frontiers in Nutrition

REVIEW
published: 16 December 2020
doi: 10.3389/fnut.2020.604488

Eating Behavior in Aging and Dementia: The Need for a Comprehensive Assessment

Silvia Fostinelli[1†], Ramona De Amicis[2†], Alessandro Leone[2], Valentina Giustizieri[2], Giuliano Binetti[3], Simona Bertoli[2,4], Alberto Battezzati[2] and Stefano F Cappa[5,6]*

[1] Molecular Markers Laboratory, IRCCS Istituto Centro San Giovanni di Dio Fatebenefratelli, Brescia, Italy, [2] Department of Food, Environmental and Nutritional Sciences, International Center for the Assessment of Nutritional Status, University of Milan, Milan, Italy, [3] Memory Clinic, IRCCS Istituto Centro San Giovanni di Dio Fatebenefratelli, Brescia, Italy, [4] Department of Endocrine and Metabolic Diseases, IRCCS Istituto Auxologico Italiano, Obesity Unit and Laboratory of Nutrition and Obesity Research, Milan, Italy, [5] University School for Advanced Studies, Pavia, Italy, [6] IRCCS Mondino Foundation, Pavia, Italy

Eating behavior can change during aging due to physiological, psychological, and social changes. Modifications can occur at different levels: (1) in food choice, (2) in eating habits, and (3) in dietary intake. A good dietary behavior, like the Mediterranean dietary pattern, can be a protective factor for some aging related pathologies, such as dementia, while a worse eating behavior can lead to pathological conditions such as malnutrition. Changes in eating behavior can also be linked to the onset of dementia: for some types of dementia, such as frontotemporal dementia, dietary changes are one of the key clinical diagnostic feature, for others, like Alzheimer's disease, weight loss is a clinical reported feature. For these reasons, it is important to be able to assess eating behavior in a proper way, considering that there are normal age-related changes. An adequate assessment of dietary behavior can help to plan preventive intervention strategies for heathy aging or can help to identify abnormal behaviors that underline aging related-diseases. In this review, we have analyzed normal age-related and dementia-related changes and the tools that can be used to assess eating behavior. Thus, we make recommendations to screening and monitoring eating behavior in aging and dementia, and to adopt these tools in clinical practice.

Keywords: eating behavior, aging, dementia, frontotemporal dementia, Alzheimer's disease

OPEN ACCESS

Edited by:
Nicholas T. Bello, Rutgers, The State University of New Jersey, United States

Reviewed by:
Cristian E. Leyton, The University of Sydney, Australia
Naomi Kakoschke, Monash University, Australia

***Correspondence:**
Silvia Fostinelli
sfostinelli@fatebenefratelli.eu

†These authors have contributed equally to this work

Specialty section:
This article was submitted to Eating Behavior, a section of the journal Frontiers in Nutrition

Received: *09 September 2020*
Accepted: *23 November 2020*
Published: *16 December 2020*

Citation:
Fostinelli S, De Amicis R, Leone A, Giustizieri V, Binetti G, Bertoli S, Battezzati A and Cappa SF (2020) Eating Behavior in Aging and Dementia: The Need for a Comprehensive Assessment. Front. Nutr. 7:604488. doi: 10.3389/fnut.2020.604488

INTRODUCTION

The role of dietary factors in the prevention of dementia is now supported by considerable evidence. The potential protective role of Mediterranean diet, in particular, is supported by a large body of evidence [for recent systematic reviews, see (1–3)]. These findings have led to the suggestion that dietary changes in the aging at risk population could represent an important protective factor (4, 5). The relationship of dietary choices with dietary behavior is a crucial factor to be considered in the development of dietary intervention programs. Moreover, in an elderly subject, a change in the dietary behavior can also be link to the onset of dementia. Malnutrition (under-or overnutrition, nutritional deficiencies) is the consequence of dietary behavior, a complex construct including multiple components spanning different domains (physiological, psychological, and socio-economical). An attempt to develop a consensus on a taxonomy of these components (6) resulted in a distinction among three levels: food choice, eating behavior

and dietary intake/nutrition. **Food Choice** includes behaviors and other factors occurring before food reaches the mouth, such as food preference and preparation. The second category, **Eating Behavior**, clusters all the outcomes related to consumption, such as eating habits and eating disorders. The third aspect, **Dietary Intake/Nutrition**, refers to what is consumed, in term of global intake and specific nutrients. This comprehensive framework needs this to consider the role of multiple determinants.

Factors Affecting Eating Behavior

Individual factors influencing eating behavior and food choice are based on both physiological (e.g., hunger, satiety, innate preference for sweet foods) and psychological processes (e.g., learned food preferences, knowledge, motivations, attitudes, values, personality traits, cognitive processes, self-regulation). The social environment is an additional factor to be considered as eating behavior is shaped indirectly, through observing others and internalization of food rules, as well as directly (i.e., one eats more in the presence of others than when alone). The physical environment is of course a crucial determinant: availability of foods, the context in which foods are provided, and the external cues, such as proximity to food, salience of food, packaging/serving size have all been shown to affect the type and amount of food eaten. Finally, the macrolevel environments is a major determinant, depending on economic systems, food and agricultural policies, food production and distribution, food marketing, and, last but not least, cultural norms and values (7). All these aspects need to be considered when assessing modifications of dietary behavior in health and disease. Changes in dietary behavior are associated with healthy aging, as well as with age-associated dementing disorders, and have been mostly investigated at the level of changes in eating behavior. Here we review the modifications observed in healthy aging and in dementia and the tools which have been developed for a comprehensive assessment of this central aspect of cognition and behavior.

CHANGES OF EATING BEHAVIOR IN PHYSIOLOGICAL AGING

Humans make hundreds of food decisions every day, influenced by a variety of personal, social, cultural, environmental and economic aspects (8). Older people are the major nutritionally vulnerable group, because of the interaction of these multiple interrelated factors (9), developing a condition called "nutritional frailty" (10). For instance, poverty causes a financially inability to satisfy their nutritional needs (11), while loneliness and social isolation cause a reduction of food preparation and the consequent decrease of food consumption (12), leading to a chronic depression that exacerbates the nutritional frailty (13). The dietary choices of elderly people are also influenced by the impaired appetite due to a physiological increase of sensory thresholds (smell and taste) (14, 15), the principle cause of geriatric anorexia (16) but also base of preference for sweet or fatty tastes (17–20). Older adults also demonstrate changes in circadian rhythms with a reduction of sleep quantity and quality, and a shift toward early rising, meaning that they eat earlier than at a younger age (21).This disruption of genetic clocks, combined to other physiological changes during aging, such as the loss of skeletal muscle mass (9) leads to dysfunctions of glucose and lipid metabolism and development of "Sarcopenic Obesity" (22). This condition is caused by hormonal changes, inflammatory patterns and myocellular mechanisms (23) and could exacerbate cognitive dysfunction (24) and consequently worsen eating behavior in a vicious cycle (14–16). The concomitant presence of diseases and the consequent polypharmacy can exacerbate dysphagia and hypermetabolism and contribute to the decreased energy balance and to changes in eating behavior (25, 26). Furthermore, eating disorders in the elderly could be disregarded (27). Geriatric anorexia could be hide a pre-existing subclinical and unrecognized anorexia nervosa in aging patients (27, 28) or the high prevalence of comorbid psychological conditions, as late-life depression or anxiety, may increase the risk of developing concomitant eating disorders, as binge eating disorder or bulimia nervosa (29–31). It is therefore clear the importance of in-depth screening to differentiate between impairments in eating behavior during aging.

Nutrients Intake

Most of the evidence reports a decline in energy intake with age, despite the prevalence of obesity (32). At all ages, men consumed more than women, but this difference is reduced with aging, as energy intake decreases faster in men than in women (33). As total energy intake decreases with age, the absolute amount of all macronutrients, i.e., proteins, lipids and carbohydrates declines accordingly (9). Despite of their greater requirements of proteins to respond to anabolic stimuli of aging, elderly tend to avoid animal proteins probably because of difficulties in chewing and swallowing or concerns about unhealthy content of cholesterol and saturated fats (9). Consumption of vegetable proteins is scarce as well, because of the declining efficiency of gastrointestinal function (34, 35). Carbohydrate intake does not alter over time as well; however, fibers intake increases, especially in women (33). Decrease in lipids consumption is the principle cause of the reduced energy intake (9), even if there is a strong gap between their consumption during the week, probably due to major social stimuli in the weekends than weekdays that push to prepare and choose more fatty and palatable foods (36). The reduction of caloric amount and the decline of sensitivity of taste and smell lead to less variety in food choices and related reduction in micronutrients intake (37). Elderly people are at high risk of deficiencies of water-soluble B12 vitamin, for the reduction of animal foods, and of fat-soluble vitamin D, because of the decrease of sun exposure. Both deficiencies are involved in the development of neurocognitive decline and dementia (38, 39). The preference of cooked over raw foods, including vegetable foods, lead also to various minerals' deficiencies, especially iron and calcium, leading to stable weakness and strong bone fragility (9) that mounting literature shows significantly related to cognitive performance (40). Indeed, bone mineral density may be reflective of cumulative estrogen associated with lower dementia risk (41), but also a predictor for cognitive performance (40).

Eating Patterns

Nutrition behavior and eating habits are formed during childhood (e.g., through nutrition education and behavior of parents) and are often retained for a lifetime. Behavior that has once been implemented is very hard to change in older age (42). However, in recent studies, elderly subjects reported a higher consumption of Mediterranean foods, tending to avoid non-Mediterranean foods (43). Such dietary habits led to the older groups having a higher adherence to the recognized-protective-Mediterranean diet than the younger. The prevalence values ranged from nearly 0% for the younger subjects to around 30–40% for the older. It is possible that the older subjects simply maintained traditional dietary habits acquired in infancy, thus remaining less affected by the process of diet-westernization. Overall, older adults seem to be more adherent to the healthy eating patterns than younger people (44) characterized by a higher consumption of fruits and vegetables, even if always less than recommended (9). This attitude is probably due to their increased consideration to food health concerns for the prevention and management of suggested diseases by specialists, in line with the recent findings on the protective role of some dietary components, as whole grains, berries, nuts and green leafy vegetables, on brain function (45). They also use more supplements than younger people for the same reason (46). At the same time, they globally reduce certain food groups ("meat, eggs, and fish" and "fruit and vegetables"), whereas the frequency of consumption of milk and cereals remains almost unchanged, especially as substitutes of dinner meal (16). Older people tend also to have a more structured eating pattern, concentrating the most of caloric intake in the first part of the day, and with three main meals and rarely small snacks (9). This physiologically change over time is probably due to the necessity of restoring disturbed circadian rhythms to improve metabolic health. Indeed, meal timing strongly contributes to the regulation of metabolic state and body weight (47–49). It appears that meal time-based strategies, associated to a restricted feeding, can be employed to prevent obesity and associated metabolic diseases in both young and older individuals (21).

CHANGES OF EATING BEHAVIOR IN DEMENTIA

Dementia is an age-associated syndrome due to several disorders affecting the central nervous system. Neurodegenerative dementia occurs mainly in people older than 65 years and is characterized by progressive cognitive impairment with consequence on multiple aspects of daily living leading to loss in daily functioning and behavior disturbances. The most common form of dementia worldwide is Alzheimer disease (AD) while frontotemporal dementia (FTD) is a common cause of early-onset dementia (50, 51). Non-cognitive, behavioral and psychiatric disturbances like apathy, disinhibition, agitation, depression, psychosis, appetite changes and sleep disturbances are key aspects normally assessed for the diagnosis of dementia (52). During the course of the disease, patients can present peculiar dietary changes and eating disorders, especially in the initial and intermediate stages. Instead, in the final stages of the disease, with a marked impairment of functional and cognitive ability and a complete dependency from others, we can find an overlap of the symptoms with main difficulties related to feeding themselves and swallowing (53). In the Neuropsychiatric Inventory (NPI), the main tool used to assess behavior disturbances in dementia, dietary changes or other eating behaviors are investigated due to their important clinical role in the course of the disease (54). However, this general assessment is often insufficient, given the complexity and diversity of eating disorders in dementia.

Alzheimer's Disease

Alzheimer's disease is the most common form of dementia accounting for about 60% of all cases (55, 56). Pathologically it is characterized by the presence in the brain of senile plaques and neurofibrillary tangles that lead to irreversible loss of neurons in the cerebral cortex and hippocampus (57). Typically, the first clinical symptom is memory impairment which is progressively followed by a deterioration of other cognitive functions and difficulties in everyday life activities and behavioral disorders (58). Due to the slow progress of the disease, nutritional behaviors and eating habits are affected gradually. In the early stages of the disease, due to initial memory/cognitive impairment and disorientation, a patient may have greater difficulty in purchasing products in a supermarket (e.g., remembering what to buy, looking for the products in the supermarket), and in remembering the steps for making cooking recipes correctly; this, can lead to the preparation of simple dishes or can increase the consumption of ready-made foods with a consequent poor dietary food intake (59, 60). Patients can also forget to eat (and drink) especially because they can experience decreased in appetite or conversely, even if it's less frequent, others can forget they have already eaten and eat multiple times in a day (61, 62). From a physical point of view, it is well-known that the decline in the sense of smell occurs in healthy elderly but even more occurs in patients with AD, already in the prodromal stages of the disease, worsening during the progression of the disease; this seems to contribute to changes in dietary choices (63–65). Additionally, the cognitive, behavioral and functional deficits can significantly affect social capability, increasing depression, isolation and loneliness, which are risk factors for malnutrition (66, 67). Disturbances in sleep and disruption of circadian rhythms are frequently reported in AD (68), with consequence of changes in eating patterns (69, 70).

As the disease progresses, eating disturbances differentiate: some dysfunctions such as "swallowing" tend to worsen with the worsening of the disease, others, such as food preference, appetite change and eating habits, tend to increase in the moderate stages of the disease and then decrease again in the more severe ones. In food preference the most common symptom is the preference for sweet foods more than before; for appetite change loss of appetite is often reported; for eating habits, to take a long time to eat or the decline in table manner are the most frequent actions described (17). Normally, starting from the moderate stage of the disease, patients are usually followed by a caregiver or in a nursery home: that improves regularity of meals and dietary

intake. As a matter of fact, people who are living alone are more at risk of malnutrition than those who are living with others perhaps because they have less ability to satisfy their nutritional needs (71). Surely, in AD patients, a common clinical disorder reported also by Alois Alzheimer in the first patient studied in the early 1900's, is weight loss (72–75). The relationship between weight loss and AD is still unclear but multiple pathophysiology explanations have been given (76): neuropathological changes have been correlated to weight loss like dysfunctions in the limbic system, atrophy of the mesial temporal cortex and reduced glucose metabolism in the anterior cingulate cortex (77, 78). Also neuroendocrine and metabolic disorders have been hypothesize (79–81). Suma et al. (82) have speculate that the weight loss in MCI and AD is due to the loss of appetite that in turn is related to depression or cognitive decline or the presence of comorbidities that are common features in AD (82). Interestingly, weight loss has been correlated to disease severity (72) and can occur before dementia, suggesting that it is not a consequence of other behavioral disorders (83–88). It is thus especially important to monitor eating disorders in healthy elderly subjects, as they could be predictive of risk of dementia.

Frontotemporal Dementia

Frontotemporal dementia (FTD) is a clinical syndrome, pathologically characterized by the degeneration of the frontal and temporal lobes of the brain. It is one of the most common form of early onset dementia, with a prevalence ranging from 2 to 31% (51). FTD presents clinically different variants: the behavioral variant frontotemporal dementia (bvFTD) characterized by behavioral disturbance like deterioration of social functioning and change in personality; two variants with predominant language impairment: non-fluent/agrammatic aphasia and semantic dementia (SD); and three clinical variants with motor disturbance: FTD with motor neuron disease (FTD-MND), corticobasal syndrome (CBS) and progressive supranuclear palsy (PSP) (89). The differences in clinical variants are the consequence of the localization of neuropathology, with the behavioral variant predominantly affecting the frontal lobes, while the variants with language disorders are predominantly related to temporal atrophy. For movement disorders posterior frontal lobe atrophy is associated with FTD-MND; midbrain atrophy with PSP and atrophy in frontal/parietal regions and the basal ganglia for CBS. Obviously, the heterogeneity of clinical variants results in consequence differences in eating abnormalities, ranging from physical difficulties in eating (predominantly in patients with movement disorders) to change in taste or eating habits. In bvFTD, the most common form of FTD, aberrant eating behaviors are frequently described also in the early stages of the disease, so they are one of the key clinical diagnostic features (90). The sudden decline in the basic activity of daily living in these patients, probably due to executive dysfunctions, immediately leads to difficulties in food choice and preparation (91, 92). Patients immediately request support from a caregiver and when the disease progresses disruptive eating disorders occur, causing the maximum distress of the caregiver (93). The most common abnormal eating behaviors reported in bvFTD are: changes in food preferences, like craving for sweets or carbohydrates (17–20) changes in appetite including overeating and binge eating (17–19, 94), and obsession with particular foods or compulsive food preference (18). Hyperorality and dietary changes are reported in more than 60% of bvFTD patients at initial presentation (20). FTD patients with these behavioral disorders showed greater BMI and higher waist circumference compared to controls, but not an increase in hunger or decrease of satiety index (19). Omar et al. (95) have identified deficit in flavor identification in FTD patients compared to controls and this altered flavor processing may have a role in abnormal eating behavior (95). Patients can have also inappropriate eating habits with decline in table manners like eating with hands or take food from other's plate (17). Less frequently, swallowing and oral exploration or ingestion of inedible objects have been described (17). All these eating abnormalities are also reported in patients with semantic dementia (SD), even if the frequency is less than bvFTD (17, 96). Typically, in semantic dementia, changes in food preference, increased selectivity of food and food fads are more prominent than other eating disturbances (19, 97) These changes, mainly related to food preference, seem to be due to the semantic deficit; the hypothesis is that the loss of knowledge relating to food leads to these eating disturbances (98).

ASSESSMENT OF EATING BEHAVIOR IN AGING AND DEMENTIA

In the light of all these social, physiological, and clinical changes and eating disorders in aging and dementia, it is clear the importance of a comprehensive assessment of eating behavior throughout the entire course of aging. A screening tool to assess the eating patterns and nutrients intake of older people could allow adequate intervention among health professionals and could potentially reduce health care costs (99).

Screening Tools for Eating Behavior in Aging

There are at least four phenomena that can be examined: (1) Eating behavior, (2) Environmental influences on eating behavior, (3) Food choices, (4) Food preferences and hunger (100). Laboratory settings are the reference methods, in which subject's behavior, in terms of meal duration, food choices, hunger and satiety, etc., is recorded. However, the average sample sizes used in these studies due to the high costs may produce unreliable results (101). For this reason, natural settings are preferred, and self-monitoring tools or caregiver-based questionnaires have been developed. Of these, the Mini Nutritional Assessment (MNA) and the Simplified Nutritional Appetite Questionnaire (SNAQ), have become the most widely used among older people to investigate anorexia (99). While MNA is able to classify older people as well-nourished, at risk for malnutrition or malnourished through 18 self-reported questions derived from four parameters of assessment (weight changes, dietary assessment and self- assessment) (102), the four-question SNAQ score may be effective in identifying individuals at risk of significant weight loss, moderately correlate with the MNA (99). This combined assessment could be useful

for a comprehensive screening of physiological anorexia and consequent risk for weight loss and malnutrition in the early phases of elderly age. For a deeper understanding of eating behavior, Adult Eating Behavior Questionnaire (AEBQ) and Self-Regulation of Eating Behavior Questionnaire (SREBQ) are recommended (103, 104). AEBQ give a better picture of the association between appetitive traits and weight across aging and can also be used to inform interventions to help individuals to control their weight, by providing tailored feedback on managing appetitive trait responses (emotional over-eating, enjoyment of food, hunger and satiety, food fussiness) (103). SREBQ focus on the capacity to self-regulate eating behavior, referring broadly to the multiple processes involved in goal-directed behavior and encompasses management of behavior, thoughts, feelings, attention and environment in the pursuit of personal goals, as eating (104). The Eating Disorder Inventory (EDI) (27) and the Yale Food Addiction Scale (YFAS) (105) are suggested to assess the presence of eating disorders, as Anorexia Nervosa both restricting and binge-eating/purging type; Bulimia Nervosa; and Eating disorder not otherwise specified including Binge Eating Disorder (BED), and to provide a validated measure of addictive-like eating behavior based upon the diagnostic criteria for substance dependence, respectively.

Screening Tools for Eating Behavior in Dementia

In dementia it is important to assess the progress of swallowing function, as well as food preferences, functional skills, appetite, taking into account the loss of patient ability and, therefore, the need for caregiver involvement in the assessment of eating behavior of the patients. The Eating Behavior Scale (EBS) is specific for monitoring the trend of patients at the early stage of dementia. It measures the ability of people with dementia to feed themselves independently, investigating six behavioral aspects observed during meals (able to initiate or maintain eating, use of utensils, able to bite and swallow) and it was positively correlated with the Mini-Mental State Examination, a screening tool for cognitive function, so a lower EBS score indicates a decline of cognitive function. At advanced phases of the diseases, changes in eating behavior were measured using caregiver-based questionnaires: the Appetite and Eating Habits Questionnaire (APEHQ) and the Cambridge Behavioral Inventory (CBI). The APEHQ comprises 34 questions that examine changes in eating behaviors in the following domains: swallowing, appetite, eating habits (stereotypic eating behavior and table manners), food preference (including sweet preference and other food fads), and other oral behaviors (e.g., food cramming, increased smoking) (19). On the other hand, CBI is a full questionnaire striking differences between patients with FTD and AD (18). Indeed, it investigates broad domains: depression, elation, irritability, anxiety, aggression, distractibility, executive functioning, risk taking, empathy, apathy, ritualistic/stereotypic behavior, aberrant motor behavior, disinhibition, social withdrawal, hallucinations, delusions, changes in food preference, personal care, and sleep patterns. These tools should be included in clinical practice and repeated at well-defined intervals to detect early signs and symptoms of eating disorders in aging and dementia so that early intervention can be taken.

MANAGEMENT OF EATING BEHAVIOR IN AGING AND DEMENTIA

Interventions to manage eating disorders in aging and dementia must combine strategies for improving dietary quality and behavioral management to enhance the well-being of older adults (106). For this, in healthy aging, multidomain interventions that combine healthy diet, physical exercises, cognitive training and social activities are showing promising results (107–109). Dietary educational programs and tailored diets must include the right variety and frequency of food groups typical of Mediterranean-type diet and Mediterranean-DASH Intervention for Neurodegenerative Delay (110–112). A higher adherence to these dietary patterns has been associated with slower rates of cognitive decline and with a significant reduction in AD incidence (113). These plant-based dietary models are characterized by a high intake of whole grains, legumes, vegetables, fruits, nuts and olive oil; a moderate to high intake of fish; a low intake of meat and eggs; and a regular but moderate intake of wine. These foods are poor in saturated fatty acids, whose intake is negatively correlated with cognitive function (114), but contain multifunctional nutrients–in particular vitamins B and E, omega-3 fatty acids, oleic acid and polyphenolic compounds–with antioxidant and anti-inflammatory effects (115) that can promote the maintenance of lean mass (116) with positive effects on synaptic plasticity and cognition (117) and are protective against chronic diseases also related to dementia, such as diabetes or prediabetes, as well as vascular risk factors and metabolic syndrome (118–120). Concerning individualized interventions on eating in dementia, little evidence is available (121–123). Conventional interventions are based on collaboration between caregivers who l know well the person's habits, preferences, and beliefs, and specialized dieticians. Suggested strategies to overcome the reduction of caloric amount and the decline of sensitivity of taste and smell, but also mealtimes disruptions (124), are:

- preparing attractive and inviting meals, helping with colorful vegetables, herbs and spices;
- if patient prefers sweet or fatty tastes, vegetable oils, dried and fresh fruit) or naturally sweet vegetables (such as carrots or sweet potato) may be a healthier option;
- combining unusual food combinations with familiar recipes and prefer finger foods such as sandwiches, pies, baked dishes;
- eliminating environmental factors, and providing a daily routine that promotes beginning a meal (food within the person eyesight and in clear contrast with the plate or immediate environment);
- sitting and chatting with the patient, giving specific instructions and encouragement during mealtimes.

If the patient is likely to experience excessive eating and other changes in eating behavior, such as changes in dietary preference

and obsession with particular foods, the suggested strategies for caregivers (53) are:

- entertain the person with playful activities so they do not feel bored or lonely;
- divide the portion in two and offer the second one only if requested;
- fill most of the plate with salad or vegetables.

CONCLUSIONS

Modifications of eating behavior frequently occur in normal aging and neurodegenerative dementias, ranging from subtle changes to diagnostically relevant features, such as in the case of frontotemporal dementia. Adequate screening of the eating patterns and nutrients intake of older people allows early intervention by health professionals and can play an important role in patient management. The clinical evaluation should consider, as a baseline, the "physiological" changes associated with healthy aging which leads to a normal lower nutrients intake. Instead, during the course of a neurodegenerative dementia, it must be take into account that the cognitive impairment affects patient's ability to perform basic and instrumental ability of daily living and that behavioral or movement disorders can occur. Some tools are available to guide the assessment of nutrition, a crucial and often neglected aspect of patients' behavior. The MNA and the SNAQ are suitable to investigate anorexia and the risk of malnutrition in elderly; the EBS can be used to monitoring patient's ability to feed himself independently in the early stages of dementia and the APEHQ and the CBI are caregiver-based questionnaires that can be useful in the advanced phases of dementia. These tools should be included in clinical practice and repeated at regular intervals to detect early signs and symptoms of eating disorders. In this review, we attempted to discuss all the eating disorders that can be meet during aging and dementia and the tools used for his assessment but there are some limitations to consider. Among the variety of tools for the assessment of eating disorders we have reported the most used in elderly and dementia. In addition, we have included some tools such as the AEBQ, the SREBQ, the EDI, and the YFAS that could be used for a more comprehensive assessment of eating behavior, even if their use in an elderly population is actually limited. Mounting literature and research is showing relation between nutrition, cognition and dementia, but the evaluation of these aspects is not yet common in the clinical management of the elderly patients. The purpose of this review was to present the main changes in eating behavior during aging and dementia and the tools actually recommended. Given the complexity of eating behavior in the elderly, with and without dementia, further studies are needed to develop more comprehensive tools.

AUTHOR CONTRIBUTIONS

SF and RDA wrote the draft of the manuscript. AL and VG contributed to literature review and manuscript editing. GB, SB, AB, and SC critically evaluated and revised the manuscript. All authors have read and approved the manuscript.

FUNDING

This work was supported by a grant from the Italian Ministry of Health, Convenzione n. 115/RF-2011-02351933 and by Ricerca Corrente Italian Ministry of Health.

REFERENCES

1. Cao L, Tan L, Wang HF, Jiang T, Zhu XC, Lu H, et al. Dietary patterns and risk of dementia: a systematic review and meta-analysis of cohort studies. *Mol Neurobiol.* (2016) 53:6144–54. doi: 10.1007/s12035-015-9516-4
2. Hardman RJ, Kennedy G, Macpherson H, Scholey AB, Pipingas A. Adherence to a mediterranean-style diet and effects on cognition in adults: a qualitative evaluation and systematic review of longitudinal and prospective trials. *Front Nutr.* (2016) 3:22. doi: 10.3389/fnut.2016.00022
3. Petersson SD, Philippou E. Mediterranean diet, cognitive function, and dementia: a systematic review of the evidence. *Adv Nutr.* (2016) 7:889–904. doi: 10.3945/an.116.012138
4. Kivipelto M, Mangialasche F, Ngandu T. Lifestyle interventions to prevent cognitive impairment, dementia and Alzheimer disease. *Nat Rev Neurol.* (2018) 14:653–66. doi: 10.1038/s41582-018-0070-3
5. Lehtisalo J, Levälahti E, Lindström J, Hänninen T, Paajanen T, Peltonen M, et al. Dietary changes and cognition over 2 years within a multidomain intervention trial-the finnish geriatric intervention study to prevent cognitive impairment and disability (FINGER). *Alzheimers Dement.* (2019) 15:410–7. doi: 10.1016/j.jalz.2018.10.001
6. Marijn Stok F, Renner B, Allan J, Boeing H, Ensenauer R, Issanchou S, et al. dietary behavior: an interdisciplinary conceptual analysis and taxonomy. *Front Psychol.* (2018) 9:1689. doi: 10.3389/fpsyg.2018.01689
7. LaCaille L. Eating behavior. In: Gellman MD, Turner JR, editors. *Encyclopedia of Behavioral Medicine.* New York, NY: Springer New York (2013). p. 641–2.
8. Gellman MD, Turner JR. *Encyclopedia of Behavioral Medicine.* New York, NY: Springer (2013). doi: 10.1007/978-1-4419-1005-9
9. Yannakoulia M, Mamalaki E, Anastasiou CA, Mourtzi N, Lambrinoudaki I, Scarmeas N. Eating habits and behaviors of older people: where are we now and where should we go? *Maturitas.* (2018) 114:14–21. doi: 10.1016/j.maturitas.2018.05.001
10. Bales CW, Ritchie CS. Sarcopenia, weight loss, and nutritional frailty in the elderly. *Annu Rev Nutr.* (2002) 22:309–23. doi: 10.1146/annurev.nutr.22.010402.102715
11. Porter Starr KN, McDonald SR, Bales CW. Nutritional vulnerability in older adults: a continuum of concerns. *Curr Nutr Rep.* (2015) 4:176–84. doi: 10.1007/s13668-015-0118-6
12. Locher JL, Ritchie CS, Roth DL, Baker PS, Bodner EV, Allman RM. Social isolation, support, and capital and nutritional risk in an older sample: ethnic and gender differences. *Soc Sci Med.* (2005) 60:747–61. doi: 10.1016/j.socscimed.2004.06.023
13. Luppa M, König HH, Heider D, Leicht H, Motzek T, Schomerus G, et al. Direct costs associated with depressive symptoms in late life: a 4.5-year prospective study. *Int Psychogeriatr.* (2013) 25:292–302. doi: 10.1017/S1041610212001688
14. Elsner RJ. Changes in eating behavior during the aging process. *Eat Behav.* (2002) 3:15–43. doi: 10.1016/S1471-0153(01)00041-1
15. Amarya S, Singh K, Sabharwal M. Changes during aging and their association with malnutrition. *J Clin Gerontol Geriatrics.* (2015) 6:78–84. doi: 10.1016/j.jcgg.2015.05.003

16. Donini LM, Poggiogalle E, Piredda M, Pinto A, Barbagallo M, Cucinotta D, et al. Anorexia and eating patterns in the elderly. *PLoS ONE.* (2013) 8:e63539. doi: 10.1371/journal.pone.0063539
17. Ikeda M, Brown J, Holland AJ, Fukuhara R, Hodges JR. Changes in appetite, food preference, and eating habits in frontotemporal dementia and Alzheimer's disease. *J Neurol Neurosurg Psychiatr.* (2002) 73:371–6. doi: 10.1136/jnnp.73.4.371
18. Bozeat S, Gregory CA, Ralph MA, Hodges JR. Which neuropsychiatric and behavioural features distinguish frontal and temporal variants of frontotemporal dementia from Alzheimer's disease? *J Neurol Neurosurg Psychiatry.* (2000) 69:178–86. doi: 10.1136/jnnp.69.2.178
19. Ahmed RM, Irish M, Kam J, van Keizerswaard J, Bartley L, Samaras K, et al. Quantifying the eating abnormalities in frontotemporal dementia. *JAMA Neurol.* (2014) 71:1540–6. doi: 10.1001/jamaneurol.2014.1931
20. Piguet O, Petersen A, Yin Ka Lam B, Gabery S, Murphy K, Hodges JR, et al. Eating and hypothalamus changes in behavioral-variant frontotemporal dementia. *Ann Neurol.* (2011) 69:312–9. doi: 10.1002/ana.22244
21. Kessler K, Pivovarova-Ramich O. Meal timing, aging, and metabolic health. *Int J Mol Sci.* (2019) 20:1911. doi: 10.3390/ijms20081911
22. Leslie W, Hankey C. Aging, Nutritional Status and Health. *Healthcare.* (2015) 3:648–58. doi: 10.3390/healthcare3030648
23. Batsis JA, Villareal DT. Sarcopenic obesity in older adults: aetiology, epidemiology and treatment strategies. *Nat Rev Endocrinol.* (2018) 14:513–37. doi: 10.1038/s41574-018-0062-9
24. Tolea MI, Chrisphonte S, Galvin JE. Sarcopenic obesity and cognitive performance. *Clin Interv Aging.* (2018) 13:1111–9. doi: 10.2147/CIA.S164113
25. Ahmed RM, Irish M, Piguet O, Halliday GM, Ittner LM, Farooqi S, et al. Amyotrophic lateral sclerosis and frontotemporal dementia: distinct and overlapping changes in eating behaviour and metabolism. *Lancet Neurol.* (2016) 15:332–42. doi: 10.1016/S1474-4422(15)00380-4
26. Pilgrim AL, Robinson SM, Sayer AA, Roberts HC. An overview of appetite decline in older people. *Nurs Older People.* (2015) 27:29–35. doi: 10.7748/nop.27.5.29.e697
27. Lapid MI, Prom MC, Burton MC, McAlpine DE, Sutor B, Rummans TA. Eating disorders in the elderly. *Int Psychogeriatr.* (2010) 22:523–36. doi: 10.1017/S1041610210000104
28. Main J, Reddy L, Lazarevic M, Whelan PJ. Are late-onset eating disorders in the elderly really the more common variant? Concerns around publication bias. *Int Psychogeriatr.* (2011) 23:670–1. doi: 10.1017/S1041610210001778
29. Gum AM, Cheavens JS. Psychiatric comorbidity and depression in older adults. *Curr Psychiatry Rep.* (2008) 10:23–9. doi: 10.1007/s11920-008-0006-5
30. Bertoli S, Leone A, Vignati L, Bedogni G, Martinez-Gonzalez MA, Bes-Rastrollo M, et al. Adherence to the mediterranean diet is inversely associated with visceral abdominal tissue in caucasian subjects. *Clin Nutr.* (2015) 34:1266–72. doi: 10.1016/j.clnu.2015.10.003
31. Conceição EM, Gomes FVS, Vaz AR, Pinto-Bastos A, Machado PPP. Prevalence of eating disorders and picking/nibbling in elderly women. *Int J Eat Disord.* (2017) 50:793–800. doi: 10.1002/eat.22700
32. Mathus-Vliegen EM. Obesity and the elderly. *J Clin Gastroenterol.* (2012) 46:533–44. doi: 10.1097/MCG.0b013e31825692ce
33. Wakimoto P, Block G. Dietary intake, dietary patterns, and changes with age: an epidemiological perspective. *J Gerontol A Biol Sci Med Sci.* (2001) 56:65–80. doi: 10.1093/gerona/56.suppl_2.65
34. Nelson JB, Castell DO. Esophageal motility disorders. *Dis Mon.* (1988) 34:297–389. doi: 10.1016/0011-5029(88)90021-1
35. Shamburek RD, Farrar JT. Disorders of the digestive system in the elderly. *N Engl J Med.* (1990) 322:438–43. doi: 10.1056/NEJM199002153220705
36. de Castro JM. Age-related changes in the social, psychological, and temporal influences on food intake in free-living, healthy, adult humans. *J Gerontol A Biol Sci Med Sci.* (2002) 57:M368–77. doi: 10.1093/gerona/57.6.M368
37. Rolls BJ. Aging and appetite. *Nutr Rev.* (1992) 50:422–6. doi: 10.1111/j.1753-4887.1992.tb02496.x
38. Anastasiou CA, Fappa E, Karfopoulou E, Gkza A, Yannakoulia M. Weight loss maintenance in relation to locus of control: the medWeight study. *Behav Res Ther.* (2015) 71:40–4. doi: 10.1016/j.brat.2015.05.010
39. Wong CW. Vitamin B12 deficiency in the elderly: is it worth screening? *Hong Kong Med J.* (2015) 21:155–64. doi: 10.12809/hkmj14 4383
40. Sohrabi HR, Bates KA, Weinborn M, Bucks RS, Rainey-Smith SR, Rodrigues MA, et al. Bone mineral density, adiposity, and cognitive functions. *Front Aging Neurosci.* (2015) 7:16. doi: 10.3389/fnagi.2015.00016
41. Fox M, Berzuini C, Knapp LA. Cumulative estrogen exposure, number of menstrual cycles, and Alzheimer's risk in a cohort of British women. *Psychoneuroendocrinology.* (2013) 38:2973–82. doi: 10.1016/j.psyneuen.2013.08.005
42. Koehler J, Leonhaeuser IU. Changes in food preferences during aging. *Ann Nutr Metab.* (2008) 52(Suppl. 1):15–9. doi: 10.1159/000115342
43. Leone A, Battezzati A, De Amicis R, De Carlo G, Bertoli S. Trends of adherence to the mediterranean dietary pattern in northern Italy from 2010 to 2016. *Nutrients.* (2017) 9:734. doi: 10.3390/nu9070734
44. Inelmen EM, Toffanello ED, Enzi G, Sergi G, Coin A, Busetto L, et al. Differences in dietary patterns between older and younger obese and overweight outpatients. *J Nutr Health Aging.* (2008) 12:3–8. doi: 10.1007/BF02982157
45. Morris MC. Nutrition and risk of dementia: overview and methodological issues. *Ann N Y Acad Sci.* (2016) 1367:31–7. doi: 10.1111/nyas.13047
46. Ervin RB, Kennedy-Stephenson J. Mineral intakes of elderly adult supplement and non-supplement users in the third national health and nutrition examination survey. *J Nutr.* (2002) 132:3422–7. doi: 10.1093/jn/132.11.3422
47. Jiang P, Turek FW. Timing of meals: when is as critical as what and how much. *Am J Physiol Endocrinol Metab.* (2017) 312:E369–80. doi: 10.1152/ajpendo.00295.2016
48. Asher G, Sassone-Corsi P. Time for food: the intimate interplay between nutrition, metabolism, and the circadian clock. *Cell.* (2015) 161:84–92. doi: 10.1016/j.cell.2015.03.015
49. Allison KC, Goel N. Timing of eating in adults across the weight spectrum: metabolic factors and potential circadian mechanisms. *Physiol Behav.* (2018) 192:158–66. doi: 10.1016/j.physbeh.2018.02.047
50. Ferri CP, Prince M, Brayne C, Brodaty H, Fratiglioni L, Ganguli M, et al. Global prevalence of dementia: a Delphi consensus study. *Lancet.* (2005) 366:2112–7. doi: 10.1016/S0140-6736(05)67889-0
51. Onyike CU, Diehl-Schmid J. The epidemiology of frontotemporal dementia. *Int Rev Psychiatry.* (2013) 25:130–7. doi: 10.3109/09540261.2013.776523
52. Lyketsos CG, Lopez O, Jones B, Fitzpatrick AL, Breitner J, DeKosky S. Prevalence of neuropsychiatric symptoms in dementia and mild cognitive impairment: results from the cardiovascular health study. *JAMA.* (2002) 288:1475–83. doi: 10.1001/jama.288.12.1475
53. Volkert D, Chourdakis M, Faxen-Irving G, Fruhwald T, Landi F, Suominen MH, et al. ESPEN guidelines on nutrition in dementia. *Clin Nutr.* (2015) 34:1052–73. doi: 10.1016/j.clnu.2015.09.004
54. Cummings JL, Mega M, Gray K, Rosenberg-Thompson S, Carusi DA, Gornbein J. The neuropsychiatric Inventory: comprehensive assessment of psychopathology in dementia. *Neurology.* (1994) 44:2308–14. doi: 10.1212/WNL.44.12.2308
55. Kalaria RN, Maestre GE, Arizaga R, Friedland RP, Galasko D, Hall K, et al. Alzheimer's disease and vascular dementia in developing countries: prevalence, management, and risk factors. *Lancet Neurol.* (2008) 7:812–26. doi: 10.1016/S1474-4422(08)70169-8
56. Fratiglioni L, De Ronchi D, Aguero-Torres H. Worldwide prevalence and incidence of dementia. *Drugs Aging.* (1999) 15:365–75. doi: 10.2165/00002512-199915050-00004
57. Serrano-Pozo A, Frosch MP, Masliah E, Hyman BT. Neuropathological alterations in Alzheimer disease. *Cold Spring Harb Perspect Med.* (2011) 1:a006189. doi: 10.1101/cshperspect.a006189
58. McKhann GM, Knopman DS, Chertkow H, Hyman BT, Jack CR Jr, Kawas CH, et al. The diagnosis of dementia due to Alzheimer's disease: recommendations from the National Institute on aging-Alzheimer's association workgroups on diagnostic guidelines for Alzheimer's disease. *Alzheimers Dement.* (2011) 7:263–9. doi: 10.1016/j.jalz.2011.03.005
59. Brown PJ, Devanand DP, Liu X, Caccappolo E, Alzheimer's disease neuroimaging initiative. functional impairment in elderly patients with mild cognitive impairment and mild Alzheimer disease. *Arch Gen Psychiatry.* (2011) 68:617–26. doi: 10.1001/archgenpsychiatry.2011.57
60. Ogama N, Sakurai T, Nakai T, Niida S, Saji N, Toba K, et al. Impact of frontal white matter hyperintensity on instrumental

activities of daily living in elderly women with Alzheimer disease and amnestic mild cognitive impairment. *PLoS ONE.* (2017) 12:e0172484. doi: 10.1371/journal.pone.0172484
61. Inelmen EM, Sergi G, Coin A, Girardi A, Manzato E. An open-ended question: Alzheimer's disease and involuntary weight loss: which comes first? *Aging Clin Exp Res.* (2010) 22:192–7. doi: 10.1007/BF03324796
62. Gillette Guyonnet S, Abellan Van Kan G, Alix E, Andrieu S, Belmin J, Berrut G, et al. IANA (International Academy on Nutrition and Aging) expert group: weight loss and Alzheimer's disease. *J Nutr Health Aging.* (2007) 11:38–48.
63. Murphy C. Olfactory and other sensory impairments in Alzheimer disease. *Nat Rev Neurol.* (2019) 15:11–24. doi: 10.1038/s41582-018-0097-5
64. Doty RL. Age-related deficits in taste and smell. *Otolaryngol Clin North Am.* (2018) 51:815–25. doi: 10.1016/j.otc.2018.03.014
65. Sakai M, Ikeda M, Kazui H, Shigenobu K, Nishikawa T. Decline of gustatory sensitivity with the progression of Alzheimer's disease. *Int Psychogeriatr.* (2016) 28:511–7. doi: 10.1017/S1041610215001337
66. Boulos C, Salameh P, Barberger-Gateau P. Social isolation and risk for malnutrition among older people. *Geriatr Gerontol Int.* (2017) 17:286–94. doi: 10.1111/ggi.12711
67. Newsom JT, Schulz R. Social support as a mediator in the relation between functional status and quality of life in older adults. *Psychol Aging.* (1996) 11:34–44. doi: 10.1037/0882-7974.11.1.34
68. Musiek ES, Xiong DD, Holtzman DM. Sleep, circadian rhythms, and the pathogenesis of Alzheimer disease. *Exp Mol Med.* (2015) 47:e148. doi: 10.1038/emm.2014.121
69. Young KW, Binns MA, Greenwood CE. Meal delivery practices do not meet needs of Alzheimer patients with increased cognitive and behavioral difficulties in a long-term care facility. *J Gerontol A Biol Sci Med Sci.* (2001) 56:M656–61. doi: 10.1093/gerona/56.10.M656
70. Potter GD, Skene DJ, Arendt J, Cade JE, Grant PJ, Hardie LJ. Circadian rhythm and sleep disruption: causes, metabolic consequences, and countermeasures. *Endocr Rev.* (2016) 37:584–608. doi: 10.1210/er.2016-1083
71. Soto M, Andrieu S, Gares V, Cesari M, Gillette-Guyonnet S, Cantet C, et al. Living alone with alzheimer's disease and the risk of adverse outcomes: results from the plan de Soin et d'Aide dans la maladie d'Alzheimer study. *J Am Geriatr Soc.* (2015) 63:651–8. doi: 10.1111/jgs.13347
72. White H, Pieper C, Schmader K. The association of weight change in Alzheimer's disease with severity of disease and mortality: a longitudinal analysis. *J Am Geriatr Soc.* (1998) 46:1223–7. doi: 10.1111/j.1532-5415.1998.tb04537.x
73. Gillette-Guyonnet S, Nourhashemi F, Andrieu S, de Glisezinski I, Ousset PJ, Riviere D, et al. Weight loss in Alzheimer disease. *Am J Clin Nutr.* (2000) 71:637S-42S. doi: 10.1093/ajcn/71.2.637s
74. Craig D, Mirakhur A, Hart DJ, McIlroy SP, Passmore AP. A cross-sectional study of neuropsychiatric symptoms in 435 patients with Alzheimer's disease. *Am J Geriatr Psychiatry.* (2005) 13:460–8. doi: 10.1097/00019442-200506000-00004
75. Maurer K, Volk S, Gerbaldo H. Auguste D and Alzheimer's disease. *Lancet.* (1997) 349:1546–9. doi: 10.1016/S0140-6736(96)10203-8
76. Vercruysse P, Vieau D, Blum D, Petersen A, Dupuis L. Hypothalamic alterations in neurodegenerative diseases and their relation to abnormal energy metabolism. *Front Mol Neurosci.* (2018) 11:2. doi: 10.3389/fnmol.2018.00002
77. Hu X, Okamura N, Arai H, Higuchi M, Maruyama M, Itoh M, et al. Neuroanatomical correlates of low body weight in Alzheimer's disease: a PET study. *Prog Neuropsychopharmacol Biol Psychiatry.* (2002) 26:1285–9. doi: 10.1016/S0278-5846(02)00291-9
78. Grundman M, Corey-Bloom J, Jernigan T, Archibald S, Thal LJ. Low body weight in Alzheimer's disease is associated with mesial temporal cortex atrophy. *Neurology.* (1996) 46:1585–91. doi: 10.1212/WNL.46.6.1585
79. Power DA, Noel J, Collins R, O'Neill D. Circulating leptin levels and weight loss in Alzheimer's disease patients. *Dement Geriatr Cogn Disord.* (2001) 12:167–70. doi: 10.1159/000051252
80. Holscher C. Insulin signaling impairment in the brain as a risk factor in Alzheimer's disease. *Front Aging Neurosci.* (2019) 11:88. doi: 10.3389/fnagi.2019.00088
81. Hiller AJ, Ishii M. Disorders of body weight, sleep and circadian rhythm as manifestations of hypothalamic dysfunction in Alzheimer's disease. *Front Cell Neurosci.* (2018) 12:471. doi: 10.3389/fncel.2018.00471
82. Suma S, Watanabe Y, Hirano H, Kimura A, Edahiro A, Awata S, et al. Factors affecting the appetites of persons with Alzheimer's disease and mild cognitive impairment. *Geriatr Gerontol Int.* (2018) 18:1236–43. doi: 10.1111/ggi.13455
83. Barrett-Connor E, Edelstein SL, Corey-Bloom J, Wiederholt WC. Weight loss precedes dementia in community-dwelling older adults. *J Am Geriatr Soc.* (1996) 44:1147–52. doi: 10.1111/j.1532-5415.1996.tb01362.x
84. Muller S, Preische O, Sohrabi HR, Graber S, Jucker M, Dietzsch J, et al. Decreased body mass index in the preclinical stage of autosomal dominant Alzheimer's disease. *Sci Rep.* (2017) 7:1225. doi: 10.1038/s41598-017-01327-w
85. Buchman AS, Wilson RS, Bienias JL, Shah RC, Evans DA, Bennett DA. Change in body mass index and risk of incident Alzheimer disease. *Neurology.* (2005) 65:892–7. doi: 10.1212/01.wnl.0000176061.33817.90
86. Stewart R, Masaki K, Xue QL, Peila R, Petrovitch H, White LR, et al. A 32-year prospective study of change in body weight and incident dementia: the Honolulu-Asia aging study. *Arch Neurol.* (2005) 62:55–60. doi: 10.1001/archneur.62.1.55
87. Hughes TF, Borenstein AR, Schofield E, Wu Y, Larson EB. Association between late-life body mass index and dementia: the kame project. *Neurology.* (2009) 72:1741–6. doi: 10.1212/WNL.0b013e3181a60a58
88. Jimenez A, Pegueroles J, Carmona-Iragui M, Vilaplana E, Montal V, Alcolea D, et al. Weight loss in the healthy elderly might be a non-cognitive sign of preclinical Alzheimer's disease. *Oncotarget.* (2017) 8:104706–16. doi: 10.18632/oncotarget.22218
89. Olney NT, Spina S, Miller BL. Frontotemporal dementia. *Neurol Clin.* (2017) 35:339–74. doi: 10.1016/j.ncl.2017.01.008
90. Rascovsky K, Hodges JR, Knopman D, Mendez MF, Kramer JH, Neuhaus J, et al. Sensitivity of revised diagnostic criteria for the behavioural variant of frontotemporal dementia. *Brain.* (2011) 134:2456–77. doi: 10.1093/brain/awr179
91. Mioshi E, Kipps CM, Dawson K, Mitchell J, Graham A, Hodges JR. Activities of daily living in frontotemporal dementia and Alzheimer disease. *Neurology.* (2007) 68:2077–84. doi: 10.1212/01.wnl.0000264897.13722.53
92. Lima-Silva TB, Bahia VS, Carvalho VA, Guimarães HC, Caramelli P, Balthazar ML, et al. Direct and indirect assessments of activities of daily living in behavioral variant frontotemporal dementia and Alzheimer disease. *J Geriatr Psychiatry Neurol.* (2015) 28:19–26. doi: 10.1177/0891988714541874
93. Mioshi E, Hodges JR, Hornberger M. Neural correlates of activities of daily living in frontotemporal dementia. *J Geriatr Psychiatry Neurol.* (2013) 26:51–7. doi: 10.1177/0891988713477474
94. Pompanin S, Jelcic N, Cecchin D, Cagnin A. Impulse control disorders in frontotemporal dementia: spectrum of symptoms and response to treatment. *Gen Hosp Psychiatry.* (2014) 36:760.e5–7. doi: 10.1016/j.genhosppsych.2014.06.005
95. Omar R, Mahoney CJ, Buckley AH, Warren JD. Flavour identification in frontotemporal lobar degeneration. *J Neurol Neurosurg Psychiatry.* (2013) 84:88–93. doi: 10.1136/jnnp-2012-303853
96. O'Connor CM, Clemson L, Hornberger M, Leyton CE, Hodges JR, Piguet O, et al. Longitudinal change in everyday function and behavioral symptoms in frontotemporal dementia. *Neurol Clin Pract.* (2016) 6:419–28. doi: 10.1212/CPJ.0000000000000264
97. Snowden JS, Bathgate D, Varma A, Blackshaw A, Gibbons ZC, Neary D. Distinct behavioural profiles in frontotemporal dementia and semantic dementia. *J Neurol Neurosurg Psychiatry.* (2001) 70:323–32. doi: 10.1136/jnnp.70.3.323
98. Vignando M, Rumiati RI, Manganotti P, Cattaruzza T, Aiello M. Establishing links between abnormal eating behaviours and semantic deficits in dementia. *J Neuropsychol.* (2019) 14:431–448. doi: 10.1111/jnp.12195
99. Warne C, Forrester IT, Jones L, Morley JE. Editorial: screening for the anorexia of aging. *J Nutr Health Aging.* (2019) 23:398–400. doi: 10.1007/s12603-019-1195-9
100. Brownell KD, Stunkard AJ. Couples training, pharmacotherapy, and behavior therapy in the treatment of obesity. *Arch Gen Psychiatry.* (1981) 38:1224–9. doi: 10.1001/archpsyc.1981.01780360040003

101. Robinson E, Bevelander KE, Field M, Jones A. Comments on methodological and reporting quality in laboratory studies of human eating behaviour. *Appetite.* (2018) 130:344–5. doi: 10.1016/j.appet.2018.07.001
102. Vellas B, Guigoz Y, Garry PJ, Nourhashemi F, Bennahum D, Lauque S, et al. The mini nutritional assessment (MNA) and its use in grading the nutritional state of elderly patients. *Nutrition.* (1999) 15:116–22. doi: 10.1016/S0899-9007(98)00171-3
103. Hunot C, Fildes A, Croker H, Llewellyn CH, Wardle J, Beeken RJ. Appetitive traits and relationships with BMI in adults: development of the adult eating behaviour questionnaire. *Appetite.* (2016) 105:356–63. doi: 10.1016/j.appet.2016.05.024
104. Kliemann N, Beeken RJ, Wardle J, Johnson F. Development and validation of the self-regulation of eating behaviour questionnaire for adults. *Int J Behav Nutr Phys Act.* (2016) 13:87. doi: 10.1186/s12966-016-0414-6
105. Gearhardt AN, Corbin WR, Brownell KD. Development of the yale food addiction scale version 2.0. *Psychol Addict Behav.* (2016) 30:113–21. doi: 10.1037/adb0000136
106. Poscia A, Milovanovic S, La Milia DI, Duplaga M, Grysztar M, Landi F, et al. Effectiveness of nutritional interventions addressed to elderly persons: umbrella systematic review with meta-analysis. *Eur J Public Health.* (2018) 28:275–83. doi: 10.1093/eurpub/ckx199
107. Toman J, Klímová B, Vališ M. Multidomain lifestyle intervention strategies for the delay of cognitive impairment in healthy aging. *Nutrients.* (2018) 10:1560. doi: 10.3390/nu10101560
108. Schneider N, Yvon C. A review of multidomain interventions to support healthy cognitive ageing. *J Nutr Health Aging.* (2013) 17:252–7. doi: 10.1007/s12603-012-0402-8
109. Ngandu T, Lehtisalo J, Solomon A, Levälahti E, Ahtiluoto S, Antikainen R, et al. A 2 year multidomain intervention of diet, exercise, cognitive training, and vascular risk monitoring versus control to prevent cognitive decline in at-risk elderly people (FINGER): a randomised controlled trial. *Lancet.* (2015) 385:2255–63. doi: 10.1016/S0140-6736(15)60461-5
110. Singh B, Parsaik AK, Mielke MM, Erwin PJ, Knopman DS, Petersen RC, et al. Association of mediterranean diet with mild cognitive impairment and Alzheimer's disease: a systematic review and meta-analysis. *J Alzheimers Dis.* (2014) 39:271–82. doi: 10.3233/JAD-130830
111. Morris MC, Tangney CC, Wang Y, Sacks FM, Bennett DA, Aggarwal NT. MIND diet associated with reduced incidence of Alzheimer's disease. *Alzheimers Dement.* (2015) 11:1007–14. doi: 10.1016/j.jalz.2014.11.009
112. Morris MC, Tangney CC, Wang Y, Sacks FM, Barnes LL, Bennett DA, et al. MIND diet slows cognitive decline with aging. *Alzheimers Dement.* (2015) 11:1015–22. doi: 10.1016/j.jalz.2015.04.011
113. Solfrizzi V, Custodero C, Lozupone M, Imbimbo BP, Valiani V, Agosti P, et al. Relationships of dietary patterns, foods, and micro- and macronutrients with Alzheimer's disease and late-life cognitive disorders: a systematic review. *J Alzheimers Dis.* (2017) 59:815–49. doi: 10.3233/JAD-170248
114. Chen X, Maguire B, Brodaty H, O'Leary F. Dietary patterns and cognitive health in older adults: a systematic review. *J Alzheimers Dis.* (2019) 67:583–619. doi: 10.3233/JAD-180468
115. Bertoli S, Spadafranca A, Bes-Rastrollo M, Martinez-Gonzalez MA, Ponissi V, Beggio V, et al. Adherence to the mediterranean diet is inversely related tobinge eating disorder in patients seeking a weight loss program. *Clin Nutr.* (2015) 34:107–14. doi: 10.1016/j.clnu.2014.02.001
116. Bloom I, Shand C, Cooper C, Robinson S, Baird J. Diet quality and sarcopenia in older adults: a systematic review. *Nutrients.* (2018) 10:308. doi: 10.3390/nu10030308
117. Gomez-Pinilla F. Brain foods: the effects of nutrients on brain function. *Nat Rev Neurosci.* (2008) 9:568–78. doi: 10.1038/nrn2421
118. Campbell NL, Unverzagt F, LaMantia MA, Khan BA, Boustani MA. Risk factors for the progression of mild cognitive impairment to dementia. *Clin Geriatr Med.* (2013) 29:873–93. doi: 10.1016/j.cger.2013.07.009
119. Dinu M, Pagliai G, Casini A, Sofi F. Mediterranean diet and multiple health outcomes: an umbrella review of meta-analyses of observational studies and randomised trials. *Eur J Clin Nutr.* (2018) 72:30–43. doi: 10.1038/ejcn.2017.58
120. Martínez-Lapiscina EH, Clavero P, Toledo E, San Julián B, Sanchez-Tainta A, Corella D, et al. Virgin olive oil supplementation and long-term cognition: the PREDIMED-NAVARRA randomized, trial. *J Nutr Health Aging.* (2013) 17:544–52. doi: 10.1007/s12603-013-0027-6
121. Cipriani G, Carlesi C, Lucetti C, Danti S, Nuti A. Eating Behaviors and Dietary Changes in Patients With Dementia. *Am J Alzheimers Dis Other Demen.* (2016) 31:706–16. doi: 10.1177/1533317516673155
122. Bunn DK, Abdelhamid A, Copley M, Cowap V, Dickinson A, Howe A, et al. Effectiveness of interventions to indirectly support food and drink intake in people with dementia: eating and Drinking Well IN dementiA (EDWINA) systematic review. *BMC Geriatr.* (2016) 16:89. doi: 10.1186/s12877-016-0256-8
123. Abdelhamid A, Bunn D, Copley M, Cowap V, Dickinson A, Gray L, et al. Effectiveness of interventions to directly support food and drink intake in people with dementia: systematic review and meta-analysis. *BMC Geriatr.* (2016) 16:26. doi: 10.1186/s12877-016-0196-3
124. Pivi GAK, Vieira NMdA, da Ponte JB, de Moraes DSC, Bertolucci PHF. Nutritional management for Alzheimer's disease in all stages: mild, moderate, and severe. *Nutrire.* (2017) 42:1. doi: 10.1186/s41110-016-0025-7

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.