The Journal of Nutrition
Critical Review

A Review of Nutritional Requirements of Adults Aged ≥65 Years in the UK

Nicole Dorrington,[1] Rosalind Fallaize,[1,2] Ditte A Hobbs,[1] Michelle Weech,[1] and Julie A Lovegrove[1]

[1]Hugh Sinclair Unit of Human Nutrition and Institute of Cardiovascular and Metabolic Research, University of Reading, Reading, United Kingdom; and [2]School of Life and Medical Sciences, University of Hertfordshire, Hatfield, United Kingdom

ABSTRACT

Appropriate dietary choices in later life may reduce the risk of chronic diseases and rate of functional decline, however, there is little well-evidenced age-specific nutritional guidance in the UK for older adults, making it challenging to provide nutritional advice. Therefore, the aim of this critical review was to propose evidence-based nutritional recommendations for older adults (aged ≥65 y). Nutrients with important physiological functions in older adults were selected for inclusion in the recommendations. For these nutrients: *1*) recommendations from the UK Scientific Advisory Committee for Nutrition (SACN) reports were reviewed and guidance retained if recent and age-specific, and *2*) a literature search conducted where SACN guidance was not sufficient to set or confirm recommendations for older adults, searching Web of Science up to March 2020. Data extracted from a total of 190 selected publications provided evidence to support age-specific UK recommendations for protein (1.2 $g \cdot kg^{-1} \cdot d^{-1}$), calcium (1000 $mg \cdot d^{-1}$), folate (400 $\mu g \cdot d^{-1}$), vitamin B-12 (2.4 $\mu g \cdot d^{-1}$), and fluid (1.6 $L \cdot d^{-1}$ women, 2.0 $L \cdot d^{-1}$ men) for those ≥65 y. UK recommendations for carbohydrates, free sugars, dietary fiber, dietary fat and fatty acids, sodium, and alcohol for the general population are likely appropriate for older adults. Insufficient evidence was identified to confirm or change recommendations for all other selected nutrients. In general, significant gaps in current nutritional research among older adults existed, which should be addressed to support delivery of tailored nutritional guidance to this age group to promote healthy aging. *J Nutr* 2020;150:2245–2256.

Keywords: older adults, elderly, nutritional requirements, nutritional recommendations, healthy aging

Introduction

UK life expectancy has risen significantly over recent years (1). However, biological senescence, combined with accumulated health deficits, has resulted in a longer time lived with morbidity (2), increasing the health and social care burden, and adversely impacting quality of life. Appropriate nutrition among older adults is important for reducing risk of chronic diseases, like cardiovascular disease (CVD) and type 2 diabetes (T2D) (3), and promoting healthy aging (4). However, altered central nervous system regulation reduces appetite (5), and changes in body composition and mobility lower energy requirements (6), predisposing individuals to inadequate dietary intake and protein and micronutrient deficiencies. Furthermore, aging is associated with impaired micronutrient absorption and synthesis (7), anabolic resistance (8), and loss of bone and muscle mass (9, 10). Consequently, nutritional recommendations for older adults should account for metabolic alterations, lower energy intake, and inevitable physiological decline, aiming to reduce the rate of functional deterioration and preserving physical and mental fitness and independence late into life (5).

In the UK, the Committee on Medical Aspects of Food and Nutrition Policy (COMA) 1992 report on *The Nutrition of Elderly People* concluded that accurately determining protein and micronutrient, particularly vitamin, requirements of the elderly population was required (11). However, no similar review has been published since, meaning few well-evidenced age-specific guidelines exist for UK older adults (aged ≥65 y), unlike the USA and Australia/New Zealand (e.g. for calcium and B vitamins), challenging delivery of tailored nutritional advice. Consequently, it seems prudent to propose UK-specific recommendations to support the aging population, particularly for nutrients with key physiological roles. Therefore, this critical review aimed to propose evidence-based nutritional recommendations for UK adults aged ≥65 y.

Methods

Initially, all macronutrients and micronutrients were considered for inclusion in the recommendations, however, nutrients were prioritized and selected based on the importance of their age-specific physiological

The authors reported no funding received for this study.
Author disclosures: The authors report no conflicts of interest. JAL sits on the UK Government's Scientific Advisory Committee for Nutrition (SACN). This manuscript reflects independent research.
Supplemental Tables 1–7 and Supplemental References are available from the "Supplementary data" link in the online posting of the article and from the same link in the online table of contents at https://academic.oup.com/jn/.
Present address for DAH: Department of Epidemiology and Population Health, University of Liverpool, Liverpool, United Kingdom.
Address correspondence to JAL (e-mail: j.a.lovegrove@reading.ac.uk).
Abbreviations used: BMD, bone mineral density; BP, blood pressure; COMA, Committee on Medical Aspects of Food and Nutrition Policy; CVD, cardiovascular disease; RCT, randomized controlled trial; SACN, Scientific Advisory Committee for Nutrition; T2D, type 2 diabetes; TE, total energy.

Manuscript received December 11, 2019. Initial review completed February 24, 2020. Revision accepted May 5, 2020.
First published online June 8, 2020; doi: https://doi.org/10.1093/jn/nxaa153.

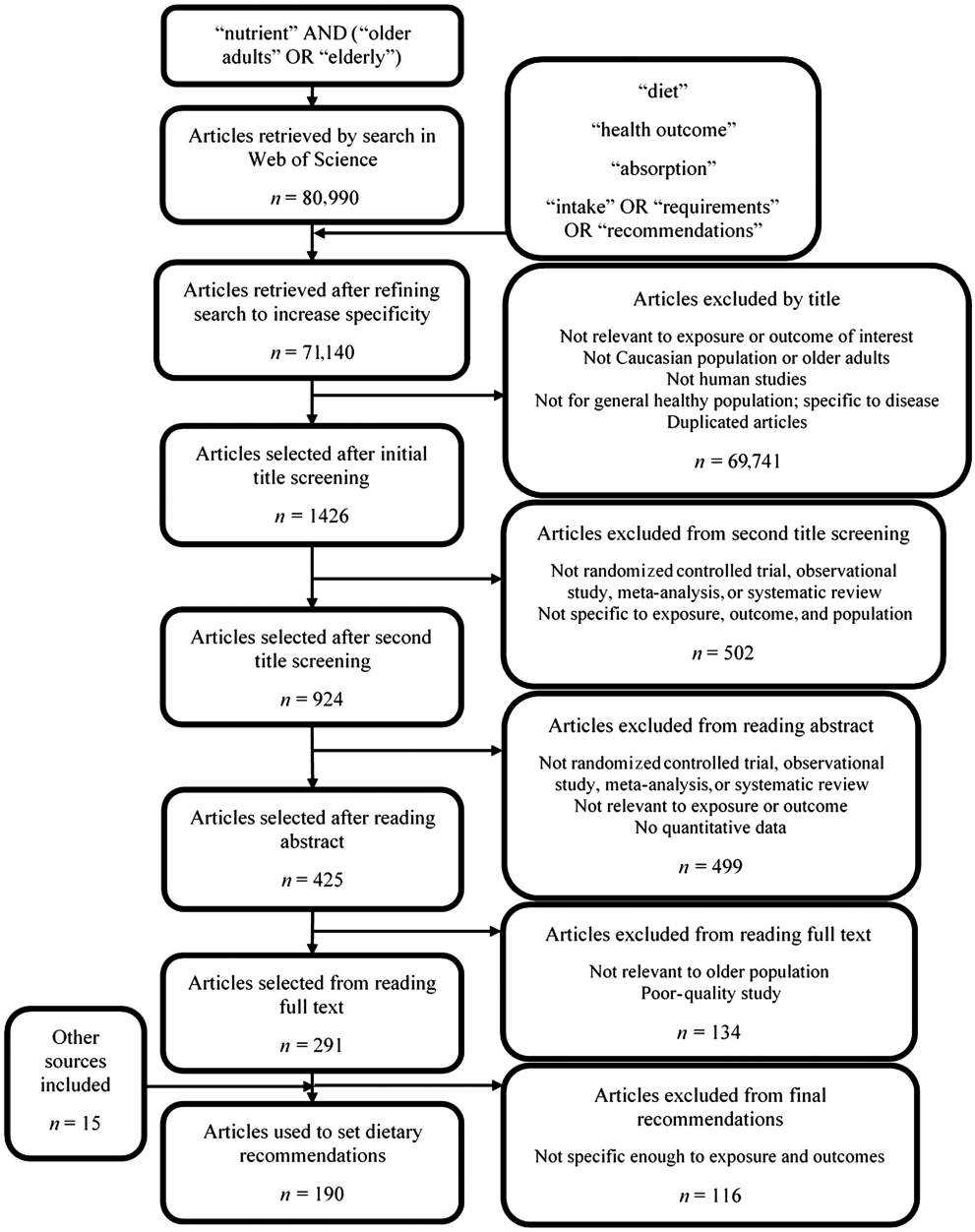

FIGURE 1 Flow chart summarizing literature searches for all nutrients.

functions (12). Current UK recommendations for the age group (≥65 y) were obtained (13–24) (**Supplemental Table 1**).

Relevant publications were identified using a systematic approach. Firstly, the UK's Scientific Advisory Committee for Nutrition (SACN) reports were assessed where available, which are underpinned by quality assessment using the *Framework for the Evaluation of Evidence* (25), and report guidelines retained if recent and age-specific due to their comprehensive nature. Secondly, for nutrients where SACN guidance was unavailable or further evidence was required for retention, Web of Science was searched using the terms "elderly" and "older adults" and the nutrient name, e.g. "calcium." Additional searches performed specified the main age-associated function (12), the word "diet" to refine results, or "absorption" for nutrients which may differ in bioavailability. The search included publications up to March 2020 to identify recent evidence.

Titles were screened for relevance by 1 researcher (ND), considering search terms and age group, excluding animal studies, those specific to individuals with disease, and those where the population was not primarily Caucasian [based on UK demographics (26)]. The evidence hierarchy (27), study quality, and relevance of results guided final study selection, from which data was extracted, and decisions relating to the nutritional recommendations and food-based advice. Study heterogeneity meant the literature was qualitatively evaluated.

Outcome of literature review

Eight SACN reports were available for selected nutrients, (17–23, 28). The vitamin D report contained advice which was up to date and well-evidenced for older adults, and therefore retained without searching for additional data (22). Literature searches for all other nutrients yielded 80,990 publications for screening. After adding 15 further documents (international recommendations and SACN reports), 190 publications were used to guide the remaining recommendations. Figure 1 summarizes the selection process.

Limited evidence was found for most nutrients (Table 1), except protein, dietary fat and fatty acids, calcium, alcohol, and the selected B vitamins (folate, vitamin B-12, and vitamin B-6). This suggests the research gaps identified by COMA for adults aged ≥65 y have not

TABLE 1 Proposed nutritional recommendations for UK adults aged ≥65 y based on the literature review[1]

Nutrient	No. publications selected	Recommendation	Maximum intake	Food-based advice
Carbohydrates[2,3]	9	50% energy intake	—	Have 1 portion of starchy carbohydrates with each meal such as pasta, rice, bread, and cereals. Opt for wholegrains 1 portion = 190 g cooked pasta, rice, or grains, 80 g bread or crackerbreads, 30 g breakfast cereal or flour
Free sugars[3,4]	7	<5% energy intake	—	Limit consumption of sweet snacks like cakes, biscuits, and pastries, as well as sugar-sweetened beverages and confectionery
Protein[3,4,5]	32	1.2 $g \cdot kg^{-1} \cdot d^{-1}$	—	Have a portion of lean meat, poultry, fish, eggs, dairy, or legumes with each meal Animal protein is beneficial for maintaining muscle strength so try to include this regularly, although red and processed meat should be limited 1 portion = 70 g red meat, 100 g poultry, 140 g fish or shellfish, 120 g or 2 eggs, 150 g legumes, 30 g nuts, 200 mL milk, 30 g cheese, 125 g yogurt, 100 g meat alternatives
Fat[2,3]	21	<33% energy intake	—	Butter should be swapped for plant-oil-based spreads and vegetable oils chosen for cooking. Limit the amount of high-fat meat, high-fat dairy, and pastries consumed
SFA[2,3,4,6]		<10% energy intake	—	
trans fatty acids[3,4,6]		<2% energy intake	—	
PUFA[2,3]		6% energy intake	—	
MUFA[2,3]		12% energy intake	—	
LC n–3 PUFA[4,7]	–	450 $mg \cdot d^{-1}$	—	Consume ≥2 portions of fish per week, 1 of which is oily, such as salmon or mackerel. Consuming ≤4 portions of oily fish per week considered safe 1 portion = 140g
Dietary fiber[3,4]	4	30 $g \cdot d^{-1}$	—	Replace refined grains like white bread and pasta with wholegrains and consume ≥5 portions of a variety of fruit and vegetables per day 1 portion = 80 g fresh, 30 g dried, 150 mL juice
Calcium[3,4]	23	1000 $mg \cdot d^{-1}$	1500 $mg \cdot d^{-1}$	Dairy products are a key source of calcium. Consume 3 portions of low-fat dairy per day such as milk, yogurt, or low-fat cheese. Alternatively, choose calcium-fortified dairy-free alternatives 1 portion = 200 mL milk, 30 g cheese, 125 g yogurt
Sodium[3,4]	8	1600 $mg \cdot d^{-1}$	Graded response	Limit consumption of processed meats and salty snacks like crisps and salted peanuts. Reduce the amount of salt added to food in cooking and at the table
Salt[3,4]		4 $g \cdot d^{-1}$	6 $g \cdot d^{-1}$	
Potassium[3,8]	7	3500 $mg \cdot d^{-1}$	—	Fruits and vegetables provide high amounts of potassium. Have ≥5 portions of a variety of fruits and vegetables per day 1 portion = 80 g fresh, 30 g dried, 150 mL juice
Iron[4,8]	5	8.7 $mg \cdot d^{-1}$	17 $mg \cdot d^{-1}$	Animal sources of protein such as lean meat, fish, and eggs provide the most easily absorbed form of iron, although red and processed meat intake should be limited Other sources include pulses, nuts, green leafy vegetables, and fortified breakfast cereals, although it is advantageous to consume a source of vitamin C alongside plant sources of iron to improve absorption

(*Continued*)

TABLE 1 (*Continued*)

Nutrient	No. publications selected	Recommendation	Maximum intake	Food-based advice
Zinc[4,8]	6	9.5 mg·d^{-1} (men) 7 mg·d^{-1} (women)	25 mg·d^{-1}	Consume lean meat, fish, legumes, nuts and seeds, wholegrains, and dairy regularly
Vitamin A[4,8]	5	700 μg·d^{-1} (men) 600 μg·d^{-1} (women)	1500 μg·d^{-1}	Dairy and fish are good sources of vitamin A, and yellow, red, and green vegetables include β-carotene which can be converted to vitamin A in the body. Liver and liver products are good sources of vitamin A but should be consumed in moderation
Vitamin C[3,8]	7	40 mg·d^{-1}	—	Have ≥5 portions of a variety of fruit and vegetables per day 1 portion = 80 g fresh, 30 g dried, 150 mL juice
Vitamin D[4,9]	1	10 μg·d^{-1}	25 μg·d^{-1}	Consume vitamin D-rich foods such as oily fish, egg yolks, and fortified dairy. Also take a 10 μg/d vitamin D supplement
Vitamin E[4,8]	6	4 mg·d^{-1} (men) 3 mg·d^{-1} (women)	540 mg·d^{-1}	Consume healthy fats from nuts, seeds, and vegetable oils
Vitamin K[4,8]	7	1 μg·kg^{-1}·d^{-1}	—	Frequently choose leafy green vegetables such as kale, spinach, and lettuce
Folate[4,8]	24	400 μg·d^{-1}	1 mg·d^{-1}	Consume foods high in folate including leafy green vegetables like spinach and broccoli, legumes, yeast extract, and fortified cereals
Vitamin B-12[4,8,10]		2.4 μg·d^{-1}	—	Consume foods fortified with vitamin B-12 such as breakfast cereals or yeast extract, or animal products including lean meat, fish, poultry, eggs, and dairy
Vitamin B-6[4,8]		1.4 mg·d^{-1} (men) 1.2 mg·d^{-1} (women)	10 mg·d^{-1}	Consume lean meat, poultry, fish, nuts and seeds, legumes, and wholegrains regularly
Alcohol[3,11]	30	≤14 units·wk^{-1}	—	Alcohol consumption should be kept to a minimum. It is not recommended to take up drinking. Do not drink large quantities of alcohol in 1 d. Spread out intake across the week 1 alcohol unit = 8 g ethanol
Fluid[3,12]	5	2.0 L·d^{-1} (men) 1.6 L·d^{-1} (women)	—	Drink ≥6–8 servings of 250 mL of fluid per day. This can include water, tea, coffee, and milk. Limit consumption of sugar-sweetened beverages and alcohol and try to have a maximum 150 mL fruit juice per day

[1]Quantitative recommendations set based on literature review; % energy intake refers to total energy; LC n–3 PUFAs, long chain n–3 PUFAs.
[2]Recommendation is for population average.
[3]Practical advice based on *UK Eatwell Guide* (16) and literature review, portion sizes based on standard portions (29).
[4]Recommendation is reference nutrient intake.
[5]Practical advice based on evidence that even protein distribution supports sufficient protein intake (30) despite inconsistent evidence for health benefits (31–34) and on evidence indicating animal protein to support muscle protein synthesis (35–39).
[6]Practical advice based on recommendations from SACN *Saturated Fat and Health* report for swapping SFA with unsaturated fatty acids (23).
[7]Practical advice based on recommendations from SACN *Advice on Fish Consumption: Risks and Benefits* report (18); maximum intake set to limit exposure to toxins such as methylmercury and polychlorinated biphenyls (40), portion size based on SACN report.
[8]Practical advice based on key sources of nutrient (41).
[9]Practical advice based on recommendations from SACN *Vitamin D and Health* report; few vitamin D-rich foods exist and there is no mandatory fortification in the UK making it challenging to meet the recommendation from dietary sources alone without supplementation (22).
[10]Vitamin B-12 in fortified foods and supplements is in the crystalline form and considered of greater bioavailability than the natural form in animal foods (42).
[11]Practical advice based on Chief Medical Officer's *Low Risk Drinking Guidelines* (24) and literature review.
[12]Practical advice remains consistent with recommendations for limiting free sugars and alcohol intake.
SACN, Scientific Advisory Committee for Nutrition.

yet been sufficiently addressed (11), particularly for micronutrients, and challenged setting of quantitative recommendations. Nonetheless, nutritional recommendations are presented in Table 1 with food-based advice to aid implementation. Supporting evidence (summarized in **Supplemental Tables 2–7**) will subsequently be discussed.

Evidence supporting the proposed nutritional recommendations

Carbohydrates, free sugars, and dietary fiber.

The SACN 2015 *Carbohydrates and Health* report concluded overall carbohydrate intake was neither beneficial nor detrimental to general population health (21). Evidence among older adults was limited, poor quality due to high attrition (43) or very small sample size (44), and subject to confounding where adjusting total carbohydrate intake alters other dietary components (45). No widely accepted physiological mechanism indicates requirements differ among older adults, therefore current recommendations of 50% total energy (TE) remain unchanged.

High free-sugar intake in the general population has been associated with increased risk of dental caries, T2D, and excess energy intake (21). No contradictory evidence was found for older adults. Moreover, Laclaustra et al. (46) reported a positive association between added sugar intake and frailty risk. However, sugar added in food production was found to be more strongly associated than table sugar, suggesting potential confounding effects of the nutritional composition of processed foods which should be considered in interpretation. Nonetheless, inverse associations have been observed between percentage energy intake from added sugars and intake of protein, dietary fiber, and several key micronutrients (47, 48), supporting the notion that free-sugar-containing foods may displace protein and micronutrient-rich dietary components (11). These inverse associations were not fully replicated when studying the UK population (49) but 4-d diet diaries may not completely capture habitual diet, unlike FFQs used in the other studies. Consequently, available evidence, COMA 1992 recommendations (11), and up-to-date SACN advice (21) suggests retaining current free-sugar recommendations of ≤5% TE may promote nutrient density and minimize risk of adverse health outcomes.

Conversely, SACN reported inverse associations between dietary fiber intake and population CVD, T2D, and colorectal cancer risk (21), diseases of importance as age is a key nonmodifiable risk factor (3). Furthermore, Gopinath et al. (50) found an inverse association between fiber intake and 5-y incident instrumental activities of daily living disability risk among older adults, although the mechanism is uncertain and fiber may be a proxy for a generally healthy diet. Nevertheless, altered gastrointestinal transit time, medication use, and poor diet mean constipation is prevalent among older adults (51), and dietary fiber supports alleviation. Therefore, despite insufficient age-specific evidence, retaining up-to-date SACN advice of 30 $g \cdot d^{-1}$ seems appropriate to promote high intake (21).

Protein.

A chronic imbalance between muscle synthesis and degradation causes skeletal muscle mass and strength loss with age (52). Contributory factors include impaired amino acid absorption and high splanchnic extraction (52), reducing available amino acids, anabolic resistance, with impaired muscle synthesis response to dietary protein (53), and increased protein catabolism, from chronic inflammation (54). Consequently, older adults may have elevated dietary protein requirements to maintain, or minimize loss of, muscle mass and strength.

Two small metabolic studies supported proposed mechanisms, demonstrating a delayed postprandial peak in serum amino acid concentration following a high-protein mixed meal (55) and reduced protein accretion in response to a 7 g amino acid bolus (53) in older compared with younger adults. A randomized controlled trial (RCT) found an increase in whole-body lean mass and knee-extension power in men aged ≥70 y consuming 1.6 $g \cdot kg^{-1} \cdot d^{-1}$ protein but no change from 0.8 $g \cdot kg^{-1} \cdot d^{-1}$ (56), although the sample size was small ($n = 29$). Nonetheless, a meta-analysis of high-quality observational studies reported protein intakes of >1.0 $g \cdot kg^{-1} \cdot d^{-1}$ and >1.2 $g \cdot kg^{-1} \cdot d^{-1}$ were also associated with a higher percentage of lean mass and higher knee-extensor power compared with a protein intake of <0.8 $g \cdot kg^{-1} \cdot d^{-1}$ (57). Moreover, almost all identified observational studies reported inverse associations between protein intake and loss of muscle mass or strength (37, 38, 58–60), although limitations exist including potential under- and overreporting and inaccurate capture of habitual intake by dietary assessment methods, and the lack of evaluating changes in intake over follow-up. Additionally, reverse causation may exist where low muscle mass and/or strength impairs functional capacity, affecting food accessibility, preparation, and choice.

Despite limitations, there is consistency in conclusions and, combined with metabolic studies and biological plausibility, higher protein intake among older adults is likely beneficial for muscle mass and function, and has potential additional benefits on other health outcomes such as risk of frailty and disability (61–63), cognition (64), and fracture risk (65). Thus, evidence suggests that increasing the current UK population protein recommendations from 0.75 $g \cdot kg^{-1} \cdot d^{-1}$ to 1.2 $g \cdot kg^{-1} \cdot d^{-1}$ 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 (54), selected as this level was associated with health benefits in several previously discussed studies, published since the PROT-AGE review.

Dietary fat and fatty acids.

A vast evidence base exists relating to dietary fat or fatty acid intake and general population chronic disease risk. For older adults, study findings generally aligned with current UK population advice (15). For example, higher PUFA intake and substitution of SFA with PUFA have been associated with reduced 11-y T2D risk (66), and serum cholesterol ester α-linolenic acid inversely associated with incident CVD (67). Additionally, Blekkenhorst et al. reported a 77% increased atherosclerotic vascular disease mortality risk per 11.26 $g \cdot d^{-1}$ higher SFA intake and a 50% lower risk per 8.7 $g \cdot d^{-1}$ higher MUFA intake (68). Finally, serum cholesterol ester linoleic acid has been inversely associated with 14.5-y all-cause mortality risk (67), and SFA positively and PUFA, linoleic acid, and n–3 fatty acids inversely associated with 12.5-y mortality risk (69).

Conversely, Houston et al. (70) observed no associations between dietary total fat and SFA, MUFA, and *trans* fatty acid intake and CVD in men and women aged 70–79 y after adjustment for dietary confounders and relevant medication. As older adults studied had not previously suffered or died prematurely from CVD, potentially low baseline risk among subjects may have influenced results and they could suggest differing susceptibility to detrimental effects of dietary components among older adults, although this requires confirmation. Therefore, in the absence of further age-specific evidence and due to elevated CVD risk with age it seems appropriate to generalize current population recommendations for dietary fat (≤33% TE), unsaturated fatty acids (12% TE MUFAs, 6% TE PUFAs), long chain n–3 PUFAs (450 $mg \cdot d^{-1}$), *trans* fatty acids (≤2% TE), and as per the 2019 SACN report (23), those for SFA (≤10% TE) to older adults.

Calcium.

After reaching peak bone mass aged 30–40 y (71) bone loss occurs (72), accelerating in the first 10 y postmenopause among women (73) then slowing to equal that of men at age 60–65 y (10). Inadequate dietary calcium can augment loss where bone mobilization is stimulated to maintain blood calcium concentration (74), making sufficient intake key in preserving musculoskeletal health.

The WHO, USA, and Australia/New Zealand have specific calcium recommendations for postmenopausal women and the elderly (12, 75, 76). However, current UK recommendations do not stipulate differences between requirements of younger adults for maintaining bone mineral density (BMD) and those of older adults for minimizing inevitable losses. The international recommendations are mainly based on supplementation studies. Such studies demonstrate benefits of high calcium with or without vitamin D on BMD maintenance over 1–7-y follow-up (77–84), but supplements are typically >1000 $mg \cdot d^{-1}$, dietary calcium intake is rarely reported, and physiological regulation

of intestinal calcium uptake (74) makes it uncertain how much supplemental calcium is absorbed, questioning whether supplemental studies should guide dietary recommendations.

Identified dietary studies reported calcium intake to be positively associated with BMD (85–88) and inversely associated with osteoporosis or fracture risk (89–91). Two large longitudinal cohort studies provide quantitative evidence to guide recommendations. Firstly, Nieves et al. (89) observed an association between calcium intake >800 mg·d^{-1} and a 25% reduced 3-y osteoporosis risk compared with <500 mg·d^{-1}, although misclassification bias is possible as nondairy calcium intake was estimated at 250 mg·d^{-1} (US average) for all subjects rather than accurately assessed. Secondly, Warensjö et al. (91) observed an association between calcium intake <751 mg·d^{-1} and an increased risk of 18% for any fracture, 29% for hip fracture, and 47% for osteoporosis after median 19.2-y follow-up compared with 822–996 mg·d^{-1}. Additionally, no benefits of >1137 mg·d^{-1} were observed and a detrimental effect on hip fracture risk compared with lower intakes reported. Repeat FFQs throughout follow-up allowed all major calcium sources to be recorded and subjects classified by the mean of their cumulative dietary intake, accounting for changes. The recent 32-y longitudinal study by Feskanich et al. (92) supported this approach as positive associations between dairy food intake and hip fracture were similar for current and cumulative average intake but attenuated when baseline intake was used as the exposure. Nonetheless, reverse causation may still exist where dietary intake changed following osteoporosis diagnosis and could explain the detrimental effects seen from >1137 mg·d^{-1} calcium intake.

Despite limitations, observations by Nieves et al. (89) and Warensjö et al. (91) in >90,000 subjects, supported by supplementation studies and biological plausibility, suggest current UK population calcium recommendations of 700 mg·d^{-1} may not be optimal for older adults. An intake ≤1000 mg·d^{-1} combined with adequate vitamin D (91) 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 y. It is uncertain whether conclusions would be replicated in analyses limited to those aged ≥65 y as Dawson-Hughes et al. reported no effect of calcium supplementation on BMD among early postmenopausal subjects (≤5 y since menopause) yet an inverse association with BMD loss in those >5 y postmenopause (85). Consequently, results by Nieves et al. (89) and Warensjö et al. (91) may be underestimated for adults aged ≥65 y who would be beyond the early postmenopausal stage of accelerated bone loss. Finally, most bone health studies focus on women, making effects in men uncertain. Greater evidence in both sexes restricted to adults aged ≥65 y is required to increase certainty regarding proposed quantitative changes to recommendations.

Sodium and salt.

In the general population, SACN reported salt intake to be positively associated with risk of hypertension (17), stroke, and ischaemic heart disease mortality (28). A meta-analysis of 11 RCTs in subjects aged ≥60 y similarly found sodium chloride intake to be positively associated with systolic and diastolic blood pressure (BP) (93). Higher sodium intake has also been associated with increased carotid intima-media thickness and atherosclerotic plaque prevalence (94). Quantitative age-specific evidence was lacking, therefore, retaining SACN recommendations for maximum salt intake of 6 g·d^{-1} (17) seems appropriate, although this may be too high due to arterial structural changes increasing hypertension risk with age (95, 96). Nonetheless, salt enhances dietary palatability, helping prevent protein-energy malnutrition, which is prevalent among older adults (97).

Potassium.

Physiological functions of potassium include supporting bone health and lowering BP. For bone health, 2 longitudinal studies reported positive associations between dietary potassium intake and BMD. However, Tucker et al. observed the association only in men (98), and Zhu et al. observed it within their female cohort but used urinary potassium excretion as the exposure which was only weakly correlated with dietary intake (99) questioning whether a true benefit existed. For BP, SACN and the Committee of Toxicity recently reported inverse associations between potassium intake and systolic and diastolic BP and stroke risk in the general population (28), results that may or may not be replicated in older adults. Nonetheless, no evidence for adverse effects was found. Notably, concerns regarding hyperkalemia associated with reduced kidney function with age are limited to those with advanced chronic kidney disease (28), when dietary priorities differ and specialist medical and dietetic support would be received. Overall, evidence suggests potential benefits of high potassium intake, but without further studies current recommendations of 3500 mg·d^{-1} cannot be confirmed nor adjusted.

Iron.

Iron deficiency is associated with impaired aerobic, endurance, and physical work capacity (100) and, within older adults, with poorer cognitive function and increased dementia risk (101). Consequently, iron deficiency should be prevented to avoid adverse effects on mental and physical function. Moreover, higher intake has been associated with improved gait speed in older men (102) and better cognitive performance in older men and women (103). However, no quantitative evidence was identified to guide setting dietary recommendations, although neither was evidence for altered absorption with age. Therefore, current recommendations for iron intake of 8.7 mg·d^{-1} has been retained which, in contrast to younger adults, is the same for both sexes due to reduced menstrual losses.

Zinc.

Immunosenescence occurs with age, therefore zinc's role in supporting immune function makes ensuring adequate status important among older adults (104). A crossover study in subjects aged ≥82 y found consumption of zinc-fortified milk for 2 mo to lower incidence of infection, increase thymulin activity, and increase T cell maturation and differentiation (105). No further evidence of benefits on immune function were found for dietary zinc or zinc supplementation at dietary concentrations in those with sufficient status. Two experimental studies reported similar zinc absorption rates within younger and older adults (106, 107) suggesting general population recommendations may be suitable in the absence of further evidence. Nonetheless, physiological adaptation to zinc status causes altered nutrient bioavailability and requirements (108), so very small sample sizes limits generalizability of results. Consequently, uncertainty exists surrounding retention of current recommendations of 9.5 mg·d^{-1} (men) and 7.0 mg·d^{-1} (women) and higher zinc intakes could potentially optimize immune function.

Vitamin A.

Vitamin A has various roles, although limited age-specific evidence was identified for beneficial effects. However, a large longitudinal cohort study reported an association between vitamin A intake ≥2000 μg·d^{-1} and an 89% increased risk of hip fracture compared with <500 μg·d^{-1} (109), indicating possible importance of avoiding excessive intake. Furthermore, Borel et al. (110) demonstrated impaired postprandial retinol transport and impaired regulation of plasma retinol concentration in elderly subjects despite similar intestinal absorption efficiency to younger adults, indicating risk of elevated serum concentrations and toxicity for older adults (111). Insufficient age-specific evidence for minimum dietary vitamin A intake and the potentially unaltered intestinal absorption rate (110) means current population recommendations of 700 μg·d^{-1} (men) and 600 μg·d^{-1} (women) are unchanged, but evidence supports consideration of the UK safe upper limit when delivering dietary advice.

Vitamin C.

Within older adults, longitudinal studies supported associations between vitamin C intake >388 mg·d^{-1} and 45% lower risk of overall and 62% lower risk of ischaemic heart disease mortality compared with an intake of <90 mg·d^{-1} (112), higher dietary vitamin C intake and

lower rate of 7-y cognitive decline (113), and higher total vitamin C intake and lower 15–17-y fracture risk (114). However, in observational studies high vitamin C intake may be a marker for a healthier diet and lifestyle. Notably, Sahyoun et al. observed no association with mortality when assessing vitamin C supplementation alone (112), suggesting other beneficial nutrients in vitamin C-rich foods (like fruit and vegetables) may confound results. Without further quantitative evidence where confounding can be eliminated, nor evidence for altered absorption with age, current recommendations for preventing deficiency disease of 40 mg·d^{-1} are retained, although meeting *UK Eatwell Guide* recommendations for fruits and vegetables (24) may facilitate reaching higher, potentially beneficial, amounts.

Vitamin D.

Vitamin D supports calcium and phosphorous homeostasis for musculoskeletal health (74). However, endogenous vitamin D production is lower in older compared with younger adults (6) due to reduced 7-dehydrocholesterol concentration in the skin, a lower rate of synthesis, and limited sun exposure from impaired mobility, making it key to consider dietary and supplemental intake within this age group. The 2016 *Vitamin D and Health* SACN report (22) found beneficial associations between higher vitamin D intake (from supplementation) and BMD, muscle strength and function, and risk of falls in adults aged ≥50 y, when considering subjects with variable baseline 25-hydroxyvitamin D concentrations. An age-specific reference nutrient intake was advised by SACN based on a modeling exercise, therefore this recommendation of 10 μg·d^{-1} is retained to support year-round maintenance of vitamin D sufficiency (22).

Vitamin E.

Vitamin E studies have reported associations between higher dietary intake or plasma or serum concentrations and lower inflammatory markers (115), better cognitive function (116), and reduced CVD events (117). Moreover, the meta-analysis by Dong et al. (118) found an inverse association between serum vitamin E and Alzheimer's disease risk in case-control studies, however, these cannot demonstrate a causal relation between exposure and outcome and reverse causation from poor cognitive function affecting food intake may exist. Due to insufficient evidence, current recommendations of 4 mg·d^{-1} (men) and 3 mg·d^{-1} (women) cannot be confirmed nor changed.

Vitamin K.

Vitamin K has a role in blood coagulation (119), bone health (120), and potentially cognition. Despite biological plausibility, evidence is somewhat lacking. In identified studies, increasing vitamin K intake was associated with reduced BMD loss (121), vitamin K deficiency with increased risk of knee osteoarthritis (122) and cartilage damage (123), higher plasma concentrations of phylloquinone with improved physical performance, gait speed, and endurance (124), higher serum or dietary phylloquinone with better cognitive function (125, 126), and higher dephospho-uncarboxylated matrix Gla protein concentration (considered a reliable marker of vitamin K status and utilization) with lower handgrip strength and calf circumference (127). These studies are not without limitations, including potential confounding by other components of vitamin K-rich foods, such as green leafy vegetables, not adjusted for in analyses. Therefore, current recommendations of 1 μg·kg^{-1}·d^{-1} are retained, although limited evidence in the general population means this is only a safe intake concentration.

Folate, vitamin B-12, and vitamin B-6.

Folate, vitamin B-12, and vitamin B-6 are of interest due to roles in DNA methylation, and risks of megaloblastic anemia and irreversible neurological impairment from folate and vitamin B-12 deficiency, respectively. Current UK recommendations for older adults are lower than suggested by the WHO (12) and set for the USA (128) and Australia/New Zealand (76).

Impaired vitamin B-12 absorption from atrophic gastritis is prevalent among older adults (129) making high dietary intake key to prevent deficiency. Furthermore, a range of evidence was identified relating to cognitive outcomes, although with inconsistent conclusions. To summarize, plasma folate has been inversely associated with measures of cognitive function and cognitive decline risk (130, 131) but also no associaton with cognitive decline or depression observed (132–134), although selection bias may exist where Hughes et al. (135) excluded those with pre-existing vitamin B-12 deficiency and Morris et al. studied a well-educated population within whom high cognitive reserve may lower dementia risk (136). Low plasma or serum vitamin B-12 have been associated with a greater 8-y decline in cognitive function (133), and cross-sectionally with reduced mental processing speed (137), increased risk of cognitive impairment (138) and depression (134), yet Tucker et al. (130) reported no association between plasma vitamin B-12 and spatial copying independent of folate, vitamin B-6, and homocysteine concentrations. Finally, plasma vitamin B-6 has been inversely associated with cognitive decline risk (135), however, Kado et al. (131) and Tucker et al. (130) reported no association between plasma vitamin B-6 and cognitive function or cognitive decline risk independent of biochemical status of other B vitamins.

Biochemical concentrations in longitudinal studies were only assessed at baseline, therefore it is possible that improvements in biochemical status in subjects with low status meant no association was observed or effects indicate benefits of supplementation (likely supradietary amounts). If true benefits of higher plasma or serum concentration exist, altered absorption among older adults, particularly for vitamin B-12, makes the dietary intake required to maintain a desired concentration uncertain. van Wijngaarden et al. (139) found doubling vitamin B-12 intake to be associated with 9% higher serum total vitamin B-12 in older adults with elevated plasma homocysteine. However, generalization to all older adults cannot be assumed, making dietary studies essential. Nonetheless, quantitative evidence was lacking, conclusions were similarly inconsistent for associations between folate, vitamin B-12, and vitamin B-6 intake and cognition (130–132, 135, 140, 141), and inverse associations were observed between folate intake and risk of frailty (142) and folate and vitamin B-6 intake and depression (132, 142, 143), yet these were supported by limited studies.

Although evidence was inconclusive, impaired vitamin B-12 absorption in older adults is of concern, a vast evidence base including observational, metabolic, and epidemiological studies underpins Australia/New Zealand and US dietary recommendations for folate and vitamin B-12 (76, 128), and no studies reported detrimental effects at their proposed higher intakes. Therefore, current UK population recommendations for older adults have been adjusted to align with these recommendations (folate, 400 μg·d^{-1}; vitamin B-12, 2.4 μg·d^{-1}). Limited evidence supported international vitamin B-6 recommendations, so current UK recommendations of 1.4 mg·d^{-1} (men) and 1.2 mg·d^{-1} (women) remain unchanged.

Alcohol.

Observational studies identified among older adults reported associations between light to moderate alcohol consumption and various outcomes including improved cognitive function (144, 145), reduced risk of cognitive impairment (146, 147) and decline (146), reduced risk of any type and vascular dementia (148), increased likelihood of healthy aging assessed based on physical performance and/or health deficits (149, 150), reduced congestive heart failure risk (151), myocardial infarction, and coronary death risk (152), and reduced mortality risk (153–155) compared with abstention.

Definitions of light to moderate alcohol intake vary from ≤1 drink·d^{-1} to 1–3 drinks·d^{-1} or 15–20 units·wk^{-1} (1 drink = 8–14 g ethanol), challenging assessment of optimal amounts. Moreover, limitations in alcohol consumption studies questions the reliability of conclusions. Firstly, never and former drinkers often differ in health status but are typically grouped as abstainers, so results may be a statistical artifact rather than indicating a relation unless the 2 groups are separated. Secondly, alcohol intake is commonly underreported, causing inaccuracies in exposure. Thirdly, only assessing baseline alcohol intake contributes to misclassification bias due to changes over time, particularly key in older adults within whom alcohol intake has been demonstrated to reduce or cease in response to heath deficit accumulation (156). Finally, moderate alcohol intake may be a proxy

marker for a generally healthy lifestyle, social class, or educational attainment, making confounding likely unless analyses are adequately adjusted.

A few studies have attempted to overcome these limitations. For example, Stampfer et al. (146) accounted for changes in intake across 20-y follow-up and minimized bias resulting from poor health of former drinkers by assessing baseline and 4-y alcohol intake and excluding participants who reported abstention when undertaking follow-up cognitive assessment but previously reported alcohol intake. Furthermore, 3 studies conducted analyses with former drinkers in isolation, in addition to the standard abstention group, reporting associations between former drinking and increased congestive heart failure risk (151), detrimental effects of former drinking and no association or a protective effect of never drinking on mortality risk (153), and a 1.5× increased risk of all-cause mortality for ex-drinkers compared with never-drinkers (157), highlighting abstainers to be a group of individuals with diverse health status. The study by Ortolá et al. (157) additionally categorized participants according to both current and lifetime alcohol intake to account for possible misclassification, with no associations between occasional, light, or moderate drinking and mortality risk observed for either exposure. Further studies similarly addressing key sources of bias are essential to increase confidence in nutritional recommendations.

Despite potential, although questionable, benefits of light to moderate alcohol intake, reduced body water, hepatic function, and blood flow increases sensitivity to alcohol's toxicity within older adults (158), meaning the adverse effects on BP, liver function, and cancer risk observed in the general population (159) may be exacerbated. Therefore, UK population safe alcohol intake of 14 units·wk^{-1} (1 alcohol unit = 8 g ethanol) for men and women (24) should be emphasized as a maximum and intake not promoted.

Fluid.

Impaired thirst sensation, poor renal function, and fear of incontinence make inadequate fluid intake common among older adults (160), increasing risk of dehydration and subsequent effects including cognitive impairment and constipation (161). Consequently, it should be a key nutritional consideration among the elderly. UK population advice is nonspecific, recommending 6–8 cups per day, equaling approximately 1.2–1.6 L (16), yet age-specific advice in several European countries (162) and in the comprehensive evidence-based European Society for Clinical Nutrition and Metabolism (ESPEN) guidelines (163) is for 2.0 L·d^{-1} (men) and 1.6 L·d^{-1} (women). Therefore, adjustments to quantitative recommendations are proposed to account for reduced homeostatic regulation with age (159).

Conclusions

The literature relating to nutritional requirements for older adults was reviewed using a systematic approach. Identified evidence was limited in many cases, but seemed to support changes to current UK population recommendations for those aged ≥65 y for protein (from 0.75 g·kg^{-1}·d^{-1} to 1.2 g·kg^{-1}·d^{-1}), calcium (from 700 mg·d^{-1} to 1000 mg·d^{-1}), folate (from 200 μg·d^{-1} to 400 μg·d^{-1}), and vitamin B-12 (from 1.5 μg·d^{-1} to 2.4 μg·d^{-1}), and emphasis on sufficient fluid intake (2.0 L·d^{-1} men, 1.6 L·d^{-1} women), as well as retention of current recommendations for carbohydrates, free sugars, dietary fiber, dietary fat and fatty acids, sodium, vitamin D, and alcohol. For the other selected nutrients (potassium, iron, zinc, vitamin A, vitamin C, vitamin E, vitamin K, vitamin B-6), insufficient evidence prevented current UK population recommendations from being confirmed or adjusted.

It should be acknowledged that, despite decisions being justified by current research, nutrients with significant yet not widely documented physiological effects in older adults may have been excluded. Moreover, the literature review was not exhaustive as all alternative nutrient names were not included and reference lists of reviews were not hand-searched, however, publications were identified based on title, content, and keywords and overall conclusions from relevant reviews and systematic reviews identified were considered alongside individual studies. No structured quality assessment was conducted but publications were critiqued qualitatively to inform the degree to which they guided setting of nutritional recommendations. Additionally, adults aged ≥65 y were assumed to be homogeneous, yet intraindividual variation in the rate of physiological change exists, with interactions between genes and lifestyle factors affecting nutrient response and disease progression. Furthermore, these recommendations are not applicable to most older adults with acute or chronic illnesses, for whom protein, dietary fat, and free-sugar requirements may be elevated due to hypermetabolism, and recommendations may be under- or overestimated for those of ethnic minority groups. This should be accounted for when considering transferability of recommendations to other populations.

Overall, the lack of age-specific evidence for most nutrients, particularly assessing dietary intake, limited the ability to confidently propose nutritional recommendations. Where changes were suggested, insufficient evidence existed to differentiate requirements of men and women or young-older adults (aged 65–79 y) and old-older adults (≥80 y), and hesitation remains regarding quantitation. Due to the increasing UK life expectancy and the likely role nutrition has in supporting maintenance of quality of life with age, it is vital that high-quality research is conducted (including meta-analyses and dietary RCTs) in adults aged ≥65 y into the areas highlighted throughout this critical review to address important gaps in the literature.

Acknowledgments

The authors' contributions were as follows— ND, RF, and JAL: designed the research; ND: conducted the research; ND: analyzed data; ND: drafted the manuscript; and all authors read and approved the final manuscript.

References

1. Public Health England. Chapter 1: Population change and trends in life expectancy. [Internet]. 2018. Available from: https://www.gov.uk/government/publications/health-profile-for-england-2018/chapter-1-population-change-and-trends-in-life-expectancy (accessed 2019 Jul 10).
2. Public Health England. Chapter 3: Trends in morbidity and risk factors. [Internet]. 2018. Available from: https://www.gov.uk/government/publications/health-profile-for-england-2018/chapter-3-trends-in-morbidity-and-risk-factors (accessed 2019 Jul 10).
3. Shlisky J, Bloom DE, Beaudreault AR, Tucker KL, Keller HH, Freund-Levi Y, Fielding RA, Cheung FW, Jensen GL, Wu D, et al. Nutritional considerations for healthy aging and reduction in age-related chronic disease. Adv Nutr 2017;8(1):17–26.
4. Jong JCK, Mathers JC, Franco OH. Nutrition and healthy ageing: the key ingredients. Proc Nutr Soc 2014;73(2):249–59.
5. Raats M, de Groot L, van Staveren W. Food for the ageing population. Cambridge (UK): Woodhead Publishing Limited; 2009.
6. Gille D. Overview of the physiological changes and optimal diet in the golden age generation over 50. Eur Rev Aging Phys Act 2010;u7(1):27–36.
7. Inzitari M, Doets E, Bartali B, Benetou V, Di Bari M, Visser M, Volpato S, Gambassi G, Topinkova E, De Groot L, et al. Nutrition in the age-related disablement process. J Nutr Health Aging 2011;15(8):599–604.

8. De Spiegeleer A, Petrovic M, Boeckxstaens P, Van den Noortgate N. Treating sarcopenia in clinical practice: where are we now? Acta Clin Belg 2016;71(4):197–205.
9. Dodds R, Sayer AA. Sarcopenia and frailty: new challenges for clinical practice. Clin Med 2016;16(5):455–8.
10. Jones G, Nguyen T, Sambrook P, Kelly PJ, Eisman JA. Progressive loss of bone in the femoral neck in elderly people: longitudinal findings from the Dubbo osteoporosis epidemiology study. BMI 1994;309(6956):691–5.
11. Committee on Medical Aspects of Food Policy. The nutrition of elderly people. London (UK): HMSO Publications; 1992.
12. World Health Organisation. Keep fit for life: meeting the nutritional needs of older persons. [Internet]. 2002. Available from: whqlibdoc.who.int/publications/9241562102_annexes.pdf (accessed 2017 Sep 20).
13. Committee on Medical Aspects of Food Policy. Dietary Reference Values for food energy and nutrients for the United Kingdom. London (UK): HMSO Publications; 1991.
14. Expert Group on Vitamins and Minerals. Safe upper levels for vitamins and minerals. London (UK): Food Standards Agency; 2003.
15. Public Health England. Government Dietary Recommendations. Government recommendations for energy and nutrients for males and females aged 1–18 years and 19+ years. London (UK): Public Health England; 2016.
16. Public Health England. The Eatwell Guide. Helping you eat a healthy, balanced diet. [Internet]. 2016. Available from: https://www.gov.uk/government/publications/the-eatwell-guide (accessed 2017 Sep 20).
17. Scientific Advisory Committee on Nutrition. Salt and health. London (UK): TSO; 2003.
18. Scientific Advisory Committee on Nutrition. Advice on fish consumption: benefits & risks. London (UK): TSO; 2004.
19. Scientific Advisory Committee on Nutrition. Folate and disease prevention. London (UK): TSO; 2006.
20. Scientific Advisory Committee on Nutrition. Update on trans fatty acids and health. London (UK): TSO; 2007.
21. Scientific Advisory Committee on Nutrition. Carbohydrates and health. London (UK): TSO; 2015.
22. Scientific Advisory Committee on Nutrition. Vitamin D and health. [Internet]. 2016. Available from: https://www.gov.uk/government/publications/sacn-vitamin-d-and-health-report (accessed 2017 Sep 15).
23. Scientific Advisory Committee on Nutrition. Saturated fats and health. [Internet]. 2019. Available from: https://www.gov.uk/government/publications/saturated-fats-and-health-sacn-report (accessed 2020 7 Apr 17).
24. UK Chief Medical Officer. Low risk drinking guidelines. [Internet]. 2016. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/545937/UK_CMOs_report.pdf (accessed 2017 Sep 20).
25. Scientific Advisory Committee on Nutrition. SACN framework for the evaluation of evidence. [Internet]. 2012. Available from: https://www.gov.uk/government/groups/scientific-advisory-committee-on-nutrition (accessed 2017 Sep 20).
26. Offices for National Statistics. Ethnicity facts and figures. [Internet]. 2019. Available from: https://www.ethnicity-facts-figures.service.gov.uk/ (accessed 2019 Jul 10).
27. Petrisor B, Bhandari M. The hierarchy of evidence: levels and grades of recommendation. Indian J Orthop 2007;41(1):11–5.
28. Scientific Advisory Committee on Nutrition, Committee on Toxicity. Potassium-based sodium replacers: assessment of the health benefits and risks of using potassium-based sodium replacers in foods in the UK. [Internet]. 2017. Available from: https://www.gov.uk/government/publications/sacn-cot-statements-on-potassium-based-sodium-replacers (accessed 2017 Dec 1).
29. British Dietetic Association. Food fact sheet: portion sizes. [Internet]. 2016. [Available from: https://www.bda.uk.com/foodfacts/portionsizesfoodfactsheet.pdf (accessed 2017 Nov 1).
30. Tieland M, Beelan J, Laan ACM, Poon S, de Groot LCPGM, Seeman E, Wang X, Iuliano S. An even distribution of protein intake daily promotes protein adequacy but does not influence nutritional status in institutionalized elderly. J Am Med Dir Assoc 2017;19(1);33–9.
31. Farsijani S, Morais JA, Payette H, Gaudreau P, Shatenstein B, Gray-Donald K, Chevalier S. Relation between mealtime distribution of protein intake and lean mass loss in free-living older adults of the NuAge study. Am J Clin Nutr 2016;104(3):694–703.
32. Gingrich A, Spiegel A, Kob R, Schoene D, Skurk T, Hauner H, Sieber CC, Volkert D, Kiesswetter E. Amount, distribution, and quality of protein intake are not associated with muscle mass, strength, and power in healthy older adults without functional limitations – an enable study. Nutrients 2017;9(12):E1358.
33. Kim I-Y, Schutzler S, Schrader AM, Spencer HJ, Azhar G, Wolfe RR, Ferrando AA. Protein intake distribution pattern does not affect anabolic response, lean body mass, muscle strength or function over 8 weeks in older adults: a randomized-controlled trial. Clin Nutr 2018;37(2);488–93.
34. Ten Haaf DSM, van Dongen EJI, Nuijten MAH, Eijsvogels TMH, de Groot LCPGM, Hopman MTE. Protein intake and distribution in relation to physical functioning and quality of life in community-dwelling elderly people: acknowledging the role of physical activity. Nutrients 2018;10(4);E506.
35. Gorissen SHM, Witard OC. Characterising the muscle anabolic potential of dairy, meat and plant-based protein sources in older adults. Proc Nutr Soc 2018;77(1):20–31.
36. Houston DK, Nicklas BJ, Ding J, Harris TB, Tylavsky FA, Newman AB, eLee JS, Sahyoun NR, Visser M, Kritchevsky SB. Dietary protein intake is associated with lean mass change in older, community-dwelling adults: the Health, Aging, and Body Composition (Health ABC) Study. Am J Clin Nutr 2008;87(1):150–5.
37. McLean RR, Mangano KM, Hannan MT, Kiel DP, Sahni S. Dietary protein intake is protective against loss of grip strength among older adults in the Framingham Offspring cohort. J Gerontol A Biol Sci Med Sci 2016;71(3):356–61.
38. Layman DK. Dietary guidelines should reflect new understandings about adult protein needs. Nutr Metab 2009;6;12.
39. McDonald CK, Ankarfeldt MZ, Capra S, Bauer J, Raymond K, Heitmann BL. Lean body mass change over 6 years is associated with dietary leucine intake in an older Danish population. Br J Nutr 2016;115(9):1556–62.
40. British Dietetic Association. Food fact sheet: omega-3. [Internet]. 2017. Available from: https://www.bda.uk.com/resource/omega-3.html (accessed 2019 Jul 12).
41. Public Health England. McCance and Widdowson's the composition of foods. 7th Summary Edition. Cambridge (UK): Royal Society of Chemistry; 2014.
42. Allen LH. Causes of vitamin B12 and folate deficiency. Food Nutr Bull 2008;29(Suppl 2):S20–34.
43. Feskens EJ, Bowles CH, Kromhout D. Carbohydrate intake and body mass index in relation to the risk of glucose intolerance in an elderly population. Am J Clin Nutr 1991;54(1):136–40.
44. Fukagawa NK, Anderson JW, Hageman G, Young VR, Minaker KL. High-carbohydrate, high-fiber diets increase peripheral insulin sensitivity in healthy young and old adults. Am J Clin Nutr 1990;52(3):524–8.
45. Sjögren P, Becker W, Warensjö E, Olsson E, Byberg L, Gustafsson I-B, Kalström B, Cederholm T. Mediterranean and carbohydrate-restricted diets and mortality among elderly men: a cohort study in Sweden. Am J Clin Nutr 2010;92(4):967–74.
46. Laclaustra M, Rodriguez-Artalejo F, Guallar-Castillon P, Banegas JR, Graciani A, Garcia-Esquinas E, Ordovas J, Lopez-Garcia E. Prospective association between added sugars and frailty in older adults. Am J Clin Nutr 2018;107(5):772–9.
47. Moshtaghian H, Louie JC, Charlton KE, Probst YC, Gopinath B, Mitchell P, Flood VM. Added sugar intake that exceeds current recommendations is associated with nutrient dilution in older Australians. Nutrition 2016;32(9):937–42.
48. Charlton KE, Wolmarans P, Lombard CJ. Evidence of nutrient dilution with high sugar intakes in older South Africans. J Human Nutr Diet 1998;11(4):331–43.
49. Gibson S. Dietary sugars and micronutrient dilution in normal adults aged 65 years and over. Public Health Nutr 2001;4(6):1235–44.
50. Gopinath B, Flood VM, Burlutksy G, Liew G, Mitchell P. Carbohydrate nutrition variables and risk of disability in instrumental activities of daily living. Eur J Nutr 2019;58(8):3221–8.

51. Gandell D, Straus SE, Bundookwalav M, Tsui V, Alibhai SMH. Treatment of constipation in older people. CMAJ 2013;185(8): 663–70.
52. Koopman R, Van Loon LJC. Aging, exercise and muscle protein metabolism. J Appl Physiol 2009;106(6):2040–8.
53. Katsanos CS, Kobayashi H, Sheffield-Moore M, Aarsland A, Wolfe RR. Aging is associated with diminished accretion of muscle proteins after the ingestion of a small bolus of essential amino acids. Am J Clin Nutr 2005;82(5):1065–73.
54. Bauer J, Biolo G, Cederholm T, Cesari M, Cruz-Jentoft AJ, Morley JE, Phillips S, Sieber C, Stehle P, Teta D, et al. Evidence-based recommendations for optimal dietary protein intake in older people: a position paper from the PROT-AGE study group. J Am Med Dir Assoc 2013;14(8):542–59.
55. Milan AM, D'Souza RF, Pundir S, Pileggi CA, Thorstensen EB, Barnett MP, Markworth JF, Cameron-Smith D, Mithcell CJ. Older adults have delayed amino acid absorption after a high protein mixed breakfast meal. J Nutr Health Aging 2015;19(8):839–45.
56. Mitchell CJ, Milan AM, Mitchell SM, Zeng N, Ramzan F, Sharma P, Knowles SO, Roy NC, Sjödin A, Wagner K-H, et al. The effects of dietary protein intake on appendicular lean mass and muscle function in elderly men: a 10-wk randomized controlled trial. Am J Clin Nutr 2017;106(6):1375–83.
57. Coelho-Junior HJ, Milano-Teixeira L, Rodrigues B, Bacurau R, Marzetti E, Uchida M. Relative protein intake and physical function in older adults: a systematic review and meta-analysis of observational studies. Nutrients 2018;10(9):E1330.
58. Farsijani S, Payette H, Morais JA, Shatenstein B, Gaudreau P, Chevalier S. Even mealtime distribution of protein intake is associated with greater muscle strength, but not with 3-y physical function decline, in free-living older adults: the Quebec longitudinal study on nutrition as a determinant of successful aging (NuAge study). Am J Clin Nutr 2017;106(1):113–24.
59. Isanejad M, Mursu J, Sirola J, Kroger H, Rikkonen T, Tuppurainen M, Erkkilä AT. Dietary protein intake is associated with better physical function and muscle strength among elderly women. Br J Nutr 2016;115(7):1281–91.
60. Isanejad M, Mursu J, Sirola J, Kroger H, Rikkonen T, Tuppurainen M, Erkkilä AT. Association of protein intake with the change of lean mass among elderly women: The Osteoporosis Risk Factor and Prevention - Fracture Prevention Study (OSTPRE-FPS). J Nutr Sci 2015;4: e41.
61. Coelho-Junior HJ, Calvani R, Gonçalves IO, Rodrigues B, Picca A, Landi F, Bernabei R, Uchida MC, Marzetti E. High relative consumption of vegetable protein is associated with faster walking speed in well-functioning older adults. Aging Clin Exp Res 2019;31(6):837–44.
62. Mendonça N, Granic A, Hill TR, Siervo M, Mathers JC, Kingston A, Jagger C. Protein intake and disability trajectories in very old adults: the Newcastle 85+ Study. J Am Ger Soc 2019;67(1):50–6.
63. Mendonça N, Kingston A, Granic A, Jagger C. Protein intake and transitions between frailty states and to death in very old adults: the Newcastle 85+ Study. Age Ageing 2020;49(1):32–8.
64. Fernando WMADB, Rainey-Smith SR, Gardener SL, Villemagne VL, Burnham SC, Macaulay SL, Brown BM, Bala Gupta V, Sohrabi HR, Weinborn M, et al. Associations of dietary protein and fiber intake with brain and blood amyloid-beta. J Alzheimers Dis 2018;61(4): 1589–98.
65. Groenendijk I, den Boeft, van Loon LJC, de Groot LCPGM. High versus low dietary protein intake and bone health in older adults: a systematic review and meta-analysis. Comput Struct Biotechnol J 2019;17:1101–12.
66. Meyer KA, Kushi LH, Jacobs DR, Folsom AR. Dietary fat and incidence of type 2 diabetes in older Iowa women. Diabetes Care 2001;24(9):1528–35.
67. Marklund M, Leander K, Vitström M, Laguzzi F, Gigante B, Sjögren, Cederholm T, de Faire U, Hellénius ML, Risérus U. Polyunsaturated fat intake estimated by circulating biomarkers and risk of cardiovascular disease and all-cause mortality in a population-based cohort of 60-year-old men and women. Circulation 2015;132(7):586–94.
68. Blekkenhorst LC, Prince RL, Hodgson JM, Lim WH, Zhu K, Devine A, Thompson PL, Lewis JR. Dietary saturated fat intake and atherosclerotic vascular disease mortality in elderly women: a prospective cohort study. Am J Clin Nutr 2015;101(6):1263–8.
69. Jayanama K, Theou O, Godin J, Cahill L, Rockwood K. Association of fatty acid consumption with frailty and mortality among middle-aged and older adults. Nutrition 2020;70;110610.
70. Houston DK, Ding J, Lee JS, Garcia M, Kanaya AM, Tylavsky FA, Newman AB, Visser M, Kritchevsky SB. Dietary fat and cholesterol and risk of cardiovascular disease in older adults: the Health ABC Study. Nutr Metab Cardiovasc Dis 2011;21(6):430–7.
71. Berger C, Goltzman D, Langsetmo L, Joseph L, Jackson S, Kreiger N, Tenenhouse A, Davison KS, Josse RG, Prior JC, et al. Peak bone mass from longitudinal data: implications for the prevalence, pathophysiology, and diagnosis of osteoporosis. J Bone Miner Res 2010;25(9):1948–57.
72. Hunter DJ, Sambrook PN. Bone loss: epidemiology of bone loss. Arthritis Res 2000;2(6):441–5.
73. Finkelstein JS, Brockwell SE, Mehta V, Greendale DA, Sowers MR, Ettinger B, Lo JC, Johnston JM, Cauley JA, Danielson ME, et al. Bone mineral density changes during the menopause transition in a multi-ethnic cohort of women. J Clin Endocrin Metab 2008;93(3):861–8.
74. Mundy GR, Guise TA. Hormonal control of calcium homeostasis. Clin Chem 1999;45(8):1347–52.
75. Institute of Medicine. Dietary Reference Intakes for calcium and vitamin D. Washington (DC): National Academies Press; 2011.
76. National Medical and Health Research Council. Nutrient Reference Values for Australia and New Zealand including recommended dietary intakes. Canberra (Australia): National Health and Medical Research Council; 2006.
77. Devine A, Dick IM, Heal SJ, Criddle RA, Prince RL. A 4-year follow-up study of the effects of calcium supplementation on bone density in elderly postmenopausal women. Osteopos Int 1997;7(1):23–8.
78. Grados F, Brazier M, Kamel S, Duver S, Heurtebize N, Maamer M, Mathieu M, Garabédian M, Sebert JL, Fardellone P. Effects on bone mineral density of calcium and vitamin D supplementation in elderly women with vitamin D deficiency. Joint Bone Spine 2003;70(3):203–8.
79. Karkkainen M, Tuppurainen M, Salovaara K, Sandini L, Rikkonen T, Sirola J, Honkanen R, Jurvelin J, Alhava E, Kroger H. Effect of calcium and vitamin D supplementation on bone mineral density in women aged 65–71 years: a 3-year randomized population-based trial (OSTPRE-FPS). Osteoporos Int 2010;21(12):2047–55.
80. Peacock M, Liu G, Carey M, McClintock R, Ambrosius W, Hui S, Johnston CC. Effect of calcium or 25OH vitamin D3 dietary supplementation on bone loss at the hip in men and women over the age of 60. J Clin Endocrinol Metab 2000;85(9):3011–9.
81. Prentice RL, Pettinger MB, Jackson RD, Wactawski-Wende J, Lacroix AZ, Anderson GL, Chlebowski RT, Manson JE, Van Horn L, Vitolins MZ, et al. Health risks and benefits from calcium and vitamin D supplementation: Women's Health Initiative clinical trial and cohort study. Osteoporos Int 2013;24(2):567–80.
82. Prince RL, Devine A, Dhaliwal SS, Dick IM. Effects of calcium supplementation on clinical fracture and bone structure: results of a 5-year, double-blind, placebo-controlled trial in elderly women. Arch Intern Med 2006;166(8):869–75.
83. Salovaara K, Tuppurainen M, Karkkainen M, Rikkonen T, Sandini L, Sirola J, Honkanen R, Alhava E, Kröger H. Effect of vitamin D(3) and calcium on fracture risk in 65- to 71-year-old women: a population-based 3-year randomized, controlled trial – the OSTPRE-FPS. J Bone Miner Res 25(7):1487–95.
84. Zhu K, Devine A, Dick IM, Wilson SG, Prince RL. Effects of calcium and vitamin D supplementation on hip bone mineral density and calcium-related analytes in elderly ambulatory Australian women: a five-year randomized controlled trial. J Clin Endocrinol Metab 2008;93(3):743–9.
85. Dawson-Hughes B, Dallal GE, Krall EA, Sadowski L, Sahyoun N, Tannenbaum S. A controlled trial of the effect of calcium supplementation on bone density in postmenopausal women. N Engl J Med 1990;323:878–83.
86. Radavelli-Bagatini S, Zhu K, Lewis JR, Prince RL. Dairy food intake, peripheral bone structure, and muscle mass in elderly ambulatory women. J Bone Miner Res 2014;29(7):1691–700.
87. Sahni S, Mangano KM, Kiel DP, Tucker KL, Hannan MT. Dairy intake is protective against bone loss in older vitamin D supplement users: The Framingham Study. J Nutr 2017;147(4):645–52.
88. Wlodarek D, Glabska D, Kolota A, Adamczyk P, Czekaj A, Grzeszczak W, Drozdzowska B, Pluskiewicz W. Calcium intake and osteoporosis:

the influence of calcium intake from dairy products on hip bone mineral density and fracture incidence – a population-based study in women over 55 years of age. Public Health Nutr 2014;17(2):383–9.
89. Nieves JW, Barrett-Connor E, Siris ES, Zion M, Barlas S, Chen YT. Calcium and vitamin D intake influence bone mass, but not short-term fracture risk, in Caucasian postmenopausal women from the National Osteoporosis Risk Assessment (NORA) study. Osteoporos Int 2008;19(5):673–9.
90. Samieri C, Coupez VG, Lorrain S, Letenneur L, Alles B, Féart C, Paineau D, Barberger-Gateau P. Nutrient patterns and risk of fracture in older subjects: results from the Three-City Study. Osteoporos Int 2013;24(4):1295–305.
91. Warensjö E, Byberg L, Melhus H, Gedeborg R, Mallmin H, Wolk A, Michaëlsoon K. Dietary calcium intake and risk of fracture and osteoporosis: prospective longitudinal cohort study. BMJ 2011;342:d1473.
92. Feskanich D, Meyer HE, Fung TT, Bischoff-Ferrari HA, Willett WC. Milk and other dairy foods and risk of hip fracture in men and women. Osteoporos Int 2018;29(2):385–96.
93. Alam S, Purdie DM, Johnson AG. Evaluation of the potential interaction between NaCl and prostaglandin inhibition in elderly individuals with isolated systolic hypertension. J Hypertens 1999;17(8):1195–202.
94. Mazza E, Ferro Y, Lamprinoudi T, Gazzaruso C, Doldo P, Pujia A, Montalcini T. Relationship between high sodium and low PUFA intake and carotid atherosclerosis in elderly women. Exp Gerontol 2018;108:256–61.
95. Buford TW. Hypertension and aging. Ageing Res Rev 2016;26:96–111.
96. Pinto E. Blood pressure and ageing. Postgrad Med J 2007;83(976):109–14.
97. BAPEN. Malnutrition matters: meeting quality standards in nutritional care. [Internet]. 2010. Available from: http://www.bapen.org.uk/pdfs/toolkit-for-commissioners.pdf (accessed 2019 Jul 20).
98. Tucker KL, Hannan MT, Chen H, Cupples LA, Wilson PW, Kiel DP. Potassium, magnesium and fruit and vegetable intakes are associated with greater bone mineral density in elderly men and women. Am J Clin Nutr 1999;69(4):727–36.
99. Zhu K, Devine A, Prince RL. The effects of high potassium consumption on bone mineral density in a prospective cohort study of elderly postmenopausal women. Osteoporos Int 2009;20(2):335–40.
100. Scientific Advisory Committee on Nutrition. Iron and health. London (UK): TSO; 2010.
101. Yavuz BB, Cankurtaran M, Haznedaroglu IC, Halil M, Ulger Z, Altun B, Ariogul S. Iron deficiency can cause cognitive impairment in geriatric patients. J Nutr Health Aging 2012;16(3):220–4.
102. van Dronkelaar C, van Velzen A, Abdelrazek M, van der Steen A, Weijs PJM, Tieland M. Minerals and sarcopenia; the role of calcium, iron, magnesium, phosphorous, potassium, selenium, sodium, and zinc on muscle mass, muscle strength, and physical performance in older adults: a systematic review. J Am Med Dir Assoc 2018;19(1):6–11.
103. Li SY, Sun WJ, Zhang DF. Association of zinc, iron, copper, and selenium intakes with low cognitive performance in older adults: a cross-sectional study from National Health and Nutrition Examination Survey (NHANES). J Alzheimers Dis 2019;72(4):1145–57.
104. Pera A, Campos C, López N, Hassouneh F, Alonso C, Tarazona R, Solana R. Immunosenescence: implications for response to infection and vaccination in older people. Maturitas 2015;82(1):50–5.
105. Costarelli L, Giacconi R, Malavolta M, Basso A, Piacenza F, DeMartiis M, Giannandrea E, Renieri C, Busco F, Galeazzi R, et al. Effects of zinc-fortified drinking skim milk (as functional food) on cytokine release and thymic hormone activity in very old persons: a pilot study. Age 2014;36(3):1421–31.
106. Couzy F, Kastenmayer P, Mansourian R, Guinchard S, Munoz-Box R, Dirren H. Zinc absorption in healthy elderly humans and the effect of diet. Am J Clin Nutr 1993;58(5):690–4.
107. Couzy F, Mansourian R, Labate A, Guinchard S, Montagne DH, Dirren H. Effect of dietary phytic acid on zinc absorption in the healthy elderly, as assessed by serum concentration curve tests. Br J Nutr 1998;80(2):177–82.
108. Haase H, Mocchegiani E, Rink L. Correlation between zinc status and immune function in the elderly. Biogerontology 2006;7(5–6):421–8.
109. Feskanich D, Singh V, Willett WC, Colditz GA. Vitamin A intake and hip fractures among postmenopausal women. JAMA 2002;287(1):47–54.
110. Borel P, Mekki N, Boirie Y, Partier A, Alexandre-Gouabau MC, Grolier P, Beaufrere B, Portugal H, Lairon D, Azais-Braesco V. Comparison of the postprandial plasma vitamin A response in young and older adults. J Gerontol A Biol Sci Med Sci 1998;53(2):B133–40.
111. Penniston KL, Tanumihardjo SA. The acute and chronic toxic effects of vitamin A. Am J Clin Nutr 2006;83(2):191–201.
112. Sahyoun NR, Jacques PF, Russell RM. Carotenoids, vitamins C and E, and mortality in an elderly population. Am J Epidemiol 1996;144(5):501–11.
113. Wengreen HJ, Munger RG, Corcoran CD, Zandi P, Hayden KM, Fotuhi M, Skoog I, Norton MC, Tschanz J, Breitner JC, et al. Antioxidant intake and cognitive function of elderly men and women: the Cache County Study. J Nutr Health Aging 2007;11(3):230–7.
114. Sahni S, Hannan MT, Gagnon D, Blumberg J, Cupples LA, Kiel DP, Tucker KL. Protective effect of total and supplemental vitamin C intake on the risk of hip fracture – a 17-year follow-up from the Framingham Osteoporosis Study. Osteoporos Int 2009;20(11):1853–61.
115. Capuron L, Moranis A, Combe N, Cousson-Gelie F, Fuchs D, De Smedt-Peyrusse V, Barberger-Gateau P, Layé S. Vitamin E status and quality of life in the elderly: influence of inflammatory processes. Br J Nutr 2009;102(10):1390–4.
116. Ortega RM, Requejo AM, Lopez-Sobaler AM, Andres P, Navia B, Perea JM, Robles F. Cognitive function in elderly people is influenced by vitamin E status. J Nutr 2002;132(7):2065–8.
117. Mezzetti A, Zuliani G, Romano F, Costantini F, Pierdomenico SD, Cuccurullo F, Fellin R. Vitamin E and lipid peroxide plasma levels predict the risk of cardiovascular events in a group of healthy very old people. J Am Geriatr Soc 2001;49(5):533–7.
118. Dong Y, Chen X, Liu Y, Shu Y, Chen T, Xu L, Li M, Guan X. Do low-serum vitamin E levels increase the risk of Alzheimer disease in older people? Evidence from a meta-analysis of case-control studies. Int J Geriatr Psychiatry 2017;33(2):e257–63.
119. Palta S, Saroa R, Palta A. Overview of the coagulation system. Indian J Anaesth 2014;58(5):515–23.
120. Hamidi MS, Gajic-Veljanoski O, Cheung AM. Vitamin K and bone health. J Clin Densitom 2013;16(4):409–13.
121. Bulló M, Estruch R, Salas-Salvado J. Dietary vitamin K intake is associated with bone quantitative ultrasound measurements but not with bone peripheral biochemical markers in elderly men and women. Bone 2011;48(6):1313–8.
122. Misra D, Booth SL, Tolstykh I, Felson DT, Nevitt MC, Lewis CE, Torner J, Neogi T. Vitamin K deficiency is associated with incident knee osteoarthritis. Am J Med 2013;126(3):243–8.
123. Shea MK, Kritchevsky SB, Hsu FC, Nevitt M, Booth SL, Kwoh CK, McAlindon TE, Vermeer C, Drummen N, Harris TB, et al. The association between vitamin K status and knee osteoarthritis features in older adults: the Health, Aging and Body Composition Study. Osteoarthritis Cartilage 2015;23(3):370–8.
124. Shea MK, Loeser RF, Hsu F-C, Booth SL, Nevitt M, Simonsick EM, Strotmeyer ES, Vermeer C, Kritchevsky SB. Vitamin K status and lower extremity function in older adults: the Health Aging and Body Composition Study. J Gerentol A Biol Sci Med Sci 2016;71(10):1348–55.
125. Chouet J, Ferland G, Feart C, Rolland Y, Presse N, Boucher K, Barberger-Gateau P, Beauchet O, Annweiler C. Dietary vitamin K intake is associated with cognition and behaviour among geriatric patients: The CLIP Study. Nutrients 2015;7(8):6739–50.
126. Presse N, Belleville S, Gaudreau P, Greenwood CE, Kergoat M-J, Morais JA, Payette H, Shatenstein B, Ferland G. Vitamin K status and cognitive function in healthy older adults. Neurobiol Aging 2013;34(12):2777–83.
127. van Ballegooijen AJ, van Putten SR, Visser M, Beulens JW, Hoogendijk EO. Vitamin K status and physical decline in older adults – The Longitudinal Aging Study Amsterdam. Maturitas 2018;113:73–9.
128. Institute of Medicine. Dietary Reference Intakes for thiamin, riboflavin, niacin, vitamin B6, folate, vitamin B12, pantothenic acid,

biotin, and choline. Washington (DC): National Academies Press; 1998.

129. Fernández-Barrés S, Martín N, Canela T, García-Barco M, Basora J, Arija V. Dietary intake in the dependent elderly: evaluation of the risk of nutritional deficit. J Hum Nutr Diet 2016;29(2):174–84.
130. Tucker KL, Qiao N, Scott T, Rosenberg I, Spiro A. High homocysteine and low B vitamins predict cognitive decline in aging men: the Veterans Affairs Normative Aging Study. Am J Clin Nutr 2005;82(3):627–35.
131. Kado DM, Karlamangla AS, Huang MH, Troen A, Rowe JW, Selhub J, Seeman TE. Homocysteine versus the vitamins folate, B-6, and B-12 as predictors of cognitive function and decline in older high-functioning adults: MacArthur studies of successful aging. Am J Med 2005;118(2):161–7.
132. Gougeon L, Payette H, Morais JA, Gaugreau P, Shatenstein B, Gray-Donald K. Intakes of folate, vitamin B6 and B12 and risk of depression in community-dwelling older adults: the Quebec Longitudinal Study on Nutrition and Aging. Eur J Clin Nutr 2016;70(3):380–5.
133. Morris MS, Selhub J, Jacques PF. Vitamin B-12 and folate status in relation to decline in scores on the Mini-Mental State Examination in the Framingham Heart Study. J Am Geriatr Soc 2012;60(8):1457–64.
134. Petridou ET, Kousoulis AA, Michelakos T, Papathoma P, Dessypris N, Papadopoulos FC, Stefanadis C. Folate and B12 serum levels in association with depression in the aged: a systematic review and meta-analysis. Aging Ment Health 2016;20(9):965–73.
135. Hughes CF, Ward M, Tracey F, Hoey L, Molloy AM, Pentieva K, McNulty H. B-vitamin intake and biomarker status in relation to cognitive decline in healthy older adults in a 4-year follow-up study. Nutrients 2017;9(1):E53.
136. Meng X, D'Arcy C. Education and dementia in the context of the cognitive reserve hypothesis: a systematic review with meta-analyses and qualitative analyses. PLoS One 2012;7(6):e38268.
137. Jelicic M, Jonker C, Deeg DJH. Effect of low levels of serum vitamin B(12) and folic acid on cognitive performance in old age: a population-based study. Dev Neuropsychol 2001;20(3):565–71.
138. Hin H, Clarke R, Sherliker P, Atoyebi W, Emmens K, Birks J, Scheneede J, Ueland PM, Nexo E, Scott J, et al. Clinical relevance of low serum vitamin B12 concentrations in older people: the Banbury B12 study. Age Ageing 2006;35(4):416–22.
139. van Wijngaarden JP, Dhonukshe-Rutten RAM, Brouwer-Brolsma EM, Enneman AW, Swart KMA, van Dijk SC, In 't Veld PH, van Schoor NM, van der Velde N, de Jonge R, et al. Vitamin B12 intake and related biomarkers: associations in a Dutch elderly population. J Nutr Health Aging 2017;21(10):1268–76.
140. Aparicio Vizuete A, Robles F, Rodriguez-Rodriguez E, Maria Lopez-Sobaler A, Maria Ortega R. Association between food and nutrient intakes and cognitive capacity in a group of institutionalized elderly people. Eur J Nutr 2010;49(5):293–300.
141. McNeill G, Jia X, Whalley LJ, Fox HC, Corley J, Gow AJ, Brett CE, Starr JM, Deary IJ. Antioxidant and B vitamin intake in relation to cognitive function in later life in the Lothian Birth Cohort 1936. Eur J Clin Nutr 2011;65(5):619–26.
142. Balboa-Castillo T, Struijk EA, Lopez-Garcia E, Banegas JR, Rodriguez-Artalejo F, Guallar-Castillon P. Low vitamin intake is associated with risk of frailty in older adults. Age Ageing 2018;47(6):872–9.
143. Moore K, Hughes CF, Hoey L, Ward M, Cunningham C, Molloy AM, Strain JJ, McCarroll K, Casey MC, Tracey F, et al. B-vitamins in relation to depression in older adults over 60 years of age: the Trinity Ulster Department of Agriculture (TUDA) Cohort Study. J Am Med Dir Assoc 2019;20(5):551–7.e1.
144. Espeland MA, Gu L, Masaki KH, Langer RD, Coker LH, Stefanick ML, Ockene J, Rapp SR. Association between reported alcohol intake and cognition: results from the Women's Health Initiative Memory study. Am J Epidemiol 2005;161(3):228–38.
145. Espeland MA, Coker LH, Wallace R, Rapp SR, Resnick SM, Limacher M, Powell LH, Messina CR. Association between alcohol intake and domain-specific cognitive function in older women. Neuroepidemiology 2006;27(1):1–12.
146. Stampfer MJ, Kang JH, Chen J, Cherry R, Grodstein F. Effects of moderate alcohol consumption on cognitive function in women. N Engl J Med 2005;352(3):245–53.
147. McGuire LC, Ajani UA, Ford ES. Cognitive functioning in late life: the impact of moderate alcohol consumption. Ann Epidemiol 2007;17(2):93–9.
148. Ruitenberg A, van Swieten JC, Witteman JCM, Mehta KM, van Duijn CM, Hofman A, Breteler MM. Alcohol consumption and risk of dementia: the Rotterdam Study. Lancet 2002;359(9303):281–6.
149. Daskalopoulou C, Stubbs B, Kralj C, Koukounari A, Prince M, Prina AM. Associations of smoking and alcohol consumption with healthy ageing: a systematic review and meta-analysis of longitudinal studies. BMJ Open. 2018;8(4);e019540.
150. Shah M, Paulson D, Nguyen V. Alcohol use and frailty risk among older adults over 12 years: the Health and Retirement Study. Clin Gerontol 2018;41(4):315–25.
151. Bryson CL, Mukamal KJ, Mittleman MA, Fried LP, Hirsch CH, Kitzman DW, Siscovick DS. The association of alcohol consumption and incident heart failure: the Cardiovascular Health Study. J Am Coll Cardiol 2006;48(2):305–11.
152. Mukamal KJ, Chiuve SE, Rimm EB. Alcohol consumption and risk for coronary heart disease in men with healthy lifestyles. Arch Intern Med 2006;166(19):2145–50.
153. Knott CS, Coombs N, Stamatakis E, Biddulph JP. All cause mortality and the case for age specific alcohol consumption guidelines: pooled analyses of up to 10 population based cohorts. BMJ 2015;350:h384.
154. Muscari A, Bianchi G, Conte C, Forti P, Magalotti D, Pandolti P, Vaccheri A, Zoli M. No direct survival effect of light to moderate alcohol drinking in community-dwelling older adults. J Am Geriatr Soc 2015;63(12):2526–33.
155. Costa P, Grassi M, Iacoviello L, Zedde M, Marcheselli S, Silvestrelli G, De Lodovici M, Sessa M, Zini A, Paciaroni M, et al. Alcohol intake and the risk of intracerebral hemorrhage in the elderly: the MUCH-Italy. Neurology 2018;91(3):e227–35.
156. Ortolá R, García-Esquinas E, Soler-Vila H, Ordovas JM, López-García E, Rodríguez-Artalejo F. Changes in health status predict changes in alcohol consumption in older adults: The Seniors-ENRICA cohort. J Epidemiol Community Health 2019;73(2):123–9.
157. Ortolá R, García-Esquinas E, López-García E, León-Muñoz LM, Banegas JR, Rodríguez-Artalejo F. Alcohol consumption and all-cause mortality in older adults in Spain: an analysis accounting for the main methodological issues. Addiction 2019;114(1):59–68.
158. Truswell AS. Dietary guidance for older Australians. Nutr Diet 2009;66(4):243–8.
159. Griswold MG, Fullman N, Hawley C, Arian N, Zimsen SRM, Tymeson HD, Venkateswaren V, Douglas Tapp A, Forouzanfar MH, Salama JS, et al. Alcohol use and burden for 195 countries and territories: a systematic analysis for the Global Burden of Disease Study 2016. Lancet 2018;392(10152):1015–35.
160. Bernstein M, Munoz N. Position of the Academy of Nutrition and Dietetics: food and nutrition for older adults: promoting health and wellness. J Acad Nutr Diet 2012;112(8):1255–77.
161. El-Sharkawy AM, Sahota O, Lobo DN. Acute and chronic effects of hydration status on Health. Nutr Rev 2015;73(Suppl 2):97–109.
162. Scherer R, Maroto-Sanchez B, Palacios G, Gonzalez-Gross M. Fluid intake and recommendations in older adults: more data are needed. Nutr Bull 2016;41(2):167–74.
163. Volkert D, Beck AM, Cederholm T, Cruz-Jentoft A, Goisser S, Hooper L, Kiesswetter E, Maggio M, Raynaud-Simon A, Sieber CC, et al. ESPEN guideline on clinical nutrition and hydration in geriatrics. Clin Nutr 2019;38(1):10–47.