levels in 98% of people, particularly the elderly and institutionalised people (nursing home or disability centres, having less exposure to sunlight for any reason). This appears to be related to a number of factors, including insufficient exposure to sunlight and inefficient conversion of the precursor to vitamin D in aging skin, routine use of sun-screens, the use of medications that enhance the catabolism of vitamin D, and consumption of diets that contain very little vitamin D (Wimalawansa, Razzaque and Al-Daghri, 2018).

You should purchase an over the counter vitamin D supplement (generic brands may be more cost effective than branded products)

- It is necessary to take a supplement to achieve adequate 25(OH)D concentrations or adequate vitamin D levels, particularly for the elderly (Grant, Al Anouti and Moukayed, 2020).
- People at risk of low sun exposure should take a 10 microgram supplement of vitamin D a day. Excess vitamin D intake may lead to hypercalcaemia and

hypercalciuria and moderate levels of intake may enhance renal stone formation in predisposed individuals (Yong, 2021).

- Vitamin D3 is commercially available as drops (10,000 units/mL) and as vials with different potency (25,000 U, 50,000 U, 100,000 U, and 300,000 U) to be administered either orally or parenterally (Cesareo *et al.*, 2018).
- Affordable, good quality and readily available vitamin D supplements for the masses are needed (Haq *et al.*, 2018)

You should take a vitamin D supplement between the months September to March

- From May through September at northern latitudes, exposure to sun, legs and arms for 20–30 min three to four times per week, usually sufficient to produce adequate amounts of vitamin D in healthy young people with fair skin. However, those with darker skin pigmentation, those who regularly use sunscreens, and the elderly, vitamin D production in the skin is less (Wimalawansa, Razzaque and Al-Daghri, 2018).
- Furthermore, from November to March the intensity of UVB rays is insufficient for the conversion of 7-dehydro-cholesterol into cholecalciferol, right above and below the 33th parallel (including also Mediterranean Europe) (Cesareo *et al.*, 2018)
- Physical characteristics can affect vitamin production, with darker skin requiring longer UV exposures to produce the same amount of vitamin D. Older people have a reduced ability to make vitamin D through their skin. People with obesity have lower 25 (OH)D levels which may be due to less sun exposure or greater uptake of vitamin D in fat tissue which might be more inaccessible. If people use whole body coverings or live in institutions they might be less exposed to the sun. During winter it is preferable to take between 28-41 micrograms per day of supplements to achieve high levels during winter (Yong, 2021).
- African Americans have denser bones than white Americans because of metabolic processes during adolescence, thus they may think they do not need much vitamin D. however their 25(OH)D concentrations may be lower than whites (Grant, Al Anouti and Moukayed, 2020)
- Based on bone density changes in response to vitamin D supplementation, a seasonal 25(OH)D appears to define a threshold below which vitamin D supplementation may produce clinically relevant benefits (Reid and Bolland, 2020)

Vitamin D3 supplement is preferable to Vitamin D2 as it is more readily absorbed. Vitamin D2 may be more acceptable to people who are Vegan.

- Primarily derived from plant sources, such as mushrooms, plants and yeast; marketed as vitamin D2 (ergocalciferol). Cholecalciferol (D3) is generated in animals and is the naturally occurring form of vitamin D in humans (Haq *et al.*, 2018).
- Vegans and vegetarians eat foods that contain little or no vitamin D3. Only animal products contain vitamin D3 (Grant, Al Anouti and Moukayed, 2020).
- Supplements containing vitamin D3 (cholecalciferol) are preferable to those containing vitamin D2 (ergocalciferol). Supplements containing only vitamin D are preferable over multi vitamins (Yong, 2021).
- D3 currently the most used therapy for the treatment of osteopenia and osteoporosis, hence should be used as first line for prevention of deficiency. However, some vegan people may prefer the use of ergocalciferol (D2) that is not of animal origin (Cesareo *et al.*, 2018).

Between late March to September you can make vitamin D from sunlight as long as you are exposing enough of your skin for at least 10 minutes a day (ensuring safe sun exposure)

- From May through September at northern latitudes, exposure to sun, legs and arms for 20–30 min three to four times per week, usually sufficient to produce adequate amounts of vitamin D in healthy young people with fair skin. However, those with darker skin pigmentation, those who regularly use sunscreens, and the elderly, vitamin D production in the skin is less (Wimalawansa, Razzaque and Al-Daghri, 2018).
- Presently it was reported that a dark skin could produce up to six-times less vitamin D than a pale skin under the same UV exposure (Cesareo *et al.*, 2018)
- Several guidelines recommend a daily sunlight exposure of 7–30 minutes (depending on latitude, skin colour and season) for hands, arms and the face to generate sufficient vitamin D and maintain serum levels of 25OHD above the minimal threshold required to maintain normal bone health (Bouillon, 2017).
- Sensible exposure to sunlight is recommended (Haq *et al.*, 2018); it is unlikely that products to protect the skin contributes significantly to vitamin D indeed deficiency.

- Sunbeds emit high levels of UVA which can cause Melanoma but do not contribute to vitamin D production (Yong, 2021).
- Vitamin D deficiency can affect immune and bone health, muscle strength. Supplementation improves this and also reduces fall risk. 10 micrograms per day or 400 IU is recommended for UK general population throughout the year. (*Scientific Advisory Committee on Nutrition (SACN)*, no date)

If you do not expose your skin to sunlight you should take a vitamin D supplement all year round

- Notably, seasonal variations in vitamin D plasma levels are well established, with values that are higher in Summer and Autumn than in Winter and Spring. The latitude (northern vs. southern), skin color (black vs. white), sex (females vs. males), and body mass index (BMI) (higher vs. lower) contribute to the variability of serum vitamin D (Cesareo *et al.*, 2018).
- Aging is associated with a decrease in the time of sun exposure, in the area of the exposed surface, and in the efficiency of the skin production of vitamin D. Furthermore, from November to March the intensity of UVB rays is insufficient for the conversion of 7-dehydro-cholesterol into cholecalciferol, right above and below the 33th parallel (including also Mediterranean Europe) (Cesareo *et al.*, 2018)
- It is important to account for the solar elevation angle which varies throughout the day and season. Above 35 degrees north, there is a low probability to make sufficient vitamin D during the darker months of the year. Time below the sun should increase when it was a cloudy day (Grant, Al Anouti and Moukayed, 2020)
- Time required to make sufficient vitamin D varies according to a number of environmental physical and personal factors but is typically short and less than the amount of time needed for skin to redden and burn. Regularly going outside for a matter of minutes around the middle of the day without sunscreen should be enough (Yong, 2021).
- In most guidelines, this dose is recommended in situations of limited exposure to UVB sunlight, but, as such exposure is generally very low in elderly individuals, it is implicitly or explicitly recommended that such an intake should be reached by nearly systematic supplementation (Bouillon, 2017).
- Clinically significant vitamin D deficiency (i.e, < 25(OH) D < 30nmol/L) is common among individuals with minimal sunlight exposure, such as frail older people and

those who are veiled, as well as in people from Africa, the Middle East and South Asia living at high latitudes (Reid and Bolland, 2020).

- Saudi older adults, for instance should take the recommended daily amount throughout the year (Haq *et al.*, 2018).
- This is largely due to low nutritional intake of vitamin D and especially due to sun-avoidance behaviour, which is aggravated by a modestly decreased synthetic capacity of the skin when exposed to sunlight (Bouillon, 2017).

Highlights

There is compelling evidence that although some foods may contain fair concentration of vitamin D, and some cultures might be more prone to consume these sources of vitamin D; levels of this vitamin cannot be secured, especially for those who do not eat animal products, through diet alone. There are not homogeneous programs across the world to fortify foods with vitamin D, thus most people need to take a supplement, especially if they live in places like the UK or institutions where they can only get limited sunlight.

Since it is necessary to buy a vitamin D supplement during some months of each year, it is essential that this is cost effective for the population. Various presentations and concentrations of vitamin D in the form of vit D2 or D3 are available in the market. There are two forms of vitamin D available for purchasing and although D3 is preferable due to its effectiveness, only D2 is suitable for vegan people.

Vitamin D intake is mostly reliant on sunlight, therefore during winter times, it is essential to supplement. The ability to make vitamin D through the skin is reduced not only in older adults but also African American, institutionalised people, and people with obesity or that use many body coverings.

Evidence suggests for healthy young adults safe sun exposure of at least 20 minutes on legs and arms 3-4 times per week to produce sufficient vitamin D. Artificial UV (e.g. sunbeds) exposure not only does not benefit vitamin D uptake but may harm the skin. People with darker skin may need more time and frequency to produce enough vitamin D or can choose supplementation if this is not possible.

Latitude plays a major role in deciding which people living in which places should take supplementation (greater latitudes mean supplementation is more likely required). Absorption is also affected by other factors, such as BMI and being older than 65 years. Thus, advising a supplement throughout the year is sensible.

Conclusion

Much evidence was found to support statements on vitamin D supplementation. This is particularly important in countries with latitude and weather like the UK, and during wintertime. Particular population groups should be warned of the potential decrease uptake and therefore supplementation is ideal, taking care of choosing an adequate supplement for patient dietary habits. References are presented at the end of this document

Nutrient Requirements

Statements

1. UK Healthy older adults have different nutritional requirements to support healthy ageing for protein, calcium, folate, vitamin B-12 compared to the general population; and the same UK recommendations as the general population for carbohydrates, free sugars, dietary fibre, dietary fat and fatty acids, sodium, and alcohol.
2. UK black and minority ethnic older adults have similar needs to the UK Caucasian population *[only Manju et al., 2019 mentioned this topic]*

Method

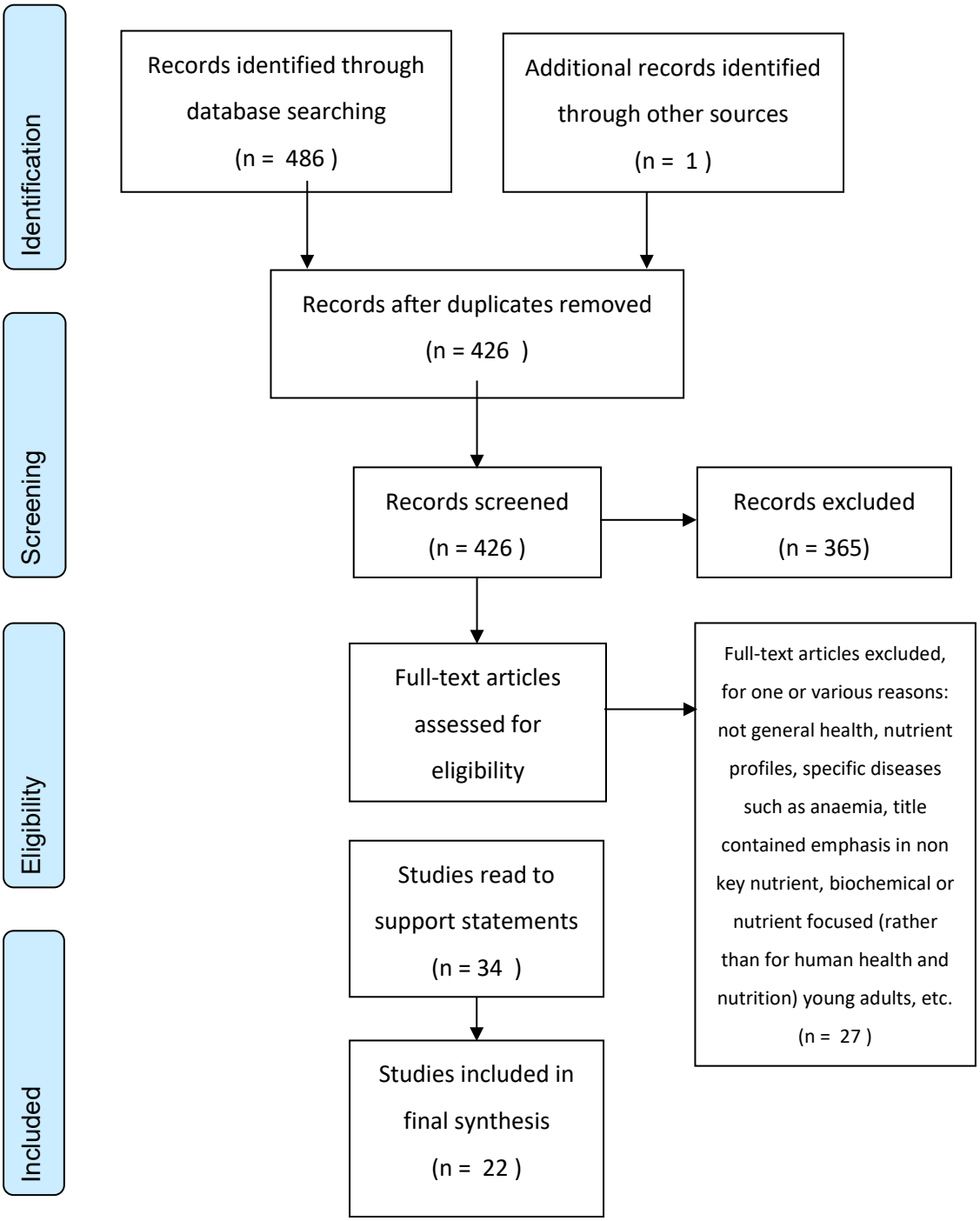
A systematic search was conducted in three specialised databases: OVID Medline, EMBASE and COCHRANE. In Appendix 2, we present the search strategy for all databases so this can be reproduced at a later date or for other purposes.

The figure 3 shows the graphic representation of how we arrived at the final selection of papers that needed to be read to extract relevant supportive information. The paper obtained from other sources was shared by the BDA team, Dorrington et al., (2020), which we ensured was retrieved with the systematic search conducted in databases.

After screening by title and abstract, the most relevant articles were read. Twelve papers were relevant for protein and folate requirements (not the same ones), seven for calcium, and six for folate. It is worth noting that Dorrington et al. (2020) excluded those who were not primarily Caucasian. Next, we present each key nutrient mentioned in the statements as well as the papers discussing this. The following

shows the collated information supporting each statement. Quotes were extracted and only occasionally paraphrasing was used.

Figure 3 PRISMA for Nutrient requirement



Findings

Protein

- Evidence suggests that increasing the current UK population protein recommendations from 0.75 g/kg to 1.2 g/kg for adults aged ≥65 y may be of

benefit. This is the higher end of recommendations suggested in the PROT-AGE study group's comprehensive literature review (Dorrington *et al.*, 2020)

- Experts in the field of protein and aging recommend a protein intake between 1.2 and 2.0 g/kg/day or higher for elderly adults. The lack of muscle responsiveness to lower doses of protein intake in elderly adults can be overcome with a higher level of protein intake. (Baum, Kim and Wolfe, 2016)
- In the UK, the reference nutrient intake for protein is equivalent to 0.75g/kg of body weight, slightly less than the recommended dietary allowance (RDA) of 0.8 g/kg of body weight proposed for men and nonpregnant and nonlactating women >18 yr of age by FAO/WHO/UNU (2007). These recommendations take no account of specific age or health status
- Overall, there is considerable agreement about the benefits of the elderly increasing protein intake to 1.0 g/kg of body weight or higher, yet there have been concerns that the strong satiating effect of protein may limit total food and energy intake (Givens, 2020)
- Whey protein that is rapidly digested and absorbed leads to greater muscle protein synthesis than proteins that are more slowly digested such as casein and those in soya (Givens, 2020)
- A protein intake of nearly 1g/kg/day is associated with a lower prevalence of frailty, independently of total energy intake (set at 30 kcal/kg/d, alone not associated with frailty). Longitudinal studies confirm these results, showing that participants with the lowest protein intake are the most at risk of becoming frail over time (Feart, 2019)
- The current protein reference nutrient intake (RNI) is 0.8 g protein/kg body weight in healthy adults of all ages. While some authors recommend an increase in protein requirements, others (COMA 1991; Institute of Medicine 2005) suggest that this increase is not necessary because of the decrease in lean body mass and thus a reduction in requirement for protein. Emerging evidence-based studies have argued that an increased protein intake may be beneficial to fulfill the needs of vulnerable older adults, particularly those with chronic diseases. (Baugreet et al., 2017)
- There is growing evidence that older adults can improve their muscle mass, muscle strength and functional performance by consuming an adequate amount of protein in combination with physical activity (de Groot, 2016)
- The indicator amino acid oxidation technique uses labelled tracer oxidation measured in expired air in response to different amounts of protein to determine

the average minimal amount of protein necessary for nitrogen balance. Two recent studies using this technique found that adults aged 65 and older require protein intakes greater than the current RDA. These studies are supported by recent consensus reports that concluded that the current protein recommendation for older adults is too low and that older adults should consume 1.0–1.2g/kg BW/day for optimal health. High protein diets are beneficial in maintaining lean body mass during weight loss

- The most common age-related causes of protein shortfall are inadequate intake of dietary protein (loss of appetite, gastrointestinal issues, reduced energy need, changes in food preference), a reduction in the utilization of available protein (anabolic resistance, insulin resistance, higher splanchnic extraction), and a higher basal requirement (acute and chronic diseases, inflammatory disease, increased oxidation of protein). (Deer and Volpi, 2015)
- Research is also emerging that higher protein diets during weight loss might help preserve muscle mass, promote fat loss and enhance function in older adults. (Johnson, 2013)
- In contrast to the US and the UK values, the Australian Recommended Daily Intake (RDIs) for protein distinguish between males and females and recommend a 25% higher intake of dietary protein for those aged 70+ years. There is increasing evidence that the current Recommended Dietary Intakes for older people of around 0.8g/kg/day are insufficient to optimise retention of muscle mass, strength and function. A low-protein diet evidenced by a reduction in skeletal muscle whilst whole-body leucine metabolism was maintained. An international expert panel recommended an average daily intake of 1.0–1.2g/kg protein per day for those aged 65+ years and even higher intakes for those who are exercising and otherwise active. It is believed that this reduced response to anabolic stimuli represents one of the key factors responsible for the age-related decline in skeletal muscle mass. (Nowson and O'Connell, 2015)
- The optimal level of protein intake in the elderly is almost certainly greater than the RDA. There have been numerous studies in which a variety of endpoints have been used to compare the effects of consuming the RDA of protein to consuming greater amounts of protein, particularly in the elderly. Although the magnitude of benefit from a higher protein intake varies among studies, depending on the specific experimental design, participants, and endpoint(s) measured, among other factors, there has never been a study in which

individuals who consumed the RDA for protein experienced benefits similar to those of individuals who consumed protein in excess of the RDA. (Wolfe, 2015)

Protein supplement studies

- Among the hospitalized elderly, women receiving 1g/kg of protein had greater bone mass density in their lumbar vertebrae, femoral neck, and thighbone than women receiving a smaller amount of protein. As a result, they have recommended the intake of 1g/kg of protein, which is slightly higher than the standard recommendation (0.8 g/kg) for maintenance of bone health (Hejazi et al., 2020)
- At the moment, there is very little evidence regarding the effect of protein supplementation on frailty, although the few studies seem to indicate a protective role of protein supplementation against frailty syndrome. (Hernández Morante, Gómez Martínez and Morillas-Ruiz, 2019)
- To date, there has been insufficient evidence to update the dietary reference value for protein based on optimal health and muscle function in European countries. While a recent review in older adults ≥50 years globally has reported that the prevalence of sarcopenia is substantial in community dwelling older adults (1–29 %), the authors also concluded that protein supplements have not shown consistent benefits on muscle mass and function. (Kehoe, Walton and Flynn, 2019)

Highlights

Although in old literature (before 2012) 0.8g/kg of protein was recommended given the muscle mass loss, current recommendations from specialist groups have suggested increasing the protein requirement to 1.0g/kg or higher (up to 1.2g/kg or higher for those who exercise regularly) in healthy older adults to prevent frailty, overcome a lack of muscle responsiveness to lower doses, loss of muscle mass if voluntarily losing weight, and experience more benefits than those only consuming the current RDA for the UK.

Special considerations need to be addressed, for instance the increase in satiety that protein has, the protein source and how there are some differences on how this is digested, the combination of protein with exercise for more effective resources. Lack of adequate protein is likely to cause loss of appetite, gastrointestinal issues, reduction in the utilisation of available protein.

Protein supplementation has only shown a few promising benefits in muscle mass, bone mass density and other outcomes that can prevent frailty. Supplementation however does not show consistent benefits on function and muscle mass.

Calcium

Recommendations from literature sources.

- Older adults (>70 years) should consume a total of 1200mg/day of calcium. (Davinelli, Corbi and Scapagnini, 2021)
- Before menopause, bone mass density remains relatively constant in women, but it starts decreasing immediately afterwards. This is why the recommended amount of calcium depends on age (1,000mg/day for men and women, and 1,200mg/day for people over 50 years) (Hejazi et al., 2020)
- Current UK population calcium recommendations of 700mg may not be optimal for older adults. An intake ≤1000mg combined with adequate vitamin D may have greater benefit, although evidence confirming this quantity is lacking and, without dietary RCTs, reverse causation at higher intakes cannot be excluded. Furthermore, most studies were in postmenopausal women, typically aged ≥50 y or ≥55 years. Additionally, most bone health studies focus on women, making effects in men uncertain. (Dorrington et al., 2020)
- There was also not enough data to recommend different calcium requirements for different ethnicities. The basis for the recommendation was derived from data obtained from 19 feeding studies undertaken by the USDA (US Department of Agriculture). An additional 200mg/day to the estimated 800mg/day (as an average requirement), as extra allowance was given, and the total adopted as the recommended dietary allowance (RDA) in men and women between the ages of 51–70 since this would cover the needs of 97.5% or more of the population. For adults above 70 years (both men and women), levels of 1000mg/day were arbitrarily adopted as estimated allowance requirement, and therefore, 1200mg/day was set as the RDA. Despite these recommendations, it is well known that the intake of dietary calcium varies widely geographically. (Manju et al., 2019)
- Calcium intake of 1000-1200mg/day is advised for elderly population for the maintenance of optimum bone health (Kaur et al., 2019)
- Total elemental calcium intake should be 1000mg/day for premenopausal women and men and 1200 to 1500mg/day for postmenopausal women, preferentially from food sources (Gonzalez-Campoy et al., 2013)

Importance of calcium

- Deficiency in the availability and impairment in the absorption of calcium, contribute to a reduction in both the mass and strength of bone and skeletal muscle. (Davinelli, Corbi and Scapagnini, 2021)
- Amongst populations such as Caucasians who are at higher risk for osteoporotic fractures, habitual calcium intakes below the UK and EU lower reference value of 400mg/day may be associated with an increased risk of these fractures. In studies from the USA, Italy, UK and Hong Kong, it has been shown that where average dietary intake is low, the risk of hip fracture increases at intakes below the average, but there is no continued risk reduction at intakes higher than the average. In those countries with higher average intakes, there is no evidence of a gradient of fracture risk with calcium intake (Manju et al., 2019)
- Elderly women are at a higher risk of bone loss which is 2-3% per year as compared to men. This greater bone loss among women occurs after menopause, which is due to oestrogen deficiency resulting in decreased intestinal calcium absorption (Kaur et al., 2019)

Highlights

Most sources recommend increasing calcium requirement from 700mg to 1000-1500mg depending on the older adult profile, as for instance, women seem to need more to protect optimum bone health. Only one study stated that there was not enough data to differentiate requirements between Caucasians and different ethnicities, although the synergy between vitamin D and calcium is well known and should be considered when assessing and advising older adults.

The main benefits mentioned were effects on bone health, preventing fractures and since the oestrogen levels drop at an advanced age, greater bone loss needs to be prevented through calcium consumption, preferably in natural foods.

Vitamin B9 or folate

Importance of folate

- Low concentrations of vitamins, such as fat-soluble vitamins A, D, and E, and water-soluble vitamins, such as B6, B12, folate, and C, have been associated with frailty and functional decline. (Davinelli, Corbi and Scapagnini, 2021)
- The adjustment of energy intake in elderly people age between 60 and 90 years by a low intake of more than three nutrients, such as protein, vitamins D, E, and C, and folate, independently and significantly results in frailty among the elderly people. (Zarei et al., 2021)

- Frail participants consume significantly less vitamin D, E, C and folate, regardless of energy consumption, than non-frail participants. An analysis of more than 1600 aged individuals reported that poor intake of several vitamins (B6, C, E and folates), and non-adherence to the recommended dietary allowances for thiamine, niacin and vitamin B6 were all independently associated with the frailty risk over 3.5 years (Feart, 2019)

Recommendations for folate

- The UK RDA is based on several considerations. First, the lower reference range is based on the quantities of pteroylmonoglutamic acid (PteGlu) shown simply to reverse the signs of acute folate deficiency (megaloblastic anaemia), following experimental depletion in (a) an undefined sample and (b) in a sample of seven moribund cancer patients. Whilst it is not even possible to comment on the sample population for the first study, determining requirements through study of advanced-stage cancer patients is problematic as derangements in cell turnover are pathognomonic. Further work in understanding the lower threshold for vitamin B9 requirements seems merited. The determination of the upper reference ranges (RNI) for vitamin B9 are based on findings of adequate liver vitamin B9 stores (>3µg) following post-mortem analysis of 560 Canadian samples, which represent a heterogeneous sample. (Aytekin, Mileva and Cunliffe, 2018)
- The UK Department of Health (DoH) has set an RNI of 200µg/d for total folate and the Nordic Nutrition Recommendations (NNR) has set a recommended intake of 300µg/d for total folate. Mean intakes of total folate in most European countries meet the recommended intake from the NNR (200µg/d), but were typically below the UK DoH RNI of 330µg/d, with the exception of intakes in France, Denmark, Belgium and Lithuania (range 348–400µg/d) (Kehoe, Walton and Flynn, 2019)
- Current UK recommendations for older adults are lower than suggested by the WHO and set for the USA and Australia/New Zealand and no studies reported detrimental effects at their proposed higher intakes. (Dorrington et al., 2020)
- As the Committee on Medical Aspects of Food and Nutrition Policy later acknowledges, intake is typically observed to decline with age and vitamin B9 status is further affected by age-associated medical conditions, and associated medications (Aytekin, Mileva and Cunliffe, 2018)

Highlights

The low consumption of folate can result in frailty and functional decline. Decisions on folate requirements in the UK were based on moribund cancer patients, which

may prove problematic since US recommendations were based in more than 560 Canadian samples with a heterogeneous sample. UK recommendations are also different from Australia and New Zealand. Nordic recommendations (200µg/d) seem more adequate for the UK to adopt. No studies have reported detrimental effects on higher intakes and this is necessary to prevent the above mentioned conditions and since some age-associated conditions show a decrement on vitamin B9 status.

Vitamin B12

Importance of vitamin B12

- Vitamin B12 deficiency is quite prevalent among the elderly. Lean body mass and skeletal muscle mass index are lower in subjects with lower vitamin B12 levels. Further, the serum concentration of vitamin B12 was reported to be 15% lower in a group of elderly individuals with sarcopenia, compared to those without this condition (Davinelli, Corbi and Scapagnini, 2021)
- Low plasma or serum vitamin B12 have been associated with a greater 8-year decline in cognitive function, and cross-sectionally with reduced mental processing speed increased risk of cognitive impairment and depression, yet these were supported by limited studies (Dorrington et al., 2020)
- The frequent use of laxatives to treat constipation in elderly disturbs the gut metabolism and affects the absorption of vitamin B complex in the digestive tract. Among elderly, deficiency of vitamin B12, B6 and folate are known to affect cognitive functioning and is accompanied with depressive symptoms prevalent among older adults (Kaur et al., 2019)
- Elderly people with H-pylori infection, or food cobalamin malabsorption may be at risk for vitamin B12 deficiency despite sufficient dietary intake. It is unclear if elderly people would generally benefit from higher vitamin B12 intake recommendations (Obeid et al., 2019)
- Crystalline vitamin B12 from fortified foods and dietary supplements is believed to be normally absorbed in those with atrophic gastritis and this form is recommended for people aged 51 years and older in the US. (Johnson, 2013)
- The absorption of protein bound vitamin B12 diminishes with age, typically as a result of higher rates of atrophic gastritis in this age group (Ruxton, Derbyshire and Toribio-Mateas, 2016)
- A high proportion (17 %) of those aged 85+ in the Newcastle 85+ study in the UK have been reported to have deficient vitamin B12 status. (Kehoe, Walton and Flynn, 2019)

- Vitamin B12, which is apparently adequate through habitual intakes, is frequently deficient in the blood values of older adults (ter Borg et al., 2015)
- In the elderly, case finding for vitamin B12 deficiency is reasonable given their high prevalence with advancing age. It is appropriate to recommend a daily multivitamin to complement food intake in older adults who cannot achieve adequate micronutrient intake otherwise (Gonzalez-Campoy et al., 2013)

Recommendations

- The UK recommendation is based on an assessment of the requirements for the prevention of megaloblastic anaemia as indicated by: (a) a small number of intake studies on narrowly defined groups of vegan/vegetarians in Sweden, Australia and South Asia; and (b) the haematological response to parenteral vitamin B12 administration in patients with pernicious anaemia. (Aytekin, Mileva and Cunliffe, 2018)
- Current UK population recommendations for older adults have been adjusted to align with international recommendations (vitamin B12, 2.4µg/d). (Dorrington et al., 2020)
- No special intake recommendations exist for elderly people, despite the evidence that vitamin B12 malabsorption and deficiency are common in the elderly. A study among 98 Danish post-menopausal women suggested that an intake of 6µg/d vitamin B12 (determined from 7-d weighed food records) is sufficient to maintain highest concentrations of vitamin B12. (Obeid et al., 2019)
- A total intake of vitamin B12 from the diet between 4 and 7µg/d is associated with normal plasma vitamin B12 and thus appears to be adequate to maintain body vitamin B12 status in adults. This intake might be insufficient if people have difficulties in chewing foods, releasing the vitamin from its food binding, and/or absorbing it due to disorders (Obeid et al., 2019)
- The RDA (RNI) for vitamin B12 in the UK is 1.5µg/d for both men and women aged 15+ years. Excluding Ireland, this value represents the lowest RNI in Europe. It was found that an intake of 6µg/d was required to normalise all parameters in individuals with normal absorptive capacity (Aytekin, Mileva and Cunliffe, 2018)
- A recent trial examining adults aged >70y with mild cognitive impairment found that a high dose of folic acid (0.8mg), vitamin B12 (0.5mg), and B6 (20mg) supplementation for 24 months was associated with a slower cognitive decline in those receiving the intervention, compared to those receiving the placebo (Baugreet et al., 2017)

- Given the high prevalence of vitamin B12 deficiency and the ease and safety of treatment, some have advocated routinely screening adults over the age of 65 for vitamin B12 deficiency. This policy has not been endorsed in formal guidelines. Whether or not individuals over 50 years of age should take vitamin B12 supplements is unclear. It is prudent to recommend an intake of at least 10 to 15µg of vitamin B12 daily for older individuals (Gonzalez-Campoy et al., 2013)

Highlights

A high number of studies reported the importance of vitamin B12, since they noted deficiency to be highly prevalent among older adults and this was considered a risk factor to develop sarcopenia, a cognitive function decline, a risk of depression and impairment.

Other factors associated with this vitamin's deficiency are the constant use of laxatives, H-pylori infection and the prevalence of gastritis, particularly at an older age.

Recommendations of vitamin B12 have been based on patients with anaemia and a few studies that measured intake in vegetarians in Australia, Sweden and South Asia. New recommendations for older adults have been increasingly published. Different authors proposals fluctuate between 2.4-7µg/d, one author suggested 10-15µg/d, with the question of supplementing still unclear.

Conclusion

This review provides an overview of the various rationale to increase the daily requirements of protein, calcium, folate and vitamin B12; key nutrients to prevent frailty, dementia and other conditions in older adults. It also points to a number of different reviews suggesting specific quantities for healthy older adults that nevertheless face various risks when deficient in these nutrients.

References can be found at the end of this document.

Nutrient density

Statements

1. Healthy older adults require a nutrient rich diet to meet nutritional recommendations and require their understanding of how to build nutrient rich meals and snacks

Method

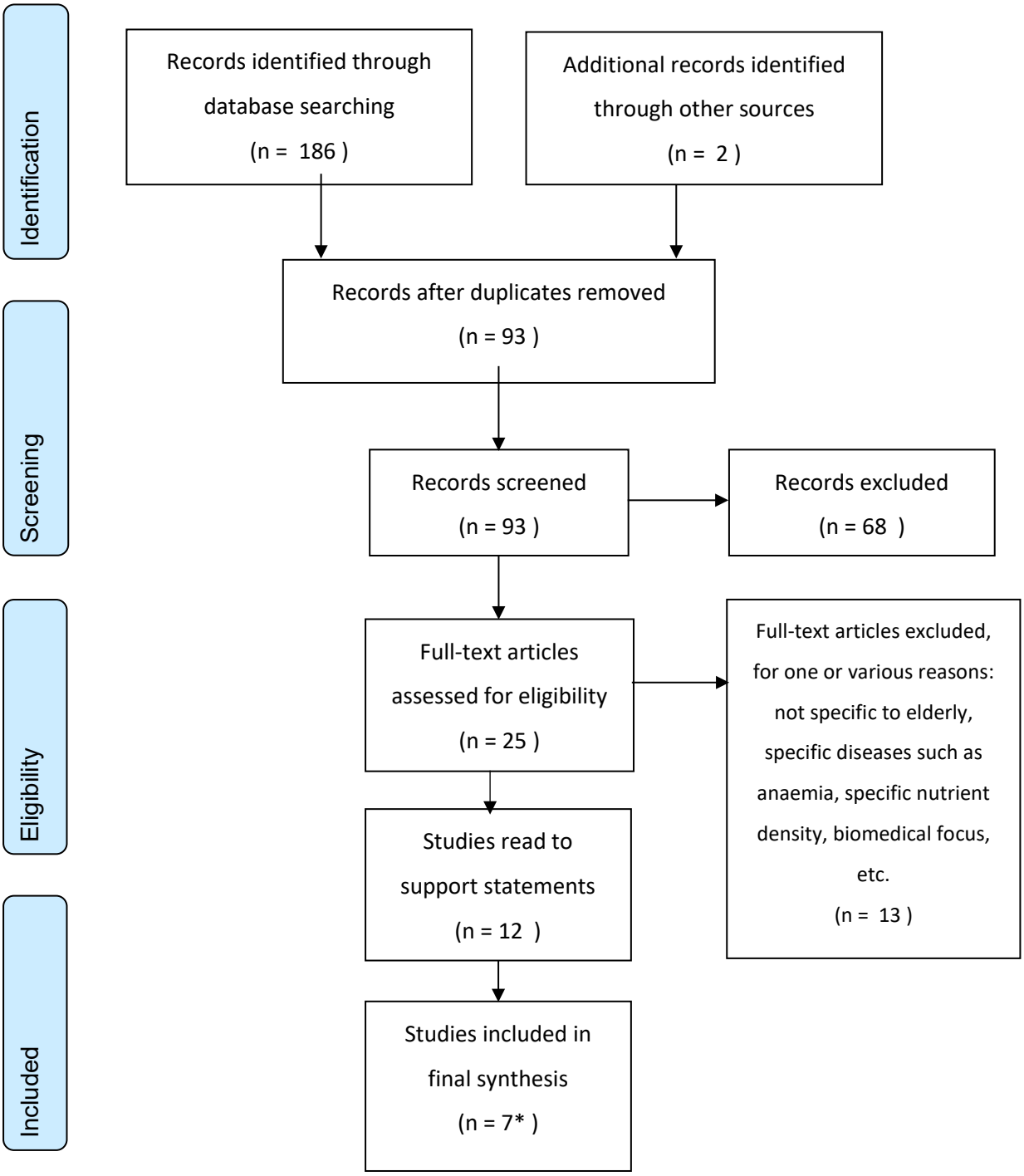
This statement was used to conduct targeted systematic searches additional to the ones already conducted for nutrient requirements. Three specialised databases were consulted: OVID Medline, EMBASE and COCHRANE. In Appendix 3, we present the search strategy for all databases so this can be reproduced at a later date or for other purposes, such as updates.

Figure 4 shows PRISMA statement to make sense of how the final papers were selected. We also included two relevant papers obtained through the nutrient requirements search, which is explained below.

The final number to scan by title was low and therefore the final papers assessed in the full text were less than ten. This is due to a lack of reviews conducted on this topic; the vast majority of papers focused on energy-rich meals for older adults rather than nutrient rich. In addition, we excluded papers including interventions such as vitamin or multivitamin supplements or the use of different products (e.g. essential aminoacids, omega-3 capsules, etc) . We then decided to look for papers which mentioned “nutrient density” or “nutrient rich” in the title using Google Scholar, however we expected to find empirical rather than review papers. We found three papers that we describe after including the relevant information from systematic searches. We hope that this covers comprehensive literature that can support the reconstruction of this statement.

Thirteen papers were not eligible for inclusion due to the reasons listed in figure 4, and therefore a total of ten papers were included in the review (seven from systematic search (see fig 4) and three from Google Scholar search).

Figure 4 PRISMA for nutrient density



*This number only accounts for the ones found through systematic searches rather than Google Scholar title search

Findings

Papers from different sources to the systematic search

(Gonzalez-Campoy et al., 2013): Clinical Practice Guidelines for Healthy Eating for the Prevention and Treatment of Metabolic and Endocrine Diseases in Adults

- Energy and nutrient-dense foods, or manipulation of energy and nutrient density of the meal plan, should be recommended for the frail elderly to promote weight gain and improve clinical outcomes
- To ensure adequacy of a wide variety of micronutrients, a daily mix of nutrient-dense foods, including fruits and vegetables, should be recommended. These foods are often more nutrient dense and are more likely to supply essential micronutrients.
- For carbohydrates, older adults are encouraged to consume more nutrient-dense whole grain foods (high nutrient-to-calorie ratio), such as brown rice, whole wheat breads, whole grains, and fortified cereals.
- To ensure adequacy of a wide variety of micronutrients, choosing a mix of nutrient-dense foods on a daily basis is preferred over narrow selection of certain foods. This recommendation may be of particular importance for older adults because a decreased variety is more prevalent in the elderly.
- Whether they are community dwelling or institutionalized, there are several proven methods that are effective for treating the frail elderly. Selection of energy- and nutrient dense foods or manipulating energy and nutrient density of the foods increases caloric and micronutrient intakes in these vulnerable older adults. Methods directed to improving the palatability of foods with various flavour enhancement techniques increase food intake, promote weight gain, and improve clinical outcomes. Successful strategies to increase caloric and micronutrient intake include the ingestion of between-meal snacks or oral nutrition supplements

Papers from systematic search for nutrient dense statement

(Marangoni et al., 2019): Snacking in nutrition and health

- When referring to “nutritionally adequate” food properties, the main factors include nutrient density and energy density which play major roles in maintaining energy balance. A literature review also highlighted an improvement in satiety after consuming nutrient rich snacks. Such effects cannot be attributed to a specific nutrient, as evidenced by the comparison between protein-rich Greek

yogurt and regular yogurt and are instead related to the snack's overall nutrient density. On the other hand, snacks that have high energy density and low nutritional density can lead to a positive energy balance, resulting in overweight, especially when consumed regularly, mindlessly and in the absence of hunger signals.

- A well-timed and nutritionally appropriate snack can exert a positive effect on the diet of elderly people. To reach this goal, snacks (like other meals) should contain foods providing essential nutrients and should meet specific criteria, which may be different from those for other age groups. For example, highly digestible yet appealing and energy dense foods should be prioritised. High energy density allows for a reduction of up to 20% in food volume whilst maintaining energy intake.

(Robinson, 2018): Improving nutrition to support healthy ageing: what are the opportunities for intervention?

- At a time of falling food consumption, and changing nutrient requirements, consumption of nutrient-dense foods and having a diet of adequate quality are key to ensuring older adults meet nutrient needs.
- As the need for a more nutrient-dense diet may coincide with a time when physical limitations are starting to impact on food access and availability, these changes are likely to affect nutritional risk.

(Yannakoulia et al., 2018): Eating habits and behaviors of older people: Where are we now and where should we go?

- Emphasis should be given to increasing the consumption of nutrient dense foods and improving overall diet quality, as micro-nutrient deficiencies are common and the adherence of older people to healthy dietary patterns is only moderate

(Baldwin et al., 2016): Supportive interventions for enhancing dietary intake in malnourished or nutritionally at-risk adults

- Provision of nutritional advice to increase nutrient intake, requires an individual to understanding and acting upon instructions given. This approach may include providing advice on food fortification, to increase the energy density of foods without increasing quantity, or dietary fortification, to increase the energy density of the diet by adding extra snacks or drinks between meals.

(Montgomery et al., 2014): Micronutrient Needs of the Elderly

- Specific dietary recommendations for the elderly have been incorporated into the Recommended Dietary Allowances (RDA). The energy needs of the elderly are lower, but the requirement for most micronutrients is not. This underscores their need to make appropriate, nutrient-dense food choices.
- Adding nutrients to foods by enrichment or fortification enhances the nutrient content of the food that we eat, considering that naturally nutrient-dense foods such as fruits, vegetables, whole grains, and lean proteins are sometimes not eaten in appropriate quantities

(Rizza, 2014): What are the roles of calorie restriction and diet quality in promoting healthy longevity?

- Data from several epidemiological and interventional studies have clearly shown that individuals who are eating diets rich in fish and nutrient-dense minimally processed plant foods have a lower risk of developing cardiometabolic abnormalities and CVD than men and women who consume Western diets rich in empty calories, saturated/trans fatty acids, animal protein and salt.

From studies or trials, not reviews

Since papers found through systematic searches were scarce, other non-reviews papers were included as the title was highly relevant for nutrient dense or rich (through search engine or bibliography list).

(Berendsen, Kramer and de Groot, 2019): The Newly Developed Elderly Nutrient-Rich Food Score Is a Useful Tool to Assess Nutrient Density in European Older Adults

- Nutrient density can be expressed by composite indices of nutritional quality. These nutrient density scores reflect the nutrient density of a food or diet in relation to dietary reference values per standard unit (e.g., per 100 gram or 100 kcal). There is no nutrient rich food score that specifically captures relevant nutrients for older European adults. However, a nutrient density score in older adults could be used to support nutrition and health claims, help older people to identify nutrient-rich foods and shape their food purchase decisions by which their diet quality could improve. Food groups that seem to have a high-density score on Dutch elderly were vegetables, legumes and fish.

- Study main outcome and conclusion: Specifically, within European older populations, there are nutrients related to health outcomes, such as protein, dietary fibre, vitamin D, folate, calcium, and magnesium, which need to be encouraged. Saturated fat, sodium, and total mono- and disaccharides are nutrients to limit in these populations.

(Huang et al., 2016): The Association between Total Protein and Vegetable Protein Intake and Low Muscle Mass among the Community-Dwelling Elderly Population in Northern Taiwan

- Obtaining adequate essential amino acids is necessary to prevent sarcopenia. The quality of vegetable protein depends on the food source and could have an equivalent nutrition value as animal protein. Legumes such as soybeans and cowpeas have high levels of leucine, which increases protein anabolism and decreases protein breakdown
- Study main outcome and conclusion: Pre-sarcopenia status was associated with a low intake of total protein density and vegetable protein density in the community-dwelling elderly population. Higher protein and vegetable protein intake are strongly associated with higher muscle mass.

(Alemán-Mateo et al., 2014): Nutrient-rich dairy proteins improve appendicular skeletal muscle mass and physical performance, and attenuate the loss of muscle strength in older men and women subjects: a single-blind randomized clinical trial

- Using nutrient-rich meat or dairy proteins is a dietary strategy to counteract the loss of skeletal muscle and sarcopenia, based on the suggestion that dietary protein supplementation boosts muscle protein synthesis and increases whole-body lean mass.
- It has been suggested that the response of skeletal muscle to protein supplementation depends on the stage of skeletal muscle mass, so in the case of subjects who have suffered accelerated and pronounced loss of muscle mass, i.e., sarcopenic older adults, it is likely that they will be less responsive to the anabolic stimulus of protein supplementation compared to nonsarcopenic subjects
- Study main outcome and conclusion: Adding nutrient-rich dairy proteins, specifically 210 g of ricotta cheese, for 12 weeks seems to significantly improve total skeletal muscle mass. Additionally, supplementation in the form

of nutrient-rich dairy proteins should be provided before sarcopenia syndrome develops.

Highlights

It is important that nutrient dense foods do not increase the energy consumed by older adults because micronutrients needs are higher than the energy needs. Snacks in between meals can help to accomplish this aim but should preferably include essential nutrients. Foods that are highly digestible are recommended, as well as foods that support reducing meal volume. Some examples include: whole wheat breads, brown rice, fruits, vegetables, and lean proteins (such as fish, ricotta cheese but also legumes such as soybeans). Encouraging a varied diet for older adults is essential. Factors that can increase the risk of undernutrition and frailty for older adults are food access and availability; this should be considered when recommending nutrient rich foods.

Nutrient dense or rich foods can improve diet quality and prevent micronutrient deficiencies. People consuming nutrient dense and plant-based foods have lower cardiometabolic risk, as well as undernutrition and frailty risk.

Advice for older adults on a nutrient rich diet is crucial; they need advice on how to fortify their diet with nutrient dense foods without increasing quantity or volume. Some research has been conducted to create indices of nutritional quality and this can be used to improve nutritional quality and help older adults to identify nutrient rich foods.

Conclusion

A large segment of the literature focussed on energy density rather than nutrient density and thus was not included. We recommend using a range of search terms (such as rich) in future searches, and perhap include literature on fortification as this may discuss in depth what nutrient density refers to and why is it important. In addition, strategies such as planning meals, including snacks and encouraging variety in older adults diet supports achieving a nutrient dense diet, thus reducing malnutrition or other chronic diseases risk. References are presented at the end of this document

Physical activity enhanced by protein intake

Statements

1. Older adults need to eat a (high biological value) protein snack or meal within 30 minutes of undertaking physical activity to maintain good muscle mass and strength
2. Older adults who build activity into their daily routines require even distribution of (high biological value) protein throughout the day

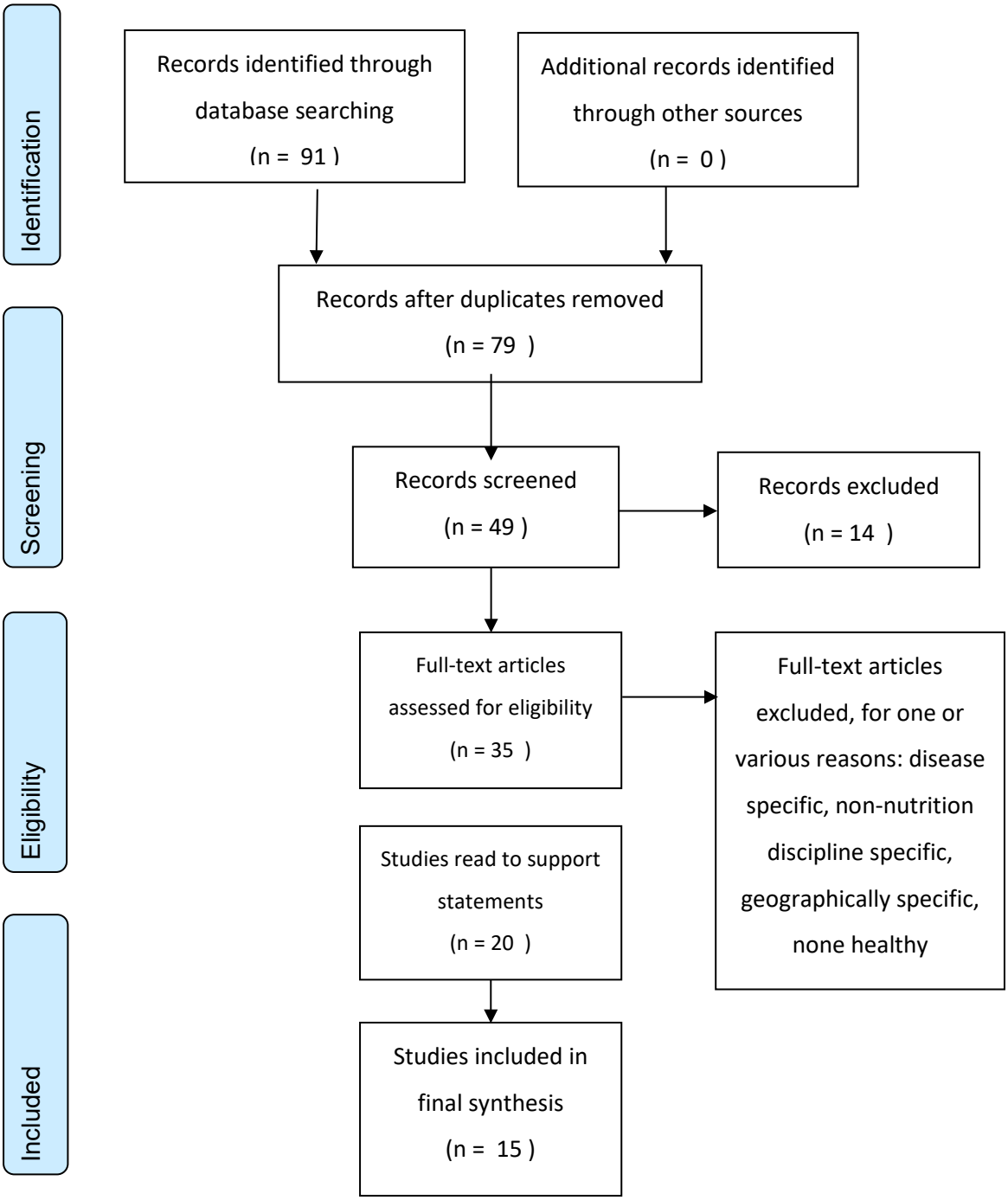
Method

A systematic search was conducted in three specialised databases: OVID Medline, EMBASE and COCHRANE. In Appendix 4, we present the search strategy for all databases so this can be reproduced at a later date or for other purposes.

In figure 5, we show the graphic representation of how we arrived at the final selection of papers that needed to be read to extract relevant supportive information. There were no papers from different sources to the systematic search.

After screening by title and abstract, the most relevant and newest (2017-2021) articles were read (20) and only fifteen papers contained relevant information to back up the provided statements. Quotes were extracted and only occasionally paraphrasing was used.

Figure 5 PRISMA for Physical activity enhanced by protein intake



Findings

Older adults need to eat a (high biological value) protein snack/meal within 30minutes of undertaking physical activity to maintain good muscle mass and strength

- Several systematic reviews investigated the effect of nutritional supplementation combined with exercise and showed a significant gain in muscle mass and strength in healthy, overweight, and sarcopenic older people. In addition to physical exercise, nutritional supplementation could have a beneficial effect compared with exercise alone in young and older adults and frail older people. In contradiction to these findings, a recent systematic review showed no effect of nutritional supplementation on top of exercise training in predominantly healthy older people. A weakness about all these findings is that studies were not appropriately randomised nor specified specifically about nutritional supplementation.(van Wijngaarden et al., 2020)
- Of six intervention studies that combined exercise with (fortified) milk supplementation, five found the main effect of exercise on several parameters of muscle mass and function, but no interaction effect of the exercise in combination with fortified milk intake in either healthy community dwelling older adults or those residing in care homes.(Granic et al., 2020)
- In a study of healthy older men and women with adequate habitual protein intake, protein supplementation of 15 g/day after a prolonged resistance-type exercise program did not augment beneficial effect of exercise on muscle mass, strength and function. A study involving older men has shown that ingestion of protein supplement (10 g protein) immediately postexercise (within five minutes) stimulated greater skeletal muscle hypertrophy compared with the ingestion two hours post training. However, a study comparing the effect of protein supplementation pre- and post- resistance exercise between young (≤40 years) and older men (≥59 years) has found no effect of supplementation on muscle mass and strength in older adults. This suggests that the dosages of protein may be more important than timing. (Granic et al., 2020)
- Protein or amino acid supplementation alone is unable to increase skeletal muscle mass or strength. Exercise may be necessary for older adults to sensitize skeletal muscle to feeding and subsequently overcome anabolic resistance. (McKendry et al., 2020)

- Hydroxymethylbutyrate (HMB) supplementation improves strength and muscle function in elderly. It also has an anticatabolic effect. HMB reduce expressions of tumour necrosis TNF and IL-6. These pathways are related to systemic low-grade inflammation, which in turn is positively associated with sarcopenia and functional impairment, which explains HMB effects in attenuating muscle loss and frailty in elderly population. Benefits however, do not have a significant difference with people who have mechanical stimulation of the musculature. Hence older adults with high susceptibility to muscle loss seem to get more benefits with the use of HMB. 1 year of HMB supplementation promoted positive effects on lean mass but not in muscle strength. Of note, supplementation was co-administered with other substances such as vitamin D, calcium, and protein, care should be taken to extrapolate results to attribute it to HMB only. The inherent stimulation of muscular hypertrophy by this type of training, overcoming the effects of supplementation. (Costa Riela et al., 2021)
- During a broad variety of interventions (times ranging between acute supplementation and 24 weeks) it was shown that there are beneficial effects of resistance training and training, when these are supplemented with whey protein, soy protein, casein and a usual protein intake (<1.2 g/kg) after the resistance training. Main improvements are shown in muscle strength, lean mass and hypertrophy.(Zanini et al., 2020)
- In older men (~75 years) protein intake (20 g) after exercising had a greater effect on muscle protein synthesis compared to protein intake at resting conditions. (Kiesswetter, Sieber and Volkert, 2020)
- Due to its high leucine content and its fast digestion and absorption kinetics, whey protein is considered particularly valuable in terms of stimulating muscle protein synthesis and consequently preserving muscle mass. (Kiesswetter, Sieber and Volkert, 2020)
- Milk-derived proteins in combination with resistance exercise were effective in stimulating gains in lean mass and strength. (Phillips and Martinson, 2018)
- A large and growing body of evidence shows that the leucine content of proteins bears direct relevance to the capacity for that protein source to stimulate muscle protein synthesis (Phillips and Martinson, 2018)
- Essential amino acid induces an enhanced effect on muscle protein synthesis if ingested following a resistance training session. Whey stimulates postprandial muscle protein accretion more effectively than casein and casein hydrolysate in

older men, and attributed this effect to whey's faster digestion and absorption kinetics and to higher leucine content.(Agostini et al., 2018)

- Animal protein diet combined with training promoted muscle remodelling more efficiently compared to other conditions applied. (Agostini et al., 2018)
- Postmenopausal women need an adequate protein intake, in association with exercise to counteract sarcopenia and related bone loss. (Agostini et al., 2018)
- The consumption of a liquid protein-based meal elicited a more rapid and greater increase in plasma amino acid concentration compared with a solid macronutrient-matched test meal in older adults. Liquid protein foods, such as milk and yoghurt, are therefore considered as effective sources of high quality protein for older and likely also, for very old adults.(Franzke et al., 2018)
- Optimizing the timing and distribution of protein ingestion, with an intake of at least ~25–30 g protein per meal and in close temporal proximity to exercise/physical activity, appears to be a promising strategy for promoting healthy ageing of skeletal muscle in the elderly and likely also in the oldest old, aged 85 years and older. (Franzke et al., 2018)
- Despite the increased concentration of leucine and mixed muscle protein synthesis rate (FSR) after consumption of whey protein supplementation, there was no increase in muscle mass in the experimental group. (Colonetti et al., 2017)
- Consuming frequent meals containing 30–45 g of protein is associated with greater leg lean mass and knee extensor muscle strength as well as lean body mass.(Lancha et al., 2017)
- High doses of protein with high biological value at rest are necessary to optimally stimulate muscle protein synthesis in older men. (Lancha et al., 2017)
- Several studies showed some positive results on the association of physical exercise together with supplementation of whey protein, especially for audiences like the elderly who may experience protein deficit. It is worth to note that protein sources with high biological value containing essential amino acids (notably leucine), such as whey protein, but of course not exclusively, are most relevant to generate the appropriate stimulus for protein synthesis.(Lancha et al., 2017)
- Sex may affect changes in muscle mass or strength in response to protein supplementation combined with resistance training (RET). Protein supplementation had an important effect on RET-induced lean mass gain in male participants, whereas no relevant effect was observed in female participants. This may be due to minor sex-based differences in the protein metabolism and muscle

protein turnover of young people. Furthermore, older women exhibit a reduced capacity for muscle hypertrophy after RET and demonstrate an inability to increase muscle protein synthesis in response to protein supplements. (Liao et al., 2017)

- Whey protein is rapidly digested and absorbed; therefore, it can be ingested immediately before, during, or after exercise (Cruz-Jentoft et al., 2020)

Older adults who build activity into their daily routines require an even distribution of (high biological value) protein throughout the day

- Inadequate dose of protein (via milk), high habitual protein intakes, fitness and sarcopenia status at baseline may be reasons for the lack of demonstrated effects of milk.(Granic et al., 2020)
- In elderly, despite the initial evidence of pre-sleep protein enhancing overnight muscle protein synthesis, the current available evidence is limited, precluding further conclusions about its chronic effects on skeletal muscle mass or strength. Additionally, the effect could have been due to timing intakes as protein intakes were uneven throughout groups.(Reis et al., 2020)
- Frequent consumption of meals with >30 g of protein was positively associated with leg lean mass and knee extensor strength. Consuming >0.25 g/kg/meal of protein at one, two, three or four daily eating occasions decreased the odds for functional disability by 40%, 52%, 53%, and 61%, respectively, compared to individuals that did not consume this amount. (McKendry et al., 2020)
- The consumption of 0.4 g/kg of protein at each meal, by increasing the total amount of protein consumed or redistributing the protein intake from the evening meal, may be an appropriate recommendation for older adults to maximally stimulate muscle protein synthesis.(McKendry et al., 2020)
- It is clearly possible to have an even distribution of dietary protein, yet also consume inadequate protein at each meal. Therefore, sufficient daily intake is necessary for an even distribution of protein to be effective. In an 8 week intervention, protein distribution did not impact whole body protein kinetics, lean body mass, strength, and function. They suggest that >1.1 g/kg/day of protein is required for individuals with three eating occasions per day. (McKendry et al., 2020)
- There are narrow differences in metabolic rates between two type of proteins whey and casein. This is why meal timing is important. Older adults need to eat protein in every meal to continually stimulate muscle anabolism throughout the day.(Paproski et al., 2019)

- Despite frail, prefrail, and non-frail community-dwelling older adults consume comparable total daily protein intakes, non-frail participants demonstrated a more even protein distribution pattern across the 3 daily meals than frail and prefrail people. (Phillips and Martinson, 2018)
- A more even pattern of protein consumption was associated with greater leg lean mass and strength, increased muscle mass, and increased strength.(Phillips and Martinson, 2018)
- Although data is not consistent regarding protein quantities, the available data collectively suggests that a balanced distribution of adequate amounts of protein intake is the most favourable for muscle protein anabolism. (Franzke et al., 2018)
- A recent consensus statement recommended a daily protein intake of 1.0–1.2 g/kg, with at least 20–25 g of high-quality protein at each meal (and post-exercise) for older people. (Daly, 2017)]
- An optimized offer of high-quality protein in the breakfast and lunch (all daily meals containing ≥0.4 g/kg/BW) by protein supplementation promotes a significant increase in appendicular lean tissue mass in healthy older individuals (Lancha et al., 2017)
- Protein dosing schedules are important to consider. Twenty-four–hour muscle protein synthesis is stimulated more effectively by protein intake throughout the day compared with skewing in take toward the evening [29]. An RCT of overweight adults reported no incremental improvements in muscle mass when 90g of protein was consumed in equal versus variable doses three times per day [30]. Research on the optimal timing of protein supplementation relative to PRT is evolving. (Cruz-Jentoft et al., 2020)
- Those in the non-frail group had evenly distributed protein throughout the day while pre-frail and frail groups ate a more skewed distribution of protein with higher protein consumption at lunch (38). Consumption of an uneven distribution of protein was associated with frailty, slower walking speed, and fatigue (Deer and Volpi, 2015)

Highlights

Currently, there is no consensus on the effect of nutritional supplementation, particularly protein combined with different types of exercise, on muscle mass and strength gains in healthy older people. Differences in results are likely due to design differences such as lack of randomisation and lack of specificity of the nutritional supplement.

Some studies used fortified milk supplementation, and did not find that interaction with exercise improved some parameters of muscle mass and function. Others used specific supplements, such as leucine or other combination of amino acids, and this resulted in another weakness because the amino acids were normally accompanied by other micro nutrients. This means that changes could not be attributable to protein alone. In one case, authors emphasised that protein or amino acid supplementation alone could not increase skeletal muscle mass or strength.

There was a range of doses used, between 10g and 35g of protein, recommended to eat in a meal after different types of exercise. There was a lack of emphasis on what authors meant by ‘prolonged’, type of resistance exercise, protein source; and it was also unclear for how long the supplementations needed to be taken to achieve the desired effect. Regarding the type of protein, although most authors emphasised that a high biological value protein was more helpful than vegetable sources to stimulate muscle protein synthesis, several studies did not find any effects with whey, casein and usual protein. When the meal contained <1.2g/kg body weight, soy protein was found beneficial to improve muscle strength and lean mass. One study showed that a liquid protein based meal provided a greater increase in amino acid concentration.

The timing for consuming protein after performing exercise was also unclear. Authors recommended a range of times between 5 minutes and the whole night (sleeping hours) to consume a protein-rich based meal or snack. Further studies are necessary to understand any differences between sexes in capacity for muscle hypertrophy, as current evidence was unclear.

There was a lack of consensus about how much protein (>0.25 g/kg BW/meal to 30g/meal) decreased the likelihood of a functional disability. The most recent consensus recommends at least 1g/kg BW of protein daily and at least 20g of high quality protein post exercise.

It was suggested that the distribution of protein consumtion throughout the day did not impact lean body mass and strength, but rather a consumption of >1.1g/kg BW/day in total was required. Only a few studies demonstrated that an even protein distribution across at least three meals maintained a healthier muscle mass (lean mass and strength).

Some studies that did not demonstrate a supportive effect from protein (milk, for instance), explained that this was due to the fitness level and sarcopenic status of individuals.

Fifteen papers were older than 2017 and these were not read given time and resource constraints, but we believe that very similar findings to the most updated evidence would have been found.

Conclusion

There seems to be a lack of consensus for the details included in the proposed statements. There was no consensus regarding timing of protein intake or the quantity needed from dietary protein or protein supplements. Moreover, many papers had to be discarded due to the use of protein supplements rather than dietary sources. Future searches need to be more specific to discern studies that discuss quantities specifically, quality of protein, or timings.

Body Mass Index

Statements

1. In older age being a little overweight is more protective to health than being in the healthy weight category, (sub-statement) including UK based ethnic minority groups. (Healthy BMI=18.5-24.9kg/m^2 and overweight=25-29.9kg/m^2)
2. Unplanned weight loss is not a normal part of healthy ageing and is associated with older adults not being able to do activities of daily living

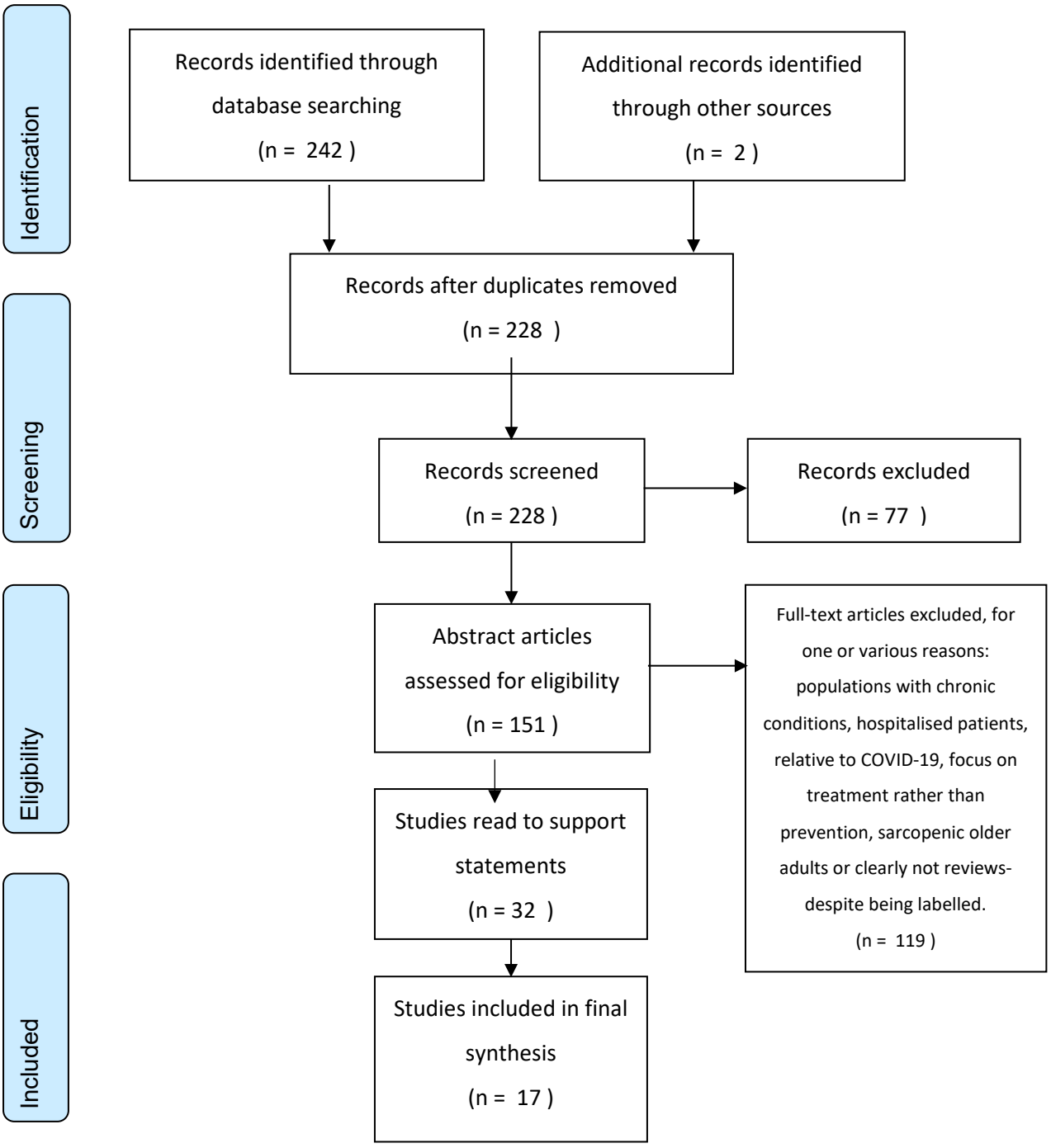
Method

Two key papers provided by the BDA served to build the search strategy and gather keywords and terms that helped gather relevant papers. Winter et al. (2014) was also retrieved in the final strategy. Only in OVID Medline database was it possible to create a combination of search terms to retrieve information about the sub statement. Appendix 5 shows systematic searches across databases.

Figure 6 (PRISMA) shows the number of papers found and deleted records due to reasons listed in this same figure. Many titles and abstracts turned out to be misleading given that BMI is a highly used measure to compare populations, points in time and treatments. Quotes were extracted and only occasionally paraphrasing was used.

Of note, the nature and content of statements led to a search for keywords related to BMI, however, it will be helpful to use more concise statements and a broad variety of keywords such as fat distribution, adiposity, life expectancy, mortality, etc; which are words obtained from papers found in google scholar, a system that does not allow conducting a systematic search. Another helpful suggestion would be to look at reference lists of final papers and look at citations of those papers as well.

Figure 6 PRISMA for BMI



Findings

In older age being a little overweight is more protective to health than being in the healthy weight category, (sub-statement) including UK based ethnic minority groups. (Healthy BMI=18.5-24.9kg/m^2 and overweight=25-29.9kg/m^2)

- In a study following 8.3 years 130,473 subjects aged 60–69 years, authors found that adiposity was associated with substantial excess mortality also in subjects with a BMI corresponding to normal-weight or overweight. They concluded that the obesity paradox in the elderly may result from failing to account for central adiposity (Bosello and Vanzo, 2021)
- Fitness, however, seems crucial. Five cohort studies of 30,104 patients (87% men) with CVD show that cardiorespiratory fitness (CRF) significantly modifies the obesity paradox. However, among patients with high CRF, studies show that the risk of all-cause mortality is not always the lowest in the overweight category. The interactions between obesity and CRF in different ages are still insufficiently understood (Bosello and Vanzo, 2021)
- It is not clear if an increased risk of functional limitations in the elderly is also associated with overweight, i.e., a BMI comprised between 25.0 and 29.9 kg/m2. A study involving 406 participants aged 70–89 years showed that the risk of developing major mobility limitations was reduced in overweight individuals compared to normal weight or obese subjects (Ponti et al., 2020)
- A systematic review and meta-analysis examining the impact of a high BMI on mortality risk in older adults concluded that BMI in the overweight range is not associated with an increased risk of mortality, whereas obesity showed a significant association with a higher mortality risk. More recent studies have supported the finding that a high BMI negatively affects healthy life expectancy, and it is also associated with an increased risk for cancer mortality, in particular for colorectal cancer (Ponti et al., 2020)
- Overweight and obesity may lead to multimorbidity through multiple mechanisms such as reduced functional capacity and fitness and/or stimulation of inflammation and insulin resistance, all of which are shared risk factors for cardiovascular and non-cardiovascular disease and for functional impairment (Calderón-Larrañaga et al., 2019)
- BMI values of less than 22 kg/m2 are associated with an increase of almost seven times the mortality at 1 year, as compared to values higher than 25 kg/m2. (Malafarina et al., 2018)

- The “BMI paradox” is valid in the elderly, in which an increase in fat mass and a decrease of muscle mass are observed, and for this reason falsely high values of BMI can mask the presence of sarcopenia (Malafarina et al., 2018)
- Compared to persons who were consistently overweight, persons who gained weight between 2004 and 2012 had the highest likelihood to become frail [OR 3.61 (95% CI 2.39–5.46)]. Persons in the consistent obesity and weight loss trajectories also had an increased risk of frailty [OR 2.72 (95% CI 2.06–3.58) and OR 2.81 (95% CI 1.84–4.30)], respectively. Weight and height were self-reported and weight change intentions were not recorded in this study, which can skew the results (Reinders, Visser and Schaap, 2017)
- An overweight BMI (25.0 to 29.9 kg/m2) is not associated with adverse mortality outcomes in older adults. In fact, being overweight is associated with the lowest mortality across all age groups, and this association is pronounced specifically in the older adults. Thus, there are protective effects of overweight on survival and, unlike for frank obesity, no need to consider efforts to change body weight for older adults with a BMI of 25 to 29.9kg/m2 (Porter Starr et al., 2016)
- A recent large meta-analysis of nearly 200 000 individuals aged 65 or older showed a U-shaped relationship between BMI and mortality, with the lowest risk seen in those with a BMI between 24.0 and 30.0 kg/m2 and risk only began to increase when BMI exceeded 33 kg/m2. (Wannamethee and Atkins, 2015)
- NT-proBNP levels, a marker of cardiac dysfunction, are lower in overweight and obese patients; lower NT-proBNP predicts lower mortality (Wannamethee and Atkins, 2015)
- In total, studies included in this review contributed 197,940 individuals (72,469 deaths) with an average duration of follow-up of 12 y. All were population-based cohorts, which included participants from Europe, North America, Canada, and Australia. (Winter et al., 2014)
- Those individuals with a BMI of ≤20 had at least a 28% greater mortality risk than did those with a BMI between 23.0 and 23.9. Participants in the overweight range (BMI of 25.0–29.9) had 4–10% lower mortality risk, however those with a BMI ranging 35.0–35.9 had a 21% increase in mortality risk. The increased risk associated with a lower BMI persisted among never-smokers but was attenuated. The WHO healthy weight range may not be suitable for older adults, and the interpretation of BMI for this group should be in the context of other existing comorbidities and functional capacity. (Winter et al., 2014)

- Aging is associated with unfavourable changes in body composition. The coexistence of muscle mass loss and increased fat mass with aging is sometimes termed “sarcopenic obesity”. Older people are also prone to underweight and cachexia because malnourishment associated with aging and undernutrition associated with chronic diseases are more prevalent in the elderly. Both overweight and underweight are predictors of functional impairment, chronic diseases, and disability. Weight gain or unintentional weight loss also predict subsequent loss or limitation of activity of daily living. Aging is associated with gradual declines in appetite, taste and smell sensitivity, and decreased gastrointestinal tract function. In these elderly people, underweight or cachexia is a major problem. The major obstacle to achieving and maintaining ideal body weight in these individuals is inadequate food intake. (Gonzalez-Campoy et al., 2013)
- In people older than 65 years, a higher BMI is associated with neutral rather than detrimental effects on length of life. Among 12,725 people aged 65 or older in the Established Populations for Epidemiologic Studies of the Elderly, life expectancy was greatest with a BMI between 25 and 27 kg/m2, but disability-free life expectancy was greatest at a BMI of 24 kg/m2 (Soenen and Chapman, 2013)

The later statement includes UK based ethnic minority groups. (Healthy BMI= 18.5-24.9kg/m2 and overweight=25kg/m2-29.9kg/m2)

- Another important predictor of mortality risk in old adults is represented by body weight change. In particular, a recent study considering a multi-ethnic cohort of 63,040 individuals showed that weight loss rather than gain was associated with an increased mortality risk. (Ponti et al., 2020)
- Black respondents reflect the greatest proportion of those with high-risk scores, yet Hispanic participants display the most concerning nutrition risk profiles. The study contributes to a growing body of research that supports the elevated nutrition risk among independent-living older adults, regardless of BMI, and offers unique findings among minority participants. Females were more likely to be at nutrition risk overall compared with men. (Sheean et al., 2019)
- The prospective Cardiovascular Health Study estimated both incidence and prevalence rates of frailty among 5317 men and women (≥65 years) of different ethnic origins. Frailty was defined by the presence of 3 or more of the following symptoms: (A) unintentional weight loss in the course of 1 year; (B) self-reported exhaustion; (c) weakness in the dominant hand; (D) slow walking speed and (E)

low physical activity. The overall prevalence rate (n = 5317) was 6.9%, which was modified by gender and age stratum [higher in women than men (7.3% vs. 4.9%) and with advancing age. (Buch et al., 2016)

- In Hispanic populations, overweight and obese participants showed much lower mortality than normal BMI people. Overweight participants lived the longest, obese participants lived longer, and participants with normal BMI lived the least long (Nam, Snih and Markides, 2016)
- In a Brazilian sample, underweight elderly according to BMI and those with a higher proportion of overweight according to BMI showed a higher prevalence of frailty (Mello, Engstrom and Alves, 2014)

Unplanned weight loss is not a normal part of healthy ageing and is associated with older adults not being able to do activities of daily living

- Even if an intentional weight loss by obese older people can be safe and likely to be beneficial when obesity-related conditions exist, rigorous caution is advised in recommending weight loss to older overweight people based on body weight alone. The distribution of fat can give a greater risk to health than BMI. (Bosello and Vanzo, 2021)
- Involuntary weight loss is always dangerous and deserves careful clinical evaluation for the search for the underlying causes. Probably, in elderly subjects, it is clinically important to try to diagnose sarcopenic obesity. (Bosello and Vanzo, 2021)
- As age is one main risk factor for the development of chronic disease, older persons are particularly susceptible to disease-related weight loss, loss of muscle mass and strength (i.e., sarcopenia) and ultimately, the frailty syndrome, all of which can fundamentally impact recovery from disease and clinical outcome in general. (Norman, Haß and Pirlich, 2021)
- Weight loss, a marker of macronutrient deficiency and/or catabolism, is a common key initial phenomenon in old patients, which sets off a catabolic cascade of unfavourable events resulting in higher morbidity and mortality. The causes for weight loss in higher age are multifactorial but can in part be attributed to both disease processes such as catabolic events, disease or age-related anorexia (“anorexia of aging”) and subsequent insufficient dietary intake, but also to increased inflammatory status, depressive or cognitive disorders as well as a decreased socio-economic status. (Norman, Haß and Pirlich, 2021)

- Malnutrition in older adults is more severe than in younger adults. Studies have not only shown that changes in body composition in malnutrition occur to a greater extent in older compared to younger adults, but also that recovery of low body cell mass or muscle mass is impaired in higher age following weight loss. This predisposes malnourished older adults to the risk of developing the so-called geriatric syndromes which greatly compromise health status, cognitive functioning, functional ability, and compensatory capacity and result in higher mortality. (Norman, Haß and Pirlich, 2021)
- Involuntary weight loss, a hallmark of malnutrition, is inevitably associated with loss of skeletal muscle mass, which appears to occur at a greater extent in higher age. This increases the risk of developing sarcopenia, a phenomenon which is characterized by the loss of both muscle mass as well as muscle strength and function. (Norman, Haß and Pirlich, 2021)
- Old patients with severe involuntary weight loss at discharge from hospital had a significantly higher risk for severe fatigue which in turn compromises post hospital recovery. (Norman, Haß and Pirlich, 2021)
- Excessive body weight, in addition to the hindrance of body mass, may jeopardize the capacity to fulfil many daily tasks, resulting in fatigability (Azzolino et al., 2020)
- Loss of weight in late life is a consequence and not the cause of quickly deteriorating health status and progressing multimorbidity. Weight loss is a strong prognostic factor for mortality in old age. The majority of people who die very old may experience a substantial decline in weight already in the 3 to 8 years prior to death. (Calderón-Larrañaga et al., 2019)
- In a cohort of almost 3,000 Italian individuals over 65 years old, a weight gain of more than 5% after their 50s was correlated with an augmented risk of limitations in activities of daily living (ADLs). However, it was also observed that a 7-years weight gain pattern among men and women over 65 years old did not increase the risk of limitation in ADL or mobility compared to individual who maintained a stable weight. Most of the weight changes reported in these studies were unintentional. (Ponti et al., 2020)
- Unintentional weight loss may increase mortality risk in older adults, but not intentional weight loss. Unintentional weight loss may be the consequence of an underlying disease. Unfortunately, in most of the studies conducted so far intentional rather than unintentional weight loss distinction is not very clear. Body

weight increase has not been found to be associated with a higher mortality risk in older adults. (Ponti et al., 2020)

- There is a potential beneficial impact of voluntary weight loss combined with exercise on frailty indices. (Reinders, Visser and Schaap, 2017)
- BMI and inflammation have also been significantly associated with muscle mass loss. (Kim et al., 2016)
- In Asian (Chinese, Japanese, etc.) older adults, BMI was predominantly associated with sarcopenia in men and women across most definitions, where greater BMI was inversely associated with the likelihood of sarcopenia. (Kim et al., 2016)
- Subjects with a low baseline weight (BMI<23.6 kg/m2) who lost more than 1.6 kg per year had a mortality rate of 22.6%, almost 20 times greater than the mortality rate of those with a baseline BMI of 23.6 to 28 kg/m2whose weight remained stable. (Soenen and Chapman, 2013)

Highlights

BMI does not seem to reflect the level of adiposity or distribution of fat in older adults, which is a risk factor for higher mortality and morbidity. This has been named BMI paradox; a high BMI can mask sarcopenia. A low BMI which indicates being underweight is also associated with higher mortality as compared with BMI higher than 25. Being overweight (between 24 and 30kg/m2) in people above 65 years has a neutral and often protective effect against all-cause mortality, cardiovascular disease and function, risk of developing mobility limitations, disability-free life expectancy; unlike obesity and underweight.

Only a couple of reviews stated that overweight or obesity leads to multimorbidity, inflammation, insulin resistance, decreased capacity for daily tasks (ADL), cardiovascular disease and functional impairment.

Regarding minority groups, weight loss seems to be a higher risk than weight gain, but Black and Hispanic older adults seem to have a higher risk than White populations, regardless of BMI. Women too had a higher risk than men in these two ethnic groups. In another study, Hispanics with overweight presented lower mortality than older adults with normal BMI. In Asian populations, BMI is inversely associated with sarcopenia.

Unintentional weight loss implies a catabolic cascade that leads to higher morbidity and mortality. It has been related to malnutrition, sarcopenia, frailty and geriatric

syndrome, impairs recovering from disease (especially from the hospital). Therefore, weight loss is not recommended for overweight people and warrants a clinic evaluation of the underlying causes as it is a prognostic factor for mortality. Involuntary weight loss seems to be more dangerous than being overweight. Maintaining a stable weight does not seem to increase the limitation of ADL. Moreover, voluntary weight loss combines with exercise seems to improve frailty indices.

Conclusion

This review provides an overview of the evidence about the importance of adjusting BMI expectations for older adults and being particularly careful to understand involuntary weight loss. Being overweight (BMI 24-30kg/m2) seems to improve functional outcomes, decrease multimorbidity and mortality risk and thus needs to be considered under this rationale for public health recommendations. It is essential to differentiate this from obesity, as prognostic has an inverse relation to overweight.

Enjoyment of eating

Provisional statements

1. Eating pleasure should be emphasized more in the promotion of healthy eating
2. Enjoyment of eating can benefit older adults both psychologically and physically

Method

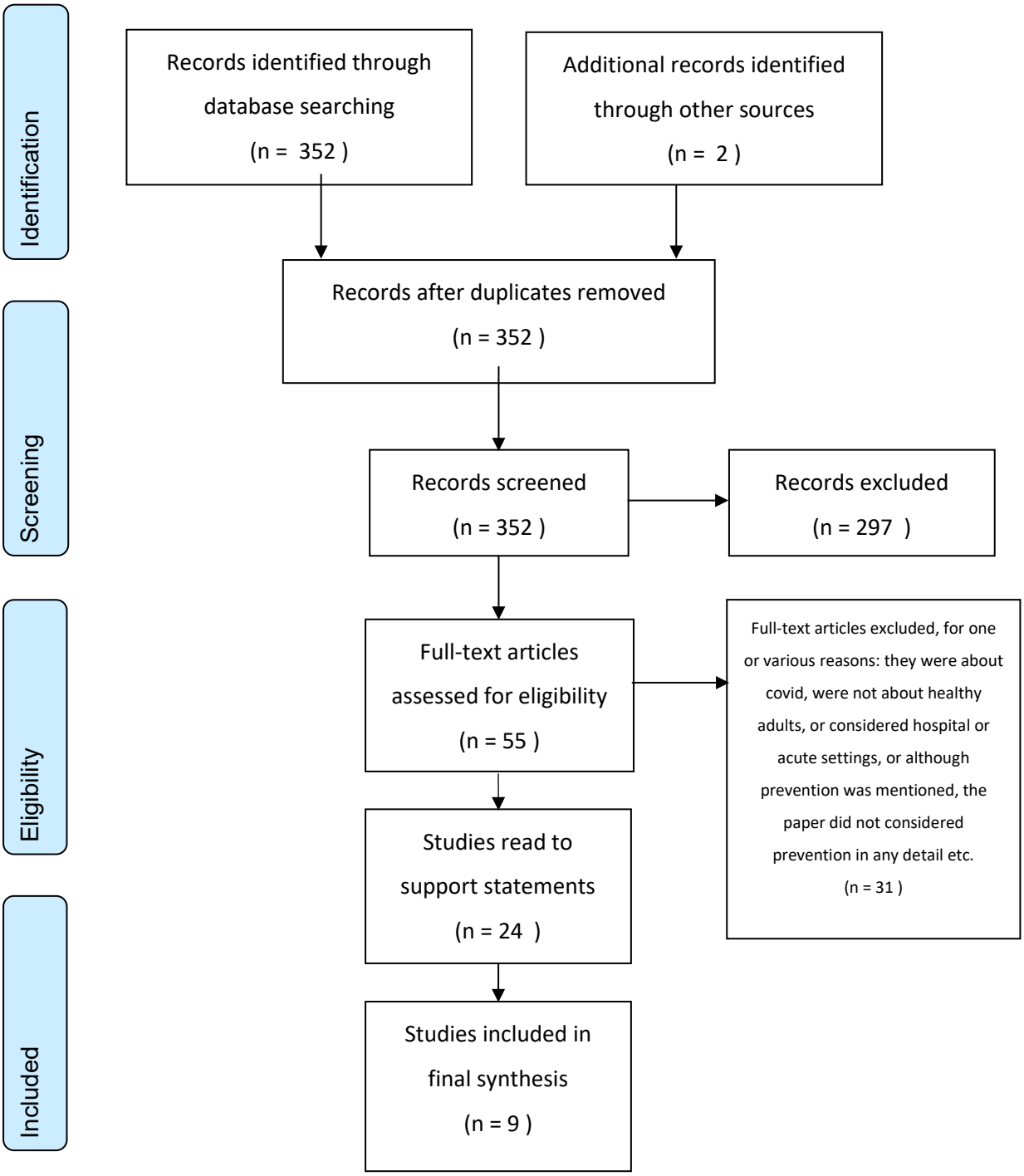
During a brainstorming session with the team to discuss the approach to take for this topic, a key paper to select viable terms and current guidelines was read and key information extracted (Gonzalez-Campoy *et al.*, 2013). Another key paper was located (Bédard *et al.*, 2020) however this review included all population groups and therefore extraction was performed from relevant statements for older adults only.

After reading these papers and discussing the topic the authors refined the search strategy (see Appendix 6). In addition to the three specialised databases that were consulted for other topics (OVID Medline, EMBASE and COCHRANE) we also searched PsychInfo.

The PRISMA flow diagram (figure 7) shows how many papers were retrieved from searching databases. These were filtered by title, abstract and finally by full text. 352 titles were screened, 55 papers were read by abstract and 24 for full text. Fifteen

papers were not eligible for inclusion due to the reasons listed in figure 7, and therefore a total of nine papers were included in the review.

Figure 7 PRISMA statement for enjoyment of eating



Findings

In the following section, evidence statements are extracted as direct quotes from the papers and occasionally paraphrased. We found that there were several social and psychological factors identified in papers linked to eating. We have included more of these statements so that the final statements used in the resource can be based on awareness of the range of psychological factors implicated in eating rather than just enjoyment. Some comments in italics were added as an open reflection relevant to the paper or paragraph

Key papers found outside the systematic search

(Gonzalez-Campoy et al., 2013): Clinical Practice Guidelines for Healthy Eating for the Prevention and Treatment of Metabolic and Endocrine Diseases in Adults.

- Eating is a social activity. Eating alone and in silence may be a major contributor to eating poorly. Efforts should be made by caregivers to assist the frail elderly individuals with meals and to improve the feeding environment. This holds true whether at home or in a long-term care facility. It has been shown that a cafeteria-like service that brings people together at a dining table is better than the traditional meal delivery service on trays. Every effort should be made to have trained person accompany frail individuals at mealtimes. Direct feeding assistance should be provided to the extent warranted by individual needs. Depression is common among older adults in social isolation and should be screened for and treated when present.
- To find out about food enjoyment it is advisable to look at studies that include quality of life tools, for instance.
- The social environment includes interactions with family, friends, peers, and others in the community and may impact food choices through mechanisms such as role modeling, social support, and social norms. Many of these factors require transculturalization in order to optimize implementation for individuals of different backgrounds.
- Social isolation, physical disability, inability to shop or prepare tasty meals, and depression can all lead to poor appetite and undernutrition in the elderly.

(Bédard et al., 2020): Can eating pleasure be a lever for healthy eating? A systematic scoping review of eating pleasure and its links with dietary behaviors and health

- Key dimensions of eating pleasure and how is this related to health outcomes, as well as interventions using eating pleasure to promote healthy eating
- Key dimensions: sensory experiences (taste, appearance, texture), social experiences (eating with others, preparing meals with others, respecting shared norms and practices such as culture and traditions), food characteristics (healthy, unhealthy, fresh) and preparations (cooking, gardening, grocery shopping), novelty (discovering new food, dishes and tastes, learning about food), variety (in type of food, flavours and ways that food is prepared) and just <15% for emotional eating (including mindful, visceral and memories) and place when this is consumed (eating at restaurants, eating while travelling, eating at home or in front of the TV). A last couple of related dimensions were health considerations (balancing pleasure and health, making healthy choices) and ideological considerations (e.g., environmental movement)
- Most studies were cross sectional and showed associations between eating pleasure and dietary outcomes. The most promising interventions were mindful eating, sensory experiences, cooking and sharing activities, and positive memories related to healthy food.
- Important to note that only 60% were peer reviewed articles, most of them published in psychology journal and fewer in food sciences, public health and business. A third of the literature came from dietary guidelines healthy eating tools and reports or program descriptions.
- Of the included studies, only a few included older adults, and only two used this as the only population group. When authors did not specify standard deviation and therefore age was difficult to predict, comments were not included here. A French study in older adults determined enjoyment of eating as a predictor of nutritional status in aging population. And Australian population showed a favourable association between enjoyment of eating and the perceived level of importance that individual place on food.
- The review looked at whether dietary outcomes and health outcomes were favourable or unfavourable links with diverse dimensions of enjoyment of eating.
- A study in Japan with various population groups had a favourable relation between enjoyment with a highly balanced diet, vegetable meals and a subjective related quality of life.
- A European sample showed an unfavourable relation between enjoyment of eating and a high intake of full fat cheese sandwich and full-fat chocolate bar and

with a high intake of light soft drink. Interestingly, neutral associations were found with non-fat or full fat milk, healthy food choice and pleasant choice.

This paper may be re-examined if the focus needs to be on successful interventions. However, it will force you to look at empirical papers rather than reviews and will not necessarilty have a focus on older adults.

Key papers found through the systematic search strategy

(Björnwall et al., 2021): Eating Alone or Together among Community-Living Older People—A Scoping Review.

- The practice of sharing a meal—commensality—has been identified as one key social influence on eating behavior in later life, which can stimulate greater pleasure from food and may improve nutritional status. [*This statement comes from a review that was older than 2012: {Vesnaver, E.; Keller, H.H. Social influences and eating behavior in later life A review. J. Nutr. Gerontol. Geriatr. 2011, 30, 2–23}. Bjornwall et al also mentions empirical papers by Vesnaver, who seems to be a key author worth looking at.]*
- A meal intervention combined with social support once a week found evident improvements within the treatment group, but also relative to participants in the control group regarding food enjoyment.
- Vesnaver et al. explored the loss of commensality and found that eating alone led to fewer regular meals and less time spent on food. However, participants also said that even if mealtimes were negatively affected by being alone at the table, cooking and eating could still be pleasurable. *{Vesnaver, E.; Keller, H.H.; Sutherland, O.; Maitland, S.B.; Locher, J.L. Alone at the Table: Food Behavior and the Loss of Commensality in Widowhood. J. Gerontol. B Psychol. Sci. Soc. Sci. 2016, 71, 1059–1069.}*
- In contrast, meals eaten alone at home was described as being enjoyable by single-living older people, in a qualitative study on domestic and communal meals. For example, dining in alone was linked with feelings of contentment and peacefulness
- Even though dealing with dementia could be challenging for food enjoyment, families enjoyed socializing by eating out, or getting together with other social groups.
- In a study where participants were categorised into groups, (“food lovers” and “nonfoodies”), authors stated that “‘[b]eing alone at the table’ was the greatest

threat to food activities and identity, especially for the food lovers who gained pleasure from the social aspect of their food activities". The food lovers coped with being alone by cooking for friends and family, while the nonfoodies had different experiences, describing eating alone as difficult. [*This article touches on isolation and does not link it directly to enjoyment; however, I think there is plenty of evidence of what sort of feelings having company may bring, including, enjoyment. In addition, we only focused on general findings and not the included tables. I therefore think that this paper can be further explored to examine factors that underpin enjoyment and that also relate to nutrition and diet.]*

- Moreover, some studies show associations between eating alone and negative health outcomes in men but not in women, regarding depressive symptoms [21], metabolic syndrome [14], and mortality [15,16] *[Please see the Björnwall paper for these numbered references]*.

(Borders and Sajjadi, 2021): Diagnosis and Management of Cognitive Concerns in the Oldest-Old.

This paper cited another paper (Bailly N, van Wymelbeke V, Maître I, Sulmont-Rossé C. The assessment of eating pleasure among older adults: development and preliminary validation of the anticipatory and Consummatory Eating Pleasure (ACEPS). J Curr Treat Options Neurol (2021) 23: 10 Page 15 of 18 10 Nutr Health Aging. 2020;24:6) which may be an alternative approach. To look for papers which have cited key empirical or methodological papers.

- Malnutrition and unintentional weight loss in the elderly are multifactorial issues that worsen with age. The oldest-old are known to experience less anticipatory pleasure of meals, a necessary response to maintain appetite.

(Gillies et al., 2021): Healthy eating strategies for socioeconomically disadvantaged populations: A meta-ethnography.

This review included adults aged 18 years and over, of socioeconomic disadvantage and from the general population, which in some cases included older adults. Therefore, care should be taken when extrapolating these results.

- A friendly atmosphere encouraged people to participate in a healthy eating education program, and that "participants explicitly mentioned that favourable interactions with other people were an important and enjoyable part of the learning experience". "There was a strong preference for active involvement, especially in

the form of cooking. Participants reported that engaging in food preparation during the sessions was a highly enjoyable activity that gave them the confidence and ability to prepare healthy meals at home, while also providing the opportunity to taste the prepared meals to ensure they were palatable”

(Krivanek et al., 2021): Promoting Successful Cognitive Aging: A Ten-Year Update

- Many of the brain-health-promoting interventions to help prevent and delay cognitive decline involve putting restrictions on one’s life, for example, reducing access to certain enjoyable foods, alcohol, or cigarette smoking, or feeling constrained by having to wear seat belts and helmets or by having to get seven or more hours of sleep at night

(Mawardi et al., 2021): Malnutrition in older adults: How interprofessional teams see it? A systematic review of the qualitative research

- Older adult with malnutrition should be supported by pleasant dining environment and encouraged to share their mealtime with others.

(Aguilera, Kim and Park, 2019): Chapter Seven—Particular Alimentations for Nutrition, Health and Pleasure.

Key paper. This paper contains wider notions on the pleasure of eating and seems to be a theoretical review that can provide concepts to further refine future searches. At times I feel translations to English are poor, but I think it is worth reading.

- Gastronomy or the art of selecting, preparing, serving and enjoying fine food highlights the eating-related pleasures, the social and cultural dimensions of eating as well as its aesthetic experience.
- When it comes to the positive effects of foods on well-being, the pleasure of eating has been paid a low attention compared to that given to nutrition. The reductionist approach that health has only to do with the body (but conveniently excluding the brain) has neglected the role of foods in so many social activities unique to humans such as family life, the practice of culinary traditions, solidarity in times of hunger, etc., not to mention the positive effects of some food components for good mental health, happiness and cognitive power
- In the same vein, the term “comfort food” has been used to refer to foods that provide consolation, improve the mood or give a feeling of well-being, in other words, foods that offer some sort of psychological or emotional reassurance

- Eating is an important source of personal pleasure (hedonics), hence, it may contribute to happiness. However, in most cases, the pursuit of happiness is not seen as something that individuals can achieve in solitude but as an experience of shared relationships
- The following is an extract from the paper summarising other research which explored enjoyment or pleasure in eating specifically in older adults:

Elderly	Interviews to find out the impact of cooking meals among retired women (some widows)	Most women had lost the meaning of cooking and felt loneliness at mealtimes. Widows, in particular, found joy in cooking for guests and the commensality during meals	Sidenvall, Nydahl, and Fjellström (2000)
	Mailed questionnaire to assess the effect of candy on men born in 1919–1934	Chocolate preference among elderly was associated with better health, optimism and better psychological well-being	Strandberg et al. (2008)
	Intervention based on nutrition education and cooking classes to 59 elderly (average 69 y/o)	The group improved their diet quality (e.g., intake of vitamin C and fiber). The intervention had a favorable effect on their psychological well-being	Jyväkorpi et al. (2014)
	Olfactory and gustatory functions were measured on 239 healthy individuals (65–101 y/o) and good cognitive status	Chemosensory impairment detected was 41% for taste and 33% for olfaction, however, it was not related with eating pleasure and loss of appetite leading to malnutrition	Arganini and Sinesio (2015)
	Randomized control study of 626 seniors at Meals on Wheels programs	Home-delivered daily meals improve the well-being of older adults beyond nutrition by reducing feelings of loneliness	Thomas, Akobundu, and Dosa (2016)
	Mailed questionnaire responded by over 11,000 adults age 65 years or older on issues like life satisfaction and food patterns	Elderly persons in Norway with "healthier" food patterns had higher scores on life satisfaction and felt less depressed than those on "unhealthy" diets	André et al. (2017)

- Commensality or sharing meals with others, that is so typical of humans and an event of daily social occurrence because of biological needs, has been associated with happiness. Eating in company enhances the emotional experience of having a meal and is an opportunity to bond with friends. Special feasts or celebrations (birthdays, anniversaries, etc.) involving food have also been found to be occasions for happiness.
- Food requirements for elderly people may be divided into those related to the oral experience (e.g., mastication, sensory enjoyment, safe swallowing) and those associated to other physiological changes of aging (e.g., changes in body composition, nutritional needs and related diseases). A large number of elderly people exhibit a progressive loss of taste, smell and trigeminal stimuli, which has a negative effect on their food preferences, dietary habits and the enjoyment of meals. This loss of chemosensory sensations often results in reduced appetite, poor meal appreciation, a decreased food intake, loss in body weight and eventually in nutritional deficiencies.
- Several studies show that elderly who eat alone have increased risks of poor nutritional status and weight control, depression and ultimately death. In conclusion, physiological dysfunctions and specific nutritional needs developed

during aging require a sourcing of special foods which in most cases have to be soft, easily and safely swallowed, nutritious and tasty. Moreover, the psycho-social aspects surrounding eating should not be underestimated.

- Several Japanese food companies offer a variety of soft-food products aimed at people presenting mastication problems, at risk of malnutrition and/or subject to aging diseases (Higashiguchi, 2015). Companies emphasize the “enjoyment of their meals” and their products are getting greater prominence on supermarket shelves

(Jadczak and Visvanathan, 2019): Anorexia of Aging—An Updated Short Review

- Eating is often a social event, although barriers of loneliness, mobility and incontinence can prevent older people participating in such occasions. Living and eating alone can cause reduced appetite, possibly due to a lack of support or motivation to shop, cook and eat well. Additionally, eating alone is less pleasurable and people living alone have fewer social engagements, which may negatively affect the appetite of many older people.
- Sense of smell and taste decrease with aging and may affect the older person’s desire to eat. With increasing age, there can be increases in pro-inflammatory cytokines, which in turn are associated with cachexia, excess catabolism and reduced food intake. Changes in the production of appetite-regulating peptides and hormones influence gastric emptying, satiety, and the feeling of satisfaction culminating in a feeling of early satiety and reduced oral intake

(Lee and Mo, 2019): The Factors Influencing Meal Satisfaction in Older Adults: A Systematic Review and Meta-analysis

Key paper. This is because the title is exactly what we are looking for. Will be useful when conducting backward and forwards snowballing. These authors say “In general, studies that focus on the effect of mental health on older adults' meal satisfaction tend to focus on negative aspects such as depression, anxiety, and helplessness”. This may be a reason why we barely found this type of literature.

- For older adults, eating is not only an important activity for life maintenance but also a great pleasure, and the desire to eat one's favorite food becomes a motivation to get out of the bed and increase the quality of life.
- Despite the importance that the domain of meal satisfaction has for older adults, its significance has not been properly acknowledged. The research on this

domain has also been limited. Previous studies on meal satisfaction in older adults have not analyzed the degree of satisfaction derived from the meal itself; instead, they focused on meal satisfaction in relation to life satisfaction and quality of life as well as dental health and the meal satisfaction of acute inpatients

- Meal satisfaction was affected by factors such as quantity, quality, temperature, the smell of food, and whether or not the food was frozen. Quality of food not only refers to the provision of fresh fruits and vegetables but also refers to the diversity of ingredients, the ease of preparing meals, and religious and cultural needs. If nursing homes and hospitals would consider the food preferences regarding these needs of older adults, this could help older adults feel satisfaction and joy and maintain a healthy life. Another finding of the study was that meal satisfaction levels were higher when one could smell the food. Regarding the temperature of food, older adults who received warm food were more satisfied with their meals, whereas those who received frozen foods were less satisfied. To increase meal satisfaction in older adults, it was beneficial to offer food choices and personally tailored meals suitable for each older adult's environment. There are insufficient evidence-based guidelines for individualized dietary service; they also argued that offering food choices, supporting independence, and promoting social interactions are key elements of mealtime care for nursing home residents.
- Physical health was found to have a positive influence on meal satisfaction. Similarly, meal satisfaction also seemed to play an important role in preventing physical and mental complications and various diseases

(Sulmont-Rossé et al., 2019): A cross-cultural perspective on feeling good in the context of foods and beverages.

This study is not a review but given the big sample used (almost 10K) I just extracted what I considered to be key and relevant information for the statements.

- Well-being is associated with two main dimensions: well-being related to pleasure (e.g., tasting good, having the choice, sharing, new flavors) and wellbeing related to health (e.g., varied diet, organic produce, healthy diet, eating in moderation).
- The Eating Motivation Survey (TEMS), Renner and collaborators (Renner, Sproesser, Strohbach, & Schupp, 2012) identified 15 motivations for eating what we eat, including physical (need & hunger, health, weight control), sensory and hedonic (liking, pleasure, visual appearance), emotional (affect regulation), social (sociability, social norms and social image), habitual (habits, traditional eating), practical (price, convenience) and natural (natural concern) aspects, all of which

have the potential to trigger positive feelings if satisfying our expectations and needs.

- Food related feeling good seems to be mainly driven by sensorial pleasure at present, but by nutrition and health in the future. This result is in line with the fact that time perspectives have been reported to influence food choices.
- Results from the present work suggest that using the concept of “feeling good” or making emphasis on positive feelings and emotions may be successful for encouraging changes in dietary patterns. Further research in this respect should be conducted.
- The most relevant category within the dimension sensory & hedonic properties of foods was tastes good (e.g., delicious, appetizing, yummy). This category was mentioned by 24% of the participants across the countries. It was particularly relevant in China with 72% of citations, but also in Russia (30%), India (29%) and United-Kingdom (29%).
- The experience of consuming products makes consumers feel good and not necessarily their specific properties (sensory, hedonic, non-sensory, nutritional). The importance of product experiences on consumers' conceptualization of feeling good was evidenced by the frequency of mention of categories related to hedonic experiences and emotional reactions to foods, such as tastes good and emotion, pleasure, happiness, enthusiasm, satisfaction and peace/calm)

These papers could not be found in full text

- Shakeri, Afsaneh, 2020, Strategies in traditional Persian medicine to maintain a healthy life in the elderly
- Draime, J. A. 2019, A systematic review of outcomes in food provision studies for older adults

Highlights

As a social activity, eating entails involving emotions and feelings. The context of eating also becomes relevant to enjoy food, particularly for older adults who are very often isolated without their partners or their family, or in nursing homes without the environment they were used to throughout their lives. Depression can lead to low appetite in the elderly.

Many papers related to the topic may be found across empirical papers discussing dimensions of eating pleasure, such as preparation processes, food characteristics,

commensality, atmosphere, and health considerations. These latter have been linked with eating enjoyment although often across topics such as eating disorders and younger populations.

Eating pleasure was described as important to prevent unintentional weight loss and maintain appetite. However, many interventions to prevent cognitive decline aim to restrict enjoyable food for participants (not because of its enjoyment but because these may contain a high energy, fat or carbohydrate amount). This is often done without considering other health issues that may also prevent enjoyment of eating across older adults, which is in turn related to malnutrition risk.

The promotion of meal enjoyment and positive emotions and thoughts about food can support positive changes to dietary patterns. More research is needed and this topic focussed on older adults may be an excellent topic for a systematic review.

Conclusion

Enjoyment of eating is a complex topic involving food quality and quantity, emotional, mental and social aspects. These latter play an essential role to promote health but also to enjoy eating in older adults. When they are satisfied, the evidence points that health is positively influenced.

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Appendices

Appendix 1. Search strategies for Vitamin D

1	(VITAMIN D or ergocarciferol or D3 or 25-hydroxivitamin D).af.
2	exp Vitamin D/
3	1 or 2
4	(older adult or elderly or old age or older person).af.
5	exp Aged/
6	4 or 5
7	3 and 6
8	supplement*.af.
9	exp Dietary Supplements/
10	8 or 9
11	7 and 10
12	((VITAMIN D or ergocarciferol or D3 or 25-hydroxivitamin D or Vitamin D) and (older adult or elderly or old age or older person or Aged) and (supplement* or Dietary Supplements)).af.
13	limit 12 to (english language and "review articles" and yr="2012 - 2021")
14	limit 12 to (english language and "review articles" and yr="2012 - 2021")
15	(sunlight or sun exposure).af.
16	exp Sunlight/
17	15 or 16
18	12 or 17
19	limit 18 to (english language and "review articles" and yr="2012 - 2021")
20	10 or 17
21	7 and 20
22	limit 21 to (english language and "review articles" and yr="2012 - 2021")
23	10 and 17
24	7 and 23
25	limit 24 to (english language and "review articles" and yr="2012 - 2021")

Appendix 2. Search strategies for Nutrient Requirements

Medline and Embase

1	elderly.mp. or exp aged/
2	nutritional requirement.mp. or exp nutritional requirement/
3	exp nutrient/ or nutrient.mp.
4	exp diet/ or diet.mp.
5	nutrient intake/ or food intake/
6	practice guideline/
7	health/ or health outcome.mp.
8	absorption/
9	2 or 3
10	1 and 9
11	5 or 6
12	2 or 3 or 4 or 5 or 6 or 8
13	1 and 7 and 12
14	limit 13 to (english language and yr="2012 - 2021" and "review")
15	limit 14 to (english language and "systematic review" and yr="2012 - 2021")
16	1 and 12
17	limit 16 to (english language and "systematic review" and yr="2012 - 2021")
18	2 or 3 or 6 or 7 or 8
19	4 or 5
20	1 and 18 and 19
21	limit 20 to (english language and yr="2012 - 2021" and "review"

COCHRANE (applicable for 2 searches of requirements and density)

#1	MeSH descriptor: [Aged] explode all trees
#2	MeSH descriptor: [Nutrients] explode all trees
#3	#1 AND #2

Search statements to find papers that discussed different ethnicities requirement in OVID Medline and same base for EMBASE

1	exp Ethnic Groups/ or exp Minority Groups/ or ethnic minority.mp. or exp Hispanic Americans/
2	nutritional requirement.mp. or exp nutritional requirement/
3	exp nutrient/ or nutrient.mp.
4	exp diet/ or diet.mp.
5	nutrient intake/ or food intake/
6	practice guideline/
7	health/ or health outcome.mp.
8	absorption/
9	2 or 3
10	1 and 9
11	5 or 6
12	2 or 3 or 4 or 5 or 6 or 8
13	1 and 7 and 12
14	limit 13 to (english language and yr="2012 - 2021" and "review")
15	limit 14 to (english language and "systematic review" and yr="2012 - 2021")
16	1 and 12
17	limit 16 to (english language and "systematic review" and yr="2012 - 2021")

Appendix 3. Search strategies for Nutrient density

Medline and Embase

1	elderly.mp. or exp Aged/
2	exp "Aged, 80 and over"/ or geriatr*.mp. or exp Aging/ or Geriatrics/
3	1 or 2
4	prevent*.mp.
5	nutrient rich.mp.
6	nutrient dense.mp.
7	micronutrient.mp. or exp Micronutrients/
8	5 or 6 or 7
9	exp Eating/ or meals.mp. or exp Meals/
10	exp Snacks/ or snack*.mp.
11	diet therapy.mp. or exp Diet Therapy/
12	food habits.mp. or Feeding Behavior/
13	9 or 10 or 11 or 12
14	3 and 8
15	3 and 8 and 13
16	limit 15 to (english language and "review articles" and yr="2012 - 2021")
17	healthy diet.mp. or exp Diet, Healthy/
18	4 and 17
19	3 and 8 and 18
20	3 and 8 and 17
21	3 and 8
22	limit 21 to (english language and "review articles" and yr="2012 - 2021")
23	9 or 10 or 11 or 12 or 17
24	3 and 8 and 23
25	limit 24 to (english language and "review articles" and yr="2012 - 2021")

Appendix 4. Search strategies for Physical activity enhanced by protein intake

a) OVID MEDLINE

elderly.mp. or exp Aged/
exp Snacks/ or exp Dietary Proteins/ or protein snack.mp. or exp Diet/
physical activity.mp. or exp Exercise/
muscle.mp. or exp Muscles/
exp Muscle Strength/ph [Physiology]
4 or 5
1 and 2 and 3 and 6
limit 7 to (english language and "review articles" and yr="2012 - 2021" and ("all aged (65 and over)" or "aged (80 and over)") and "systematic review")
limit 7 to (english language and "review articles" and yr="2012 - 2021")

b) EMBASE

elderly.mp. or exp Aged/
exp Snacks/ or exp Dietary Proteins/ or protein snack.mp. or exp Diet/
physical activity.mp. or exp Exercise/
muscle.mp. or exp Muscles/
[exp Muscle Strength/ph [Physiology]]
4 or 5
1 and 2 and 3 and 6
limit 7 to (english language and yr="2012 - 2021")
limit 8 to (english language and yr="2012 - 2021" and "review" and aged <65+ years>)

c) COCHRANE

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#1	MeSH descriptor: [Aged] explode all trees	MeSH	211221
#2	MeSH descriptor: [Proteins] explode all trees	MeSH	122007
#3	MeSH descriptor: [Meals] explode all trees	MeSH	1421
#4	#2 AND #3	Limits	443
#5	MeSH descriptor: [Exercise] explode all trees	MeSH	25356
#6	MeSH descriptor: [Muscle Strength] explode all trees	MeSH	5853
#7	#5 AND #6	Limits	2899
#8	#1 AND #4 AND #7	Limits	2

Appendix 5. Search strategies for BMI

MEDLINE and EMBASE (though the latter did not include BAME allusion, as it is more Europe rather than UK based). BAME statements are shown in bold.

elderly.mp. or exp Aged/
exp "Aged, 80 and over"/ or geriatr*.mp. or exp Aging/ or Geriatrics/
body mass index.mp. or exp Body Mass Index/
exp Overweight/ or exp Obesity/ or exp Body Mass Index/ or BMI.mp.
1 or 2
weight loss.mp. or exp Weight Loss/
thinness.mp. or exp Thinness/
3 or 4 or 6 or 7
exp Ethnic Groups/ or exp Minority Groups/ or ethnic minority.mp. or exp Hispanic Americans/
black.mp. or exp African Continental Ancestry Group/
asian.mp. or exp Asian Continental Ancestry Group/
9 or 10 or 11
activities daily living.mp. or "Activities of Daily Living"/
risk factors.mp. or exp Risk Factors/
5 and 8
12 and 15
13 and 16
limit 17 to (english language and "review articles" and yr="2012 - 2021")
13 and 15
limit 19 to (english language and "review articles" and yr="2012 - 2021")
14 and 15
limit 21 to (english language and "review articles" and yr="2012 - 2021")
sarcopenia.mp. or exp Sarcopenia/ [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]
frailty.mp. or exp Frailty/ [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

malnutrition.mp. or (exp Malnutrition/ or exp Protein-Energy Malnutrition/) [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]
23 or 24 or 25
15 and 26
limit 27 to (english language and "review articles" and yr="2012 - 2021")
12 and 28
22 and 28
17 or 30

COCHRANE (applicable for 2 searches of BMI and weight loss)

#1	MeSH descriptor: [Aged] explode all trees
#2	MeSH descriptor: [Body Mass Index] explode all trees
#3	#1 AND #2

Appendix 6. Search strategies for Enjoyment of eating

Population (group 1):

Above 65 years old, elderly, elder nutritional physiological phenomena, 65 and over, elder*

Topic: (group 2)

eating. Food habits, Choice, Preference, eating behaviour, dietary exposure, foodway*,
feeding behaviour/
food preferences/
(eat* or meal* or nutrition)
((shop* or eat* or consum* or food* or feed* or diet*) adj3 (behave* or habit* or strateg* or decid* or decis* or pattern* or choice* or preference*)).mp.
culinary practi*.mp.
meals/
DIET/
“DIET, FOOD, AND NUTRITION”/
EATING/

Observations:

pleasure/
(Pleasur* or pleasant* or fun of enjoy* or epicur* or hedon*).tw.
(Delight, happ*, joy* satisfact*, treat*).tw.

Medline and Embase

elderly.mp. or exp Aged/
exp Elder Nutritional Physiological Phenomena/ or elder*.mp.
exp "Aged, 80 and over"/ or above 65.mp.
exp Feeding Behavior/ or feeding behaviour.mp. or exp Eating/
food preferences.mp. or exp Food Preferences/
(eat* or meal* or nutrition).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

((shop* or eat* or consum* or food* or feed* or diet*) adj3 (behave* or habit* or strateg* or decid* or decis* or pattern* or choice* or preference*)).mp.
culinary practi*.mp.
exp meals/
exp diet/
exp EATING/
1 or 2 or 3
4 or 5 or 6 or 7 or 8 or 9 or 10 or 11
exp pleasure/
(Pleasur* or pleasant* or fun of enjoy* or epicur* or hedon*).tw.
(Delight* or happ* or joy* or satisfact* or treat*).tw.
14 or 15 or 16
12 and 13 and 17
limit 18 to (english language and "review articles" and yr="2012 - 2021")
Can eating pleasure be a lever.m_titl.
13 and 17
20 and 21
limit 18 to (english language and "review articles" and yr="2017 - 2021")

COCHRANE

#1	MeSH descriptor: [Aged] explode all trees
#2	MeSH descriptor: [Happiness] explode all trees
#3	#1 AND #2

Psychinfo

MAINSUBJECT.EXACT.EXPLODE("Eating Behavior") OR
(MAINSUBJECT.EXACT.EXPLODE("Food Intake") OR
MAINSUBJECT.EXACT.EXPLODE("Food Refusal") OR
MAINSUBJECT.EXACT.EXPLODE("Food") OR
MAINSUBJECT.EXACT.EXPLODE("Food Preferences") OR
MAINSUBJECT.EXACT.EXPLODE("Food Preparation")) OR
(MAINSUBJECT.EXACT("Eating Behavior") OR
MAINSUBJECT.EXACT("Eating Attitudes") OR
MAINSUBJECT.EXACT("Eating Disorders")) AND
(MAINSUBJECT.EXACT.EXPLODE("Pleasure") OR
MAINSUBJECT.EXACT.EXPLODE("Emotional Style") OR
MAINSUBJECT.EXACT.EXPLODE("Emotional States") OR
MAINSUBJECT.EXACT.EXPLODE("Emotions") OR
MAINSUBJECT.EXACT.EXPLODE("Pleasure"))