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Efficacy of Mealtime Interventions for Malnutrition and Oral Intake in Persons with Dementia: A Systematic Review

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Abstract

Malnutrition and weight loss are highly prevalent in persons with Alzheimer's and related dementias. Oral intake is an important interventional target for addressing these nutritional consequences. However, the efficacy of interventions remains poorly understood as prior syntheses have failed to examine the impact of intervention approaches on malnutrition and hypothesized mechanisms of action in persons with dementia. This review aimed to determine the efficacy of mealtime interventions to improve oral intake and nutritional outcomes in persons with dementia. Four databases yielded 1712 studies, resulting in 32 studies that met inclusion criteria. Studies included education, environmental modifications, feeding, oral supplementation, and other pharmacologic/ecopsychological interventions. While the majority of studies reported statistically significant improvements in at least one nutritional outcome, study design and outcome measures were heterogeneous with many lacking adequate statistical power or blinding. Collectively, we found moderate evidence to suggest the efficacy of oral supplementation, and preliminary evidence to suggest that feeding interventions, education, and environmental modifications may confer improvements. Findings clarify the state of existing evidence regarding various

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interventional strategies for improving malnutrition in persons with dementia. While some approaches are promising, adequately powered and rigorously designed multi-dimensional intervention trials are needed to inform clinical decision-making in real-world contexts.

Keywords

Dementia; Malnutrition; Mealtime; Nutrition; Treatment

INTRODUCTION

Weight loss and malnutrition are highly prevalent in both post-acute and long-term care residents as well as persons with Alzheimer's and related dementias, and are associated with poor functional outcomes, including an increased rate of hospitalizations, falls, cognitive impairment, and dependency with activities of daily living.¹⁻³ Oral intake is an important interventional target for addressing these more distal nutritional consequences, and feasible and efficacious interventions have been identified as a priority for patients, caregivers, and funding agencies.⁴ Determinants of poor oral intake in persons with dementia are multifactorial, and integrated approaches to addressing contributing mechanistic and contextual factors have been proposed in a recent conceptual model that presents core modifiable domains of meal access, meal quality, and the mealtime experience.^{5,6} In addition to these domains, staff, environmental, cultural, and societal characteristics are relevant contextual factors that shape care delivery and eating-related activities.⁶

Patients with dementia encounter many barriers to adequate nutritional intake within each mealtime domain. Cognitive impairments can negatively affect one's ability to participate and engage in physical and psychosocial aspects of the mealtime experience, often requiring feeding assistance and modifications.⁷ For example, impairments in memory, executive functioning, and visual perception can negatively impact one's awareness of the mealtime situation, self-feeding abilities, and visual recognition of food.⁸ Additionally, impairments in cognitive flexibility, attention, and orientation can affect swallowing safety.^{9,10} Furthermore, non-cognitive behavioral symptoms such as verbal or physical aggression and agitation are common during mealtimes¹¹, resulting in decreased consumption¹² and increased rates of aspiration.¹³ Mealtime interventions targeting social interactions, food access, and the mealtime environment have shown promising results in improving these behavioral and psychosocial symptoms in post-acute and long-term care residents.¹⁴

Dysphagia, or swallowing impairment, is also a highly prevalent barrier to adequate and safe oral intake among older nursing home residents and persons with dementia.¹⁵⁻¹⁷ Age-related swallowing dysfunction has been attributed to sarcopenia of pharyngeal musculature^{18,19}, as well as oral and pharyngeal sensory deficits.²⁰⁻²² These difficulties are exacerbated in persons with dementia, worsening with disease progression.²³ Impairments in the efficiency of oral intake during meals commonly results in weight loss, dehydration, and malnutrition.²⁴ Aspiration is also a common adverse sequela, placing persons with dementia at a two-fold increased risk of pneumonia-associated mortality.^{25,26}

Mealtimes interventions often address various determinants of poor nutritional status and have been successfully implemented among post-acute and long-term care populations.²⁷ Readily available syntheses of the efficacy of various mealtimes interventions in dementia populations are lacking. Furthermore, existing evidence summaries are outdated and have not attempted to delineate specific mechanistic and modifiable environmental and caregiving factors that are specific to dementia, limiting the evidence-base for informing clinical management of these patients in post-acute and long-term care settings. Furthermore, prior syntheses of existing evidence have failed to provide conclusive evidence regarding the impact of intervention approaches on malnutrition, features of interventional strategies, intervention doses, or hypothesized mechanisms of action in persons with dementia.^{14,27–31}

The efficacy of specific interventional strategies for improving oral intake and nutritional outcomes in individuals with dementia remains poorly understood due to heterogeneity in approaches and outcomes. To address this gap, the current paper reports findings from a systematic review designed to identify, synthesize, and critically appraise existing evidence surrounding the efficacy of mealtimes interventions to improve nutritional outcomes in persons with dementia.

METHODS

Overview

The objective of this systematic review was to determine the efficacy of mealtimes interventions in improving malnutrition and oral intake in persons with dementia. We initially attempted to identify articles for a homogenous dementia population to draw stronger inferences; however, upon reviewing the literature, it was clear that a broader approach was necessary due to multiple criteria for defining Alzheimer's and related dementias.³² Thus, broad inclusion criteria was established regarding dementia subtypes, study setting, and types of nutritional outcomes to allow for a variety of study interventions and designs in order to comprehensively assess existing evidence and inform clinical practice. The goal of the review was to examine the efficacy of interventions specifically in persons with Alzheimer's and related dementias; thus, known studies that examined mealtimes interventions in heterogeneous post-acute or long-term care cohorts without a specific emphasis on dementia were excluded.^{33–35}

Search Strategy

Methodological standards established by the Cochrane Collaborative³⁶ were followed in determining a prior search strategy, study selection procedures, data extraction, and synthesis approach. Four databases were searched (PubMed, Scopus, CINAHL, and CENTRAL) from inception to March 2019 using terms developed by two authors (SB & NRP) and a librarian (SJ) in order to capture all articles related to mealtimes interventions, malnutrition, and dementia (For MeSH terms, see Supplementary Table 1). The search strategy did not include dissertations or grey literature. A manual search of reference lists was performed on articles meeting inclusion.

Inclusion and Exclusion Criteria

Full-text articles were included if they reported on mealtime interventions and its effect on at least one nutritional outcome in persons with dementia. Dementia was broadly defined to include the following subtypes: Alzheimer's disease, Lewy body dementia, Vascular dementia, Parkinson's dementia, Frontotemporal dementia, Huntington's disease, mixed dementia, and Creutzfeldt-Jakob disease. Inclusion criteria for articles were the following: 1) persons with dementia; and 2) the outcome(s) for the study were objective measures of nutritional status and/or oral intake. No requirement was established regarding the methodology of diagnosing dementia, which could include a documented diagnosis in the medical chart. Exclusion criteria for articles were the following: 1) studies with a focus on end of life care; 2) qualitative methods/analyses; 3) geriatric populations without dementia, 4) enteral interventions and 5) non-English articles.

Data Extraction

Results from each database search were imported into EndNote software, where duplicate papers were removed. Two authors (JCB and SB) independently screened articles for potential inclusion based on titles and abstracts, assessed the eligibility of full-text articles, extracted relevant variables from articles meeting full-text inclusion, and performed quality assessments outlined below. A third author (NRP) resolved all disagreements that occurred in the screening, full-text review, extraction, or quality assessment process. The following information was extracted from articles meeting final inclusion: author, year, sample size, study design, study setting, type and severity of dementia, criteria to define dementia and cognition, age, gender, type of mealtime intervention, type of swallowing evaluation, nutritional outcome, and statistical and power analysis.

Assessment of Study Quality

All studies were reviewed through duplicate independent review using the Cochrane Risk of Bias Assessment Tool to appraise study quality.³⁷ Criteria for quality assessment as outlined by Cochrane includes sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete data, and selective outcome reporting. Studies were appraised as either high, low, or unclear risk of bias.

RESULTS

Study Characteristics

The database search yielded 1,712 distinct articles. Thirty-two studies were determined to meet criteria. Thirty articles were retrieved directly from database searches^{38–67} and two were identified through manual search of citations^{68,69} (Fig. 1). Characteristics of study interventions, outcome measures, and results are detailed in Table 1. All but one study employed a prospective design, including 14 randomized controlled trials (Table 2). Sample size ranged from 6 to 1912 patients, and power analyses were reported in 8 studies. Given broad variation in interventions and outcomes, as well as a small number of studies in certain categories, a meta-analysis was conceptually and statistically infeasible.

Patient Characteristics

The majority of studies examined persons with Alzheimer's disease.^{44,46–48,52,54–58,60,62,63,65–68} Studies predominantly relied on the Mini-Mental State Exam (MMSE)^{42,44,47,49,50,58,65,66} and the Diagnostic and Statistical Manual of Mental Disorders (DSM)^{43,53,57–59} for diagnosis of dementia. Additional diagnostic criteria, dementia diagnoses, and measures of cognition across studies are detailed in Table 3.

Assessment of Dysphagia

Twenty-three studies (66%) did not specify whether participants had clinical signs or a diagnosis of dysphagia.^{41,42,44–51,53–56,60,61,64,66–69} One study included a subset of individuals with dysphagia, but did not report diagnostic criteria.⁶⁵ Seven studies excluded participants with dysphagia, defined as requiring modified food and liquids^{38,52,62,63} or speech pathology services³⁹. Two studies excluded persons with dysphagia but did not specify operational definitions.^{40,59} Four studies excluded individuals with enteral or parental nutritional requirements.^{43,57,58} Riley and colleagues⁵⁵ reported that a nutritional supplement reduced choking in one patient, whereas another patient did not exhibit improvements in the frequency of asphyxiation.

Nutritional Outcome Measurements

Twenty-nine studies (91%) considered oral intake or nutritional status as a primary study outcome^{38–40,42–48,50–57,59–69}, as opposed to a secondary outcome.^{41,49,58} In studies examining nutritional status as a secondary outcome, primary outcomes included knowledge and behaviors of nursing assistants⁴¹, feeding ability⁴⁹, and the functional level of residents.⁵⁸ There was significant heterogeneity in nutritional outcomes across studies, as twenty-three studies (72%) included multiple nutritional outcomes. These included weight^{42–45,48,49,51,53,55–60,64,66,69}, body mass index (BMI)^{43,45–51,53,54,58–64,66}, blood assays^{43,45,46,48,53–55,57,59,60}, body composition assessments^{43,45,46,48,53,54}, oral intake^{38–41,44,48,49,51,52,54,60,62,63,65,67,68}, the mini nutritional assessment (MNA)^{43,46,48–50,56–61}, and vitamin levels determined through blood assays.^{43,45,46,54,57,59,60}

Mealtime Interventions

Mealtime interventions were classified into one of five categories: feeding interventions, environmental modifications, oral supplementation, education of patient, family, and staff, and other pharmacologic/ecopsychological interventions (Table 4). One study⁵³ separately assessed two intervention types (oral supplementation, education) and was included in both categories.

Patient, Caregiver, and Staff Education: Five studies examined the efficacy of patient^{53,58}, caregiver^{53,56,58}, and staff^{39,41,58} education. The hypothesized mechanisms of action for these studies were related to increased knowledge and self-efficacy of patients, caregivers, or staff with education^{39,41,53,58}, whereas one study targeted caregiver stress reduction.⁵⁶ Improvements were evident in weight^{53,56}, blood assays⁵³, and self-report measures^{56,58}, but not in body composition outcomes.⁵³ Batchelor-Murphy et al.³⁹

documented beneficial trends in oral intake, but did not perform statistical analyses due to low sample size. Intervention duration ranged from a forty-five minute session³⁹ to nine sessions across twelve months.⁵⁶ Two studies included patients with Alzheimer's dementia^{56,58}, whereas three studies did not specify dementia subtype.^{39,41,53}

Environmental Modifications: Four studies examined the efficacy of environmental modifications, including the introduction of music⁶⁷ or an aquarium during mealtime⁴⁴ to reduce behavioral symptoms, manipulating the visual contrast of cups and plates to improve the perceptual salience and discrimination of tableware⁶⁸, and olfactory priming targeting non-conscious memory processes to stimulate appetite.⁶⁵ Variability in hypothesized mechanisms of action was evident, including enhanced visual discrimination⁶⁸, a calming environment targeting agitation reduction^{44,67}, and increased food-related mental representations targeting appetite stimulation.⁶⁵ Three studies reported oral intake^{44,67,68} and two examined weight.^{44,65} Improvements in both outcomes were evident across all studies, though Thomas & Smith⁶⁷ only reported mean trends and did not perform statistical analyses. Intervention duration ranged from four consecutive meals⁶⁵ to eight weeks with a three month follow-up.⁴⁴ All studies included patients with a diagnosis of Alzheimer's dementia.

Feeding Interventions: Six studies examined feeding interventions, including hand-over-hand feeding techniques⁴⁰, altering consumption methods of liquids with either a glass or straw³⁸, shared mealtime with staff and residents⁴², and Montessori-based feeding activities with^{49,61} or without spaced retrieval⁵⁰. Hypothesized mechanisms of action included increased compliance due to ease of consumption method³⁸, increased patient autonomy during feeding⁴⁰, increased mealtime interactions⁴², and targeting repetition priming and procedural memory during feeding.^{49,50,61} Four studies examined weight^{42,49,50,61}, and three studies reported oral intake^{38,40,49} and/or self-report measures.^{49,50,61} Improvements were evident in two studies reporting weight^{42,61}, two studies examining self-report measures^{49,61}, and two studies on oral intake^{38,49}. Intervention duration ranged from one week³⁸ to six months⁴², and implementation of feeding strategies ranged from every meal³⁸ to three times per week.^{49,50} Dementia subtype was unspecified across all studies.

Oral Supplementation: Fifteen studies examined oral nutritional supplementation, specifically oral supplementation with^{45,60} or without^{43,46–48,51–55,62,63,69} staff education, or a whole formula diet.⁵⁷ All studies examined weight as a primary outcome and improvements were reported in eight studies^{43,45,47,48,52,53,57,69}. Hypothesized mechanisms of action were largely multi-factorial including disease-related metabolic alterations^{46,48}, neuroplasticity^{47,54,70}, and appetite regulation.^{52,62} The majority of studies reported improvements in oral intake^{48,52,60,62,63,70}, blood assays^{43,46,48,53,55,57,60}, and body composition outcomes.^{43,45,46,48,53} Six studies included self-report measures, two of which reported statistically significant improvements.^{43,48} Average intervention duration lasted 174 days, ranging from 21^{43,52,62,63} to 630 days.⁶⁹ The majority of studies included individuals with Alzheimer's dementia^{46–48,52,54,55,57,62,63,70}, whereas one study also included Parkinson's dementia, multi-infarct, and Korsakoff syndrome⁶⁹, and two studies did not specify dementia subtype.^{43,53}

Other Pharmacologic/Ecopsychological Interventions: Three studies described pharmacologic and ecopsychological interventions that did not fit into the aforementioned categories. Interventions included acetylcholinesterase inhibitor therapy⁵⁹, music therapy⁶⁶, and a comprehensive preventative care model involving various intervention components such as nutritional supplements, weight control, eating support, medication review, oral health care, patient education, parenteral and nutritional support, and end of life care.⁶⁴ Johansson and Christensson⁶⁴ found improvements in body weight for patients who completed each step of an interdisciplinary and individualized preventative care process. McHugh and colleagues⁶⁶ found no differences in oral intake between patients receiving vocal re-creative music therapy four times a week for three weeks compared to control patients. After 6 months, Soysal and Isik⁵⁹ demonstrated improvements in some blood assay outcomes following acetylcholinesterase inhibitor therapy, but none were seen in weight, BMI, or self-report.

Assessment of Study Quality

According to criteria outlined in the Cochrane handbook³⁷, most studies demonstrated high risk of bias due to blinding of either the participant (n = 21, 66%) or outcome measure (n = 25, 78%). Detailed risk of bias ratings is provided in Table 2.

DISCUSSION

In this comprehensive systematic review, we identified 32 articles examining various mealtime interventions to improve oral intake and nutritional outcomes in persons with dementia. Results revealed five broad categories: education, environmental modifications, feeding, oral supplementation, and other pharmacologic/ecopsychological interventions which were commonly comprised of pharmacotherapy, music therapy, or multi-factorial interventions involving several components of the aforementioned categories (e.g. feeding, education, oral supplementation). Though heterogenous with regard to study design, nutritional outcomes, and length of intervention, there is some evidence to suggest that these mealtime interventions are efficacious in improving malnutrition or oral intake in persons with dementia. The majority (n = 27, 84%) of studies reported a statistically significant improvement with at least one nutritional outcome. Among studies examining two or more nutritional outcomes (n = 23), 17 (74%) reported improvements in at least two outcomes and 8 (35%) in three or more outcomes.

Studies included a wide range of nutritional outcomes to define and quantify changes in malnutrition, including weight loss, oral intake, blood assays, and body composition assessments. A recent consensus report by the Global Leadership Initiative on Malnutrition recommended at least one phenotypic (e.g. weight loss, low body mass index, reduced muscle mass) and one etiologic criteria (e.g. reduced food intake, inflammation or disease burden) to diagnose malnutrition.⁷¹ Nineteen (59%) studies included outcomes that adhere to this recommendation. Dehydration, a common fluid and electrolyte disorder among post-acute and long-term care residents⁷², was rarely examined across included studies and primarily included measures of liquid intake^{38,68} and relevant blood assays, such as hemoglobin.^{45,57,59} Our search terms did not include dehydration, which is a type of

malnutrition that has been shown to affect persons with dementia. As a result, this may have excluded relevant studies.

There is moderate evidence to suggest that oral supplementation is efficacious in improving malnutrition in persons with dementia. This included three randomized controlled trials, though some degree of bias was evident in each study. All but one study showed improvements in at least one nutritional outcome. The effects of oral supplementation were most evident in weight and blood assay outcomes though the efficacy of oral supplementation likely varies as a function of many different factors including dementia subtype, disease severity, and psychosocial support. Despite these promising results, it is difficult to further assess related factors when prescribing oral supplementation given significant heterogeneity in the type and dosage of supplements, as well as the duration of supplementation. Future studies will be required to systematically examine the relative effects of these patient and intervention-related variables.

There appears to be preliminary evidence to suggest that some interventions targeting feeding, environmental modifications, and caregiver education demonstrate improvements in malnutrition and oral intake. Four of the six studies examining feeding interventions reported improvements in at least one nutritional outcome, most notably with oral intake. Feeding interventions such as shared mealtimes⁴², consumption of liquids in a glass³⁸, and spaced retrieval combined with Montessori-based activities^{49,61} demonstrated promising preliminary benefits on nutritional status. Improvements in weight and oral intake were evident across all four studies addressing environmental modifications during the mealtime; however, the small number of studies with heterogeneous designs and small sample sizes warrants caution when interpreting and aggregating these results. Patient, family, or staff education alone appears to improve self-report of nutritional status, whereas outcomes of weight and oral intake showed mixed results. Interestingly, the only studies reporting improvements in objective nutritional outcomes provided education on both nutritional supplementation and management of behavioral symptoms during meals.^{53,56}

Though the aforementioned intervention categories provide varying levels of evidence from diverse disciplines, such as nursing, nutrition, and speech pathology, a lack of interdisciplinary interventions addressing multiple mealtime domains was apparent. Only three studies included in this review examined interventions that integrated multiple domains of the mealtime experience.^{45,60,64} A Swedish national preventative care program incorporated nutritional supplementation, weight control, eating support, medication review, oral health, nutritional education, and end-of-life care⁶⁴, and two studies integrated both oral supplementation and nutrition education.^{45,60} Though studies involving multiple domains are unable to elucidate the efficacy of domain-specific interventions, their ease of translation to clinical practice is greatly needed in this area of research.

This review identified several areas of improvement across studies that might inform future research. In order for findings to generalize to clinical practice, studies must diagnose and characterize dementia subtypes. Inadequate diagnostic methods were commonly employed, such as the MMSE, DSM, or medical charts, which alone are insufficient in diagnosing and characterizing dementia. For example, performing structural imaging, such as computed

tomography or magnetic resonance imaging, and a comprehensive neuropsychological assessment is well supported by best-practice guidelines^{73,74}. Thus, the external validity of included articles in this review is a limitation and prohibited examining the efficacy of interventions across different dementia subtypes or severities. In order to better elucidate the impact of interventions across the broad spectrum of Alzheimer's and related dementias and identify potential modifiers of effectiveness, comprehensive and valid diagnostic assessments are required. Future studies must also appropriately evaluate and characterize swallowing impairments in this patient population when assessing the efficacy of a nutritional intervention. Dysphagia, often characterized by tongue weakness in this population, is highly correlated with both malnutrition and longer mealtime durations in residents of long-term care facilities.⁷⁵ Furthermore, studies should incorporate instrumental swallowing evaluations, such as videofluoroscopic swallow studies or flexible endoscopic evaluations of swallowing, since bedside evaluations have not demonstrated adequate sensitivity for dysphagia detection.⁷⁶

There are several limitations of this systematic review that should be acknowledged. Since our review focused solely on articles in English, we might have missed articles in other languages. Additionally, improvements in study outcomes was based solely on statistical significance. Studies that were underpowered and reported non-significant results might have been susceptible to commit a type two error. Furthermore, direct comparisons between studies via meta-analysis was infeasible due to significant heterogeneity in study outcomes.

Malnutrition is prevalent among persons with dementia with known detrimental effects on health outcomes. Individual studies in this review contain varying levels of evidence to suggest that interventions targeting aspects of the mealtime experience can improve nutritional outcomes in this patient population. Patients, caregivers, clinicians, and stakeholders can integrate this preliminary evidence into clinical practice. However, future large-scale, adequately powered interdisciplinary studies will be required to examine pragmatic interventions spanning multiple domains of the mealtime experience. These studies are needed to provide further guidance and evidence regarding the feasibility and efficacy of mealtime interventions across various disease stages and co-morbid conditions, which are insufficiently characterized in the existing literature.

CONCLUSION

This review evaluated the efficacy of mealtime interventions to improve malnutrition or oral intake in persons with dementia. We found moderate evidence to suggest the efficacy of oral supplementation to improve nutritional outcomes, though future studies are required to better understand the optimal dosage, duration of supplementation, and effect modifiers on dementia subtypes and severities. There is preliminary evidence to suggest that some interventions targeting feeding, environmental modifications, and education might demonstrate improvements in malnutrition and oral intake. Findings from this review serve as a concise summary of the state of the literature for both clinicians and researchers. Future interdisciplinary studies are paramount to addressing the impact of malnutrition in persons with dementia and understanding the efficacy of pragmatic mealtime interventions.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Study characteristics and results

Table 1:

Author	Year	Type of Intervention(s)	Comparator	Hypothesized Mechanism of Action	Duration	Setting	Nutritional Outcome	Statistical Significance
Education (n = 5)								
Batchelor-Murphy et al.	2015	Web-based staff feeding skills training	Usual care	Increased knowledge and self-efficacy of staff feeding	45 minutes (follow-up: 8 weeks)	Nursing home	Meal intake	Not reported
Chang & Lin	2005	Staff feeding skills training program	Usual care	Increased knowledge, attitudes, and quality of staff feeding	2 days	Nursing home	Food intake	No
Pivi et al.	2011	Patient, caregiver, and staff education	Usual care; Nutritional supplement	Increased knowledge of nutritional interventions with disease progression	Education: 10 classes; Oral supplementation: 6 months	Hospital	BMI	Yes
							Weight	No
							Arm circumference	Yes
							Arm muscle circumference	Yes
							Tricep skinfold thickness	No
							Serum albumin	No
							Total protein	Yes
							Total lymphocyte	Yes
Riviere et al.	2001	Caregiver nutrition education program	Usual care	Caregiver stress reduction	9 sessions across 12 months	Day Center	Weight	Yes
Salva et al.	2011	Staff, caregiver, and patient nutrition education program	Usual care	Increased knowledge of nutritional interventions	4 sessions (follow-up: 12 months)	Home	MNA	Yes
							MNA	Yes
							BMI	No
							Weight	No
Environmental Modifications (n = 4)								
Dunne et al.	2004	High contrast (red) plates and cups	Low contrast (white) plates and cups	Enhanced mealtime visual discrimination	10 days (follow-up: 20 days)	Nursing home	Food intake	Yes
							Liquid intake	Yes

Author	Year	Type of Intervention(s)	Comparator	Hypothesized Mechanism of Action	Duration	Setting	Nutritional Outcome	Statistical Significance
Edwards & Beck	2013	Aquarium during mealtime	Routine mealtime	Calming mealtime environment targeting agitation reduction	8 weeks (follow-up: 3 months)	Nursing home	Food intake	Yes
Sulmont-Rosse et al.	2018	Olfactory priming with a meat odor	N/A	Increased food-related mental representations and appetite stimulation	4 consecutive meals	Nursing home	Weight Food intake	Yes Yes
Thomas & Smith	2009	Music during mealtimes	Usual care	Calming mealtime environment targeting agitation reduction	4 weeks	Unclear	Total caloric intake	Not reported
Feeding (n = 6)								
Allen et al.	2014	Glass without a straw	Glass with a straw	Increased compliance due to ease of consumption method	1 week, 3 times per day on alternating days	Hospital	Liquid intake	Yes
Batchelor-Murphy et al.	2017	Direct, under or over handfeeding technique	N/A	Patient autonomy and behavioral disturbance reduction	6 meals, changing technique every 2 days	Nursing home	Energy & protein intake Meal intake	No No
Charras & Fremontier	2010	Shared mealtime between staff and residents	Usual care	Culturally traditional mealtime interactions	6 months	Nursing home	Weight	Yes
Lin et al.	2010	Montessori-based or spaced retrieval feeding intervention	Routine activities	Enhanced procedural memory, learning, and retention	8 weeks (3 sessions per week)	Nursing home	MNA	Yes
							BMI	No
							Weight	No
							Food intake	Yes
Lin et al.	2011	Montessori feeding intervention	Routine activities	Enhanced procedural memory and learning	8 weeks (3 sessions per week)	Nursing home	MNA	No
							BMI	No
Wu & Lin	2013	Individualized or fixed spaced retrieval combined with Montessori activities	Routine activities	Enhanced procedural memory and learning	8 weeks (follow-up: 6 months)	Hospital	MNA	Yes
Oral Supplementation (n = 13)								
Gregorio et al.	2003	Nutritional supplement	Usual care	Supplementation for disease-related metabolic	12 months	Nursing home	Albumin	No

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Author	Year	Type of Intervention(s)	Comparator	Hypothesized Mechanism of Action	Duration	Setting	Nutritional Outcome	Statistical Significance
Keller et al.	2003	Enhanced dietitian time and menu	Usual care	Personalized attention to dietary needs with disease progression	21 months	Nursing home	Energy intake	Yes
							Protein intake	Yes
							Weight	Yes
Lauque et al.	2004	Nutritional supplement	Usual care	Supplementation targeting metabolic disturbances	3 months (follow-up: 6 months)	Day center	Weight	Yes
							BMI	Yes
							MNA	Yes
							Albumin	No
							C-reactive protein	No
							Total fat-free mass	Yes
							Appendicular fat free mass	Yes
							Energy intake	Yes
Navratilova et al.	2007	Nutritional supplement	Usual care	Supplementation targeting muscle mass and neuroplasticity	12 months	Unclear	Protein intake	Yes
							BMI	No
							Weight	No
							Energy intake	Yes
							Carbohydrate intake	Yes
Parrott et al.	2006	Nutritional supplement	N/A	Increased energy intake due to blunting of long-term appetite signals	3 weeks	Nursing home	Food intake	Yes
							Protein intake	Yes
							Energy intake	Yes
							BMI	Yes
							BMI	Yes
Pivi et al.	2011	Nutritional supplement	Usual care; Caregiver and staff education	Supplementation targeting biochemical parameters and immune status	Oral supplementation: 6 months Nutrition education: 10 classes	Hospital	Weight	Yes
							Arm circumference	Yes
							Arm muscle circumference	Yes

Author	Year	Type of Intervention(s)	Comparator	Hypothesized Mechanism of Action	Duration	Setting	Nutritional Outcome	Statistical Significance
Planas et al.	2004	Nutritional supplement with micronutrients	Nutritional supplement without micronutrients	Reduction of inflammatory and oxidative stress processes, and cognitive decline	6 months	Day center	Tricep skinfold thickness	No
							Serum albumin	No
							Total protein	Yes
							Total lymphocyte	Yes
							Energy intake	No
Riley & Volicer	1990	High-calorie nutritional supplement	Usual care nutritional supplement	Supplementation to maintain nutritional status	35 days	Nursing home	BMI	No
							Tricep skinfold thickness	No
							Mid-upper-arm circumference	No
							Albumin	No
							Cholesterol	No
							HDL-Cholesterol	No
							LDL-Cholesterol	No
							Magnesium	No
							Pre-albumin	No
							Selenium	No
							Vitamin E	No
							Zinc	No
							Weight	No
Salas-Salvado et al.	2005	Whole formula diet	Usual care	Supplementation targeting energy intake	3 months	Unclear	Albumin	Yes
							Lymphocytes	No
							Transferrin	No
							Weight	Yes
							MNA	No
							C-reactive protein	No
							Cholesterol	No

Author	Year	Type of Intervention(s)	Comparator	Hypothesized Mechanism of Action	Duration	Setting	Nutritional Outcome	Statistical Significance
Sousa & Amaral	2012	Nutritional supplement	Usual care	Supplementation targeting energy intake	21 days	Erythrocyte sedimentation rate	No	
						Ferritin	Yes	
						Folic acid	No	
						Glucose	No	
						Hemoglobin	Yes	
						Lymphocytes	No	
						Pre-albumin	No	
						Serum albumin	Yes	
						Triglycerides	No	
						Vitamin B12	No	
Young et al.	2004	Nutritional supplement	N/A	Supplementation targeting appetite regulation	21 days	Hospital	MNA	Yes
							BMI	Yes
							Weight	Yes
							Arm muscle circumference	Yes
							Tricep skinfold thickness	Yes
							Folic acid	No
							Serum albumin	Yes
							Total protein	Yes
							Total cholesterol	Yes
							Vitamin B12	No
Young et al.	2005	High carbohydrate dinner	Usual care with a mid-morning supplement	Supplementation targeting impaired olfaction, increased carbohydrate	21 days	Nursing home	BMI	No
							Carbohydrate intake	Yes
							Food intake	Yes

Author	Year	Type of Intervention(s)	Comparator	Hypothesized Mechanism of Action	Duration	Setting	Nutritional Outcome	Statistical Significance
food preferences, behavioral disturbances, and changes in food intake patterns								
Oral Supplementation & Education (n = 2)								
Faxen-Irving et al.	2002	Staff feeding education and nutritional supplementation	Usual care	Supplementation and education targeting staff feeding skills, and cognitive function	5 months (follow-up: 6 months)	Nursing home	BMI	Yes
Suominen et al.	2015	Patient and caregiver nutrition education and nutritional supplementation	Usual care	Personalized nutritional education and supplementation to improve patient/caregiver knowledge, oral intake, and quality of life	12 months	Home	Weight	Yes
							Arm muscle circumference	No
							Tricep skinfold thickness	Yes
							Hemoglobin	No
							Insulin-like growth factor	No
							Serum albumin	No
							Serum c-reactive protein	No
							Vitamin B12	No
							MNA	No
							BMI	No
							Weight	No
							Protein intake	Yes
							Calcium	Yes
							Fiber	No
							Folic acid	No
							Iron	No
							Total protein	No
							Vitamin C	No
							Vitamin E	No
							Vitamin B12	No

Author	Year	Type of Intervention(s)	Comparator	Hypothesized Mechanism of Action	Duration	Setting	Nutritional Outcome	Statistical Significance
Other Pharmacologic/Ecopsychological (n = 3)								
Johansson & Christensson	2017	Preventative care program	N/A	Interdisciplinary and individualized preventative care	Not reported	Home and Nursing Home	BMI Weight	Yes Yes
McHugh et al.	2012	Pre-meal vocal re-creative music therapy	Usual care	Behavioral symptom reduction and increased mealtime engagement	3 weeks (4 sessions per week)	Nursing home	Food intake	Not reported
Soysal & Isik	2016	Acetylcholinesterase inhibitor therapy	N/A	Reduction in cognitive dysfunction with disease progression	6 months	Hospital	BMI	No
							Weight	No
							MNA	No
							Albumin	No
							C-reactive protein	Yes
							Creatinine	Yes
							Folic acid	No
							Free T3	No
							Free T4	No
							HDL-Cholesterol	Yes
							Hemoglobin	No
							LDL-Cholesterol	No
							Thyroid-Stimulating Hormone	No
							Total cholesterol	No
							Vitamin B12	No

BMI = body mass index; MNA = mini nutritional assessment; N/A = not applicable; HDL-Cholesterol = High-density lipoprotein cholesterol; LDL-Cholesterol = Low-density lipoprotein cholesterol

Quality assessment

Table 2.

Author	Year	Sample Size	Sequence Generation	Allocation Concealment	Blinding of Participants	Blinding of Outcome	Incomplete Outcome Data	Selective Reporting	Power Analysis	Study Design	Mean Age	Gender (% male)
Allen et al.	2014	45	–	–	+	+	–	–	Yes	RCT	87	78%
Batchelor-Murphy et al.	2015	35	–	–	+	–	–	–	No	Prospective cohort, randomized sites	NR	NR
Batchelor-Murphy et al.	2017	30	–	?	+	+	–	–	No	Prospective, randomized within-subject	89	10%
Chang et al.	2005	20	–	?	+	?	–	–	No	Prospective cohort, randomized sites	78	NR
Charras et al.	2010	18	N/A	N/A	+	+	–	–	No	Prospective cohort	86	NR
Dunne et al.	2004	9	N/A	N/A	+	+	–	–	No	Prospective, within-subject repeated measures	83	NR
Edwards et al.	2013	70	N/A	N/A	+	+	–	–	No	Prospective, within-subject repeated measures	82	26%
Faxen-Irving et al.	2002	33	N/A	N/A	+	+	–	–	No	Prospective, non-randomized, un-blinded	84	11%
Gregorio et al.	2003	99	?	?	+	+	–	–	No	RCT	87	20%
Johansson et al.	2017	1912	N/A	N/A	–	–	+	+	No	Prospective within-subject longitudinal	83	38%
Kamphuis et al.	2011	225	–	–	–	–	–	–	No	RCT	74	50%
Keller et al.	2003	83	N/A	N/A	+	+	–	–	No	Prospective, cohort, non-randomized	72	35%
Lauque et al.	2004	91	–	–	+	+	–	–	Yes	RCT	79	NR
Lin et al.	2010	82	?	?	+	?	–	–	No	Prospective, sites randomized, single blinded	81	47%
Lin et al.	2011	29	?	?	+	–	–	–	No	Prospective, crossover design	83	59%

Author	Year	Sample Size	Sequence Generation	Allocation Concealment	Blinding of Participants	Blinding of Outcome	Incomplete Outcome Data	Selective Reporting	Power Analysis	Study Design	Mean Age	Gender (% male)
McHugh et al.	2012	15	?	?	+	+	+	–	No	Prospective cohort randomized	81	20%
Navratilova et al.	2007	100	?	?	+	+	–	–	No	Prospective, randomized	NR	NR
Parrott et al.	2006	30	–	–	–	+	–	–	Yes	Prospective, randomized, crossover, non-blinded	88	NR
Pivi et al.	2011	78	?	?	–	+	–	–	No	Prospective cohort randomized	75	32%
Planas et al.	2004	44	?	?	–	–	–	–	No	Prospective, randomized, double-blind	75	45%
Riley et al.	1990	13	?	?	–	+	–	–	No	Prospective, randomized	NR	NR
Riviere et al.	2001	225	N/A	N/A	–	+	–	–	No	Prospective, non-randomized convenience sample	77	23%
Salas-Salvado et al.	2005	53	?	–	–	+	–	–	No	Prospective, randomized cohort	85	17%
Salva et al.	2011	946	?	?	–	+	–	–	Yes	Prospective cohort, non-randomized	79	61%
Sousa et al.	2012	35	?	?	–	+	–	–	No	Prospective, randomized, non-blinded	79	26%
Soysal et al.	2016	116	N/A	N/A	+	+	–	–	No	Retrospective	78	44%
Sulmont-Rosse et al.	2018	32	+	?	–	–	–	–	No	Prospective, randomized within-subject	86	22%
Suominen et al.	2015	78	–	?	+	+	–	–	Yes	RCT	78	51%
Thomas et al.	2009	12	N/A	N/A	+	+	–	–	No	Prospective, time-series crossover design	84	8%
Wu et al.	2013	90	N/A	N/A	+	–	–	–	Yes	Prospective, non-randomized, single blind, repeated measures	83	100%

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Author	Year	Sample Size	Sequence Generation	Allocation Concealment	Blinding of Participants	Blinding of Outcome	Incomplete Outcome Data	Selective Reporting	Power Analysis	Study Design	Mean Age	Gender (% male)
Young et al.	2004	34	–	–	+	+	–	–	Yes	Prospective, randomized, crossover, non-blinded	88	21%
Young et al.	2005	34	–	–	+	+	–	–	Yes	Prospective, randomized, crossover, non-blinded	88	21%

+ High risk of bias
– Low risk of bias
? Unable to determine risk of bias
N/A Not applicable
NR Not reported

Table 3.

Study characteristics of dementia subtype and cognition

Author	Year	Dementia Assessment	Dementia Subtype	Cognitive Assessment	Cognitive Severity
Allen et al.	2014	NR	Unspecified [*]	MMSE	Moderate
Batchelor-Murphy et al.	2015	Medical record	Unspecified	MMSE	Mild to severe
Batchelor-Murphy et al.	2017	BIMS	Unspecified	NR	Moderate to severe
Chang & Lin	2005	NR	Unspecified	NR	NR
Charras & Fremontier	2010	NR	Unspecified	MMSE	Severe
Dunne et al.	2004	NR	Alzheimer's	MMSE	Severe
Edwards & Beck	2013	MMSE	Alzheimer's	NR	NR
Faxen-Irving et al.	2002	NR	Varied [†]	MMSE	Severe
Gregorio et al.	2003	NINCDS-ADRD, FAST	Alzheimer's		Moderate to severe
		FAST			
Johansson & Christensson	2017	NR	Varied [‡]	MMSE	Mild
Kamphuis et al.	2011	MMSE	Alzheimer's	MMSE	Mild
Keller et al.	2003	Physician	Varied [§]	MMSE	Severe
Laque et al.	2004	NINCDS-ADRD	Alzheimer's	MMSE	Moderate
Lin et al.	2010	MMSE	Unspecified	MMSE	Mild to moderate
Lin et al.	2011	MMSE	Unspecified	MMSE	Moderate
McHugh et al.	2012	MMSE	Alzheimer's	MMSE	Moderate
Navratilova et al.	2007	ICD-10	Alzheimer's	MMSE	Not reported
Parrott et al.	2006	NR	Alzheimer's	GDS	Moderate
Pivi et al.	2011	DSM-IV	Unspecified	MMSE	Moderate
				CDR	Mild to severe
Planas et al.	2004	NINCDS-ADRD	Alzheimer's	GDS	Moderate
Riley & Volicer	1990	NR	Alzheimer's	NR	NR
Riviere et al.	2001	GDS	Alzheimer's	GDS	Very mild to moderately severe
Salas-Salvado et al.	2005	DSM-IV	Alzheimer's	GDS	Moderately severe to severe
Salva et al.	2011	DSM-IV	Alzheimer's	MMSE	Normal to severe

Author	Year	Dementia Assessment	Dementia Subtype	Cognitive Assessment	Cognitive Severity
		MMSE			
Sousa & Amaral	2012	DSM-IV	Unspecified	MMSE	Moderate
Soysal & Isik	2016	DSM-IV	Varied //	MMSE	Mild
Sulmont-Rosse et al.	2018	MRI	Alzheimer's	MMSE	Severe
Suominen et al.	2015	NINCDS-ADDA	Alzheimer's	MMSE	Mild
Thomas & Smith	2009	GDS	Alzheimer's	GDS	Moderate to severe
Wu & Lin	2013	NR	Unspecified	MMSE	Mild to severe
Young et al.	2004	NR	Alzheimer's	GDS	Moderate
Young et al.	2005	NR	Alzheimer's	GDS	Moderate

MMSE = mini mental state exam; NR = not reported; BIMS = brief interview for mental status; FAST = functional assessment staging; NINCDS-ADDA = National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer's disease and Related Disorders Association; CDR = clinical dementia rating; GDS = global deterioration scale; MRI = magnetic resonance imaging

* included mild cognitive impairment

† Alzheimer's disease, vascular, and unspecified

‡ Alzheimer's disease, vascular dementia, disease-related, alcohol-related, and unspecified

§ Alzheimer's disease, multi-infarct, Parkinson's disease, and korsakoff syndrome

// Alzheimer's disease, lewy body dementia, vascular dementia, and corticobasal degeneration

Table 4.

Aggregated study results by intervention type

	Year	Weight	Oral Intake	Blood Assays	Body Composition	Self-Report
Education (n = 5)						
Batchelor-Murphy et al.	2015	—	NR ⁺	—	—	—
Chang & Lin	2005	—	→	—	—	—
Pivi et al.	2011	↑	—	↑	→	—
Riviere et al.	2001	↑	—	—	—	↑
Salva et al.	2011	→	—	—	—	↑
Environmental Modifications (n = 4)						
Dunne et al.	2004	—	↑	—	—	—
Edwards & Beck	2013	↑	↑	—	—	—
Sulmont-Rosse et al.	2018	↑	—	—	—	—
Thomas & Smith	2009	—	NR ⁺	—	—	—
Feeding (n = 6)						
Allen et al.	2014	—	↑	—	—	—
Batchelor-Murphy et al.	2017	—	→	—	—	—
Charras & Fremontier	2010	↑	—	—	—	—
Lin et al.	2010	→	↑	—	—	↑
Lin et al.	2011	→	—	—	—	↑
Wu & Lin	2013	↑	—	—	—	↑
Oral Supplementation (n = 13)						
Gregorio et al.	2003	→	—	↑	↑	↑
Kamphuis et al.	2011	↑	—	—	—	—
Keller et al.	2003	↑	—	—	—	—
Lauque et al.	2004	↑	↑	↑	↑	↑
Navratilova et al.	2007	→	↑	—	—	—
Parrott et al.	2006	↑	↑	—	—	—
Pivi et al.	2011	↑	—	↑	↑	—
Planas et al.	2004	→	→	→	→	↑
Riley & Volicer	1990	→	—	↑	—	—

	Year	Weight	Oral Intake	Blood Assays	Body Composition	Self-Report
Salas-Salvado et al.	2005	↑	—	↑	—	↑
Sousa & Amaral	2012	↑	—	↑	↑	↑
Young et al.	2004	→	↑	—	—	—
Young et al.	2005	→	↑	—	—	—
Oral Supplementation & Education (n = 2)						
Faxen-Irving et al.	2002	↑	—	→	↑	—
Suominen et al.	2015	→	↑	↑	→	↑
Other Pharmacologic/Ecopsychological (n = 3)						
Johansson & Christensson	2017	↑	—	—	—	—
McHugh et al.	2012	NR ⁺	—	—	—	—
Soysal & Isik	2016	→	—	↑	—	↑

↑ A statistically significant difference was reported for one or more outcomes in this category; the effect was beneficial

↓ A statistically significant difference was reported for one or more outcomes in this category; the effect was not beneficial

→ No statistically significant differences were reported for this study in this outcome category

— No outcomes in this category were reported for this study

NR⁺ Statistical analyses were not performed, but beneficial trends were reported

Supplementary Table 1: MeSH Terms Included in Database Search