
Article:
Essat, M., Archer, R., Williams, I. et al. (10 more authors) (2019) Interventions to promote oral nutritional behaviours in people living with neurodegenerative disorders of the motor system : a systematic review. Clinical Nutrition. ISSN 0261-5614

https://doi.org/10.1016/j.clnu.2019.11.015

Interventions to promote oral nutritional behaviours in people living with neurodegenerative disorders of the motor system: A systematic review

Authors: Munira Essat[a], Rachel Archer[a], Isobel Williams[b], Nicolò Zarotti[c], Elizabeth Coates[a], Mark Clowes[a], Daniel Beever[a], Gemma Hackney[a], Sean White[d], Theocharis Stavroulakis[c], David White[a], Paul Norman[b*] and Christopher McDermott[c] on behalf of the HighCALS group

Affiliations:

[a]School of Health and Related Research (ScHARR), The University of Sheffield, Sheffield, UK.

[b]Department of Psychology, The University of Sheffield, Sheffield, UK

[c]Sheffield Institute for Translational Neuroscience (SITraN), The University of Sheffield, Sheffield, UK.

[d]Sheffield Teaching Hospitals NHS Foundation Trust, Sheffield, UK.

*Corresponding author: Paul Norman, Professor of Health Psychology, Department of Psychology, University of Sheffield, Cathedral Court, 1 Vicar Lane, Sheffield, S1 2LT, UK

E-mail: p.norman@sheffield.ac.uk

Tel: +44 (0) 114 222 6533

Fax: +44 (0) 114 276 6515

Author version of paper accepted for publication in Clinical Nutrition on 11 November 2019. This article may not exactly replicate the authoritative document published in the journal. It is not the copy of record.

Abbreviations: BCT, Behaviour change techniques; BIA, bioelectrical impedance analysis; CD, Chin Down Posture; EAT MORE, E-health Application To Measure Outcomes Remotely; EMST, Expiratory Muscle Strength Training; FEES, Fibreoptic Endoscopic Evaluation of Swallowing; HD, Huntington's Disease; HDL, high density- lipoprotein; HT, honey-thick liquids; LDL, low-density-lipoprotein; LVR, Lung Volume Recruitment; MOD, modes of delivery; MND, Motor Neurone Disease; NDMS, Neurodegenerative disorders of the motor system; NT, nectar-thick liquid; ONS, oral nutritional supplement; PA, penetration-aspiration; PDQ-39, Parkinson's disease Questionnaire-39; POE, Pleasure of Eating Scale; SDQ, Swallowing Disturbances Questionnaire; SWAL-CARE, Swallowing Quality of Care; SWAL-QOL, Swallowing Quality of Life; VAST; Video-assisted swallowing therapy.

Abstract

Background & Aims

Weight loss is common in people with neurodegenerative diseases of the motor system (NDMS), such as Parkinson's disease and Amyotrophic Lateral Sclerosis, and is associated with reduced quality of life, functional ability and survival. This systematic review aims to identify interventions and intervention components (i.e. behaviour change techniques [BCTs] and modes of delivery [MoDs]) that are associated with increased effectiveness in promoting oral nutritional behaviours that help people with NDMS to achieve a high-calorie diet.

Methods

Eight electronic databases including MEDLINE and CINAHL were searched from inception to May 2018. All interventions from included studies were coded for relevant BCTs and MoDs. Methodological quality of studies was assessed using the Cochrane risk of bias tool.

Results

Fourteen studies were included. Of these, eight studies reported interventions to assist with swallowing difficulties and six studies reported interventions targeting dietary content. Beneficial effects in managing swallowing difficulties were observed with video assisted swallowing therapy, lung volume recruitment and swallowing management clinics with outpatient support. In contrast, studies reporting effectiveness of chin down posture, use of thickened liquids and respiratory muscle training were inconclusive. Positive effects in interventions targeting dietary content included the use of food pyramid tools, individualised nutritional advice with nutritional interventions, electronic health applications, face-to-face dietary counselling and high fat, high carbohydrate and milk whey protein supplements. Individualised nutritional advice with weekly phone contact did not appear to be effective. Most frequently coded BCTs were 'instructions on how to perform the behaviour', 'self-monitoring' and 'behavioural practice/rehearsal'. Most commonly identified MoDs were

‘human’, ‘face-to-face’ and ‘somatic therapy’. However, the robustness of these findings are low due to small number of studies, small sample sizes and large between-study variability.

Conclusions

Despite the limited evidence, these findings may help inform the development of more effective interventions to promote oral nutritional behaviours in people with NDMS. However, further research is needed to demonstrate which interventions, or intervention components, yield most benefit.

Keywords

Nutrition, diet, amyotrophic lateral sclerosis, Parkinson’s disease, Huntington’s disease, swallowing

Introduction

Weight loss is a common problem in neurodegenerative disorders of the motor system (NDMS, e.g. Parkinson's disease (PD), Amyotrophic Lateral Sclerosis (ALS), Huntington's disease (HD), Progressive Supranuclear Palsy) and may occur due to a number of factors including dysphagia, loss of appetite, progressive weakness of limb muscles and respiratory muscles, difficulty in handling utensils, and increased energy expenditure due to a hypermetabolic state.[1-6] Weight loss is well recognised as a poor prognostic factor in people with NDMS.[7] For instance in PD, early weight loss is associated with greater risk of dementia, loss of independency and premature death.[8] Similarly in ALS, body mass index (BMI) is an independent predictor of survival, with mild obesity having a protective effect and lower BMI associated with a worse prognosis.[9] Such findings point to the importance of maintaining or increasing body weight, particularly in the early stages of the disease, in order to improve survival, functional ability and quality of life in people with NDMS. Therefore there is a clear need for interventions that help people with NDMS to achieve a high calorie diet to maintain or increase their weight and overcome eating-related barriers (e.g. dysphagia, loss of appetite) that are associated with poorer nutritional outcomes (e.g. weight loss, malnutrition). However, the evidence base in this area is lacking. Reviews in ALS have largely focused on interventions such as enteral feeding (via nasogastric tubes or gastrostomy) when patients are unable to safely maintain an adequate oral intake,[10] rather than on the use of oral nutritional interventions (e.g. food fortification, oral nutritional supplements) in early stages of the disease. Reviews in PD have discussed a range of nutritional issues but have not considered the effectiveness of nutritional interventions.[11] Very little evidence has been reported in other NDMS.

The aim of this systematic review was to identify studies on the effectiveness of oral nutritional interventions to help people with NDMS achieve a high calorie diet. In addition, the review sought to identify any intervention components (i.e. behaviour change techniques) and modes of delivery that are associated with greater effectiveness.

Methods

This systematic review was reported in accordance with the general principles recommended in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.[12] A protocol was developed and registered on the PROSPERO international prospective register of systematic reviews (http://www.crd.york.ac.uk/PROSPERO/display_record.php?ID=CRD42018105902).

Data sources and searches

Systematic searches were undertaken in relevant electronic databases and research registers including MEDLINE, MEDLINE in Process, EMBASE, the Cochrane Library, CINAHL, PsychINFO and Web of Science. The search strategy used a combination of subject headings and free text terms (e.g. food, fortified/; dietary supplements/; ONS; oral nutrition* supplement*; high calori*; patient compliance/adherence) combined with keywords for NDMSs (e.g. ALS or Motor Neurone Disease or Parkinson's disease or Huntington's Disease or Progressive Supranuclear Palsy etc.) to identify papers that examined factors associated with nutritional behaviours and outcomes in people with NDMS. A filter to identify intervention studies (by the inclusion of terms such as intervention, randomized controlled trial, RCT, cluster trial) was subsequently applied. Due to lack of evidence identified in relation to dietary and nutritional advice and counselling, targeted follow-up searches were conducted, searching for the terms "diet* or nutrition*" in close proximity to "advice or

counselling". Databases were searched from inception to May 2018 for the main searches, and to August 2018 for the targeted searches. No language or date restrictions were applied. Searches were supplemented by hand-searching the reference lists of relevant reviews and included studies, citation searching and contact with experts in the field. Details of the search strategies are provided in Supplementary Appendix 2.

Study selection

All titles were examined for inclusion by one reviewer and any citations that clearly did not meet the inclusion criteria (e.g. non-human, unrelated to nutrition behaviour) were excluded. All abstracts and full text articles were then examined independently by two reviewers. Any disagreements in the selection process were resolved by discussion, with involvement of a third reviewer when necessary. A summary of the inclusion and exclusion criteria is presented in Table 1.

Data abstraction

Data relating to study design, patient characteristics and outcomes were extracted by one reviewer into a standardised data extraction form, and independently checked for accuracy by a second reviewer. Any discrepancies were resolved by discussion, with involvement of a third reviewer, if required. Identified intervention components were coded according to the Behaviour Change Techniques (BCTs) taxonomy[13] and the Modes of Delivery (MoDs) classification.[14] The coding was undertaken by one reviewer and independently checked by another. Any disagreement was resolved by discussion. Definitions of the BCTs and MoDs coded in the review are provided in Supplementary Appendices 3 and 4.

Table 1

Study selection criteria.

	INCLUSION CRITERIA	EXCLUSION CRITERIA
Population	Adults (aged ≥ 18 years) with NDMS i.e. MNDs, ALS, PD, HD, PSP, PBP, PMA, PLS, or Kennedy's disease (at any stage of disease)	People without NDMS, healthy volunteers, children (aged <18 years) and studies in animals
Intervention	Any interventions delivered to individuals (to change their beliefs, knowledge, skills, etc.) to promote nutritional behaviour (e.g. uptake of oral nutritional supplement, food fortification) OR eating behaviour (e.g. swallowing, use of adapted cutlery) to achieve a high calorie diet.	Studies on tube feeding/gastrostomy, other dietary supplements (e.g. vitamins, minerals and herbs), drug interventions, acupuncture, transcranial direct current stimulation (TDCS) etc. Studies not on nutritional or eating behaviour
Comparator	Control, active comparator or standard care	None
Outcomes	Nutritional behaviour outcomes (e.g. calories consumed, number of ONS consumed etc.). Eating behaviour outcomes (e.g. swallowing, use of adapted cutlery). Weight loss, weight gain, weight maintenance	Data unrelated to nutritional or eating behaviour
Study design	RCTs, non-RCTs, or observational cohort studies with a control group	Studies without a control group, systematic reviews, reviews, opinion pieces, letters, commentaries, editorials, preclinical and biological studies, and reports published as meeting abstracts only with insufficient data
Language	English language	Non-English-language

MND, Motor Neurone Disease; NDMS, Neurodegenerative disorders of the motor system; HD, Huntington's Disease; non-RCTs, non-randomised trials; PBP, Progressive Bulbar Palsy; PMA, Progressive Muscular Atrophy; PLS, Primary Lateral Sclerosis; PD, Parkinson's disease; PSP, Progressive Supranuclear Palsy; RCT, randomised controlled trials.

Quality assessment

The methodological quality of each included study was assessed using the Cochrane Collaboration's tool for assessing the risk of bias in randomised controlled trials (RCTs)[15] across the following domains: sequence generation (selection bias), allocation sequence concealment (selection bias), blinding of participants and personnel (performance bias), blinding of outcome assessment (detection bias), incomplete outcome data (attrition bias), selective outcome reporting (reporting bias) and other potential sources of bias. Each domain was rated a being at high, low or unclear risk of bias according to criteria detailed in the tool. The studies were assessed by one reviewer and independently checked by another reviewer.

Data synthesis

A meta-analysis was not conducted on the data, as the studies were considered to be too heterogeneous with regards to the study designs, interventions and types of outcome data available. Therefore, as suggested by the guidance produced by the Cochrane Collaboration[15] and the Centre for Reviews and Dissemination for undertaking systematic reviews,[16 17] a narrative synthesis of included studies was undertaken. Effect sizes were planned to be computed for specific BCTs and MODs. However, the small number of studies identified and heterogeneity between studies did not provide sufficient data to allow this analysis.

Results

After removal of duplicates, a total of 4326 records were screened, of which 150 full-text articles were considered potentially eligible for inclusion. Following detailed screening 14 articles[18-31] were included in the systematic review. The majority of the excluded articles did not relate to oral nutrition or the study design did not include a control group. A summary of the process of identifying and selecting the relevant literature is presented in Figure 1.

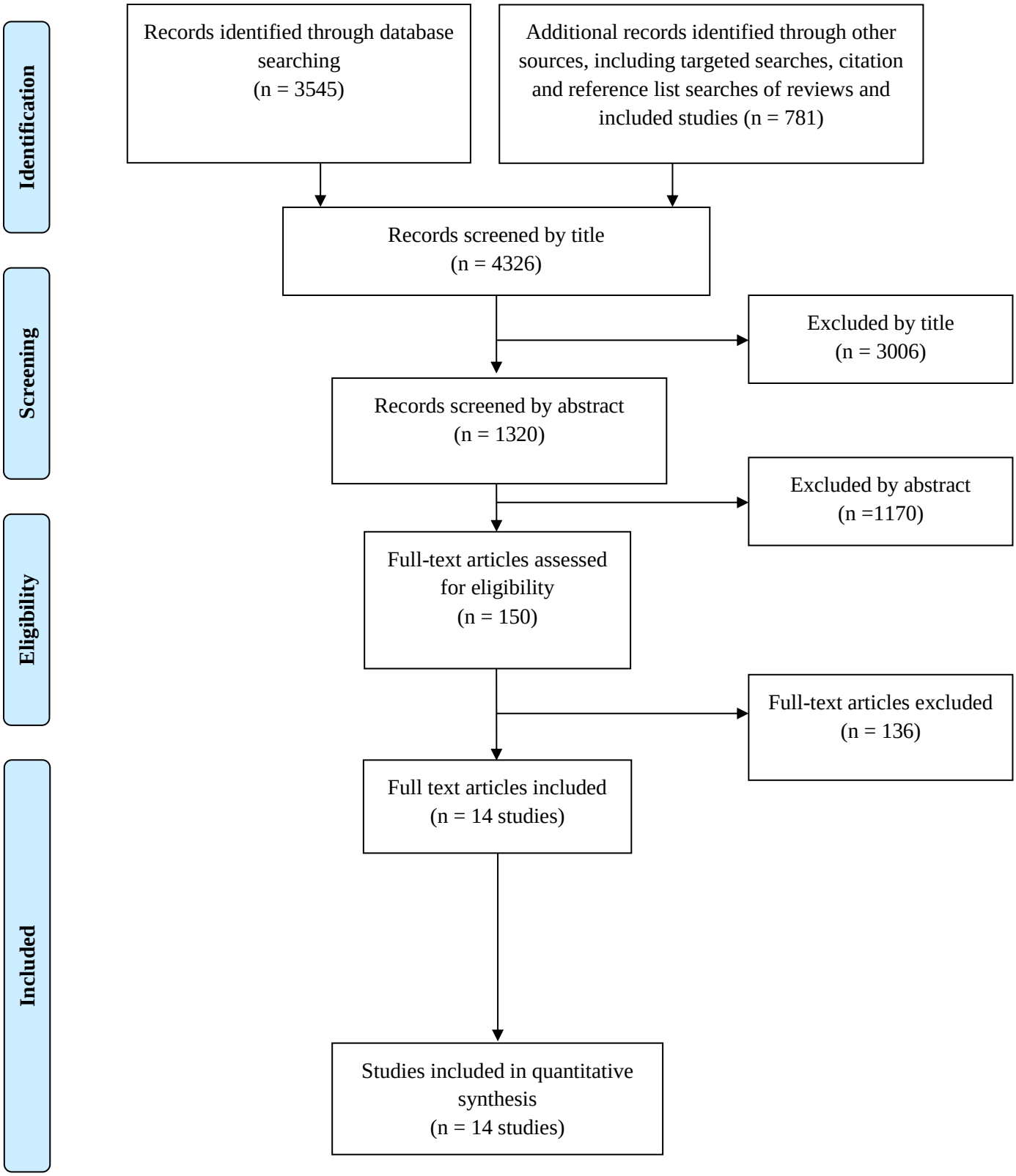

Figure 1

Study selection flow chart (adapted).

Characteristics of included studies

The characteristics of the 14 included studies are reported in Tables 2 and 3 as well as Supplementary Table 1.[18-31] All included studies were intervention studies with a control group reporting on interventions used to promote oral nutritional behaviours in participants with NDMS. Eight studies reported on interventions used to assist with swallowing difficulties[19 20 22 23 25 26 29 30] and six studies[18 21 24 27 28 31] reported on interventions targeting dietary content. Of the 14 included studies, two studies[20 31] were reported as a conference meeting abstract with limited reporting details whilst the remaining studies were available as journal articles. The studies were published between 2008[22] and 2017[19 31]and were conducted in the USA (n = 4),[22 26 29 31]Australia (n = 2),[25 27] Brazil (n = 3),[18 19 28] China (n = 1),[30] Germany (n = 1),[21] Israel (n = 1),[23] Italy (n = 1)[24] and Canada (n = 1).[20] Care settings comprised of clinics/units in eight studies[18 19 21 23 24 28-30] and acute-care hospitals and subacute residential facilities in four studies.[22 26 27 31] Two studies[20 25] did not report the settings. The size of the studies varied considerably with the number of participants ranging from 16[28] to 228.[22] The mean age of included participants ranged from 50 years[25] to 81 years,[26] however in one study[20] age was not reported and in another[22] the data could not be extracted. Six studies included participants with ALS,[18 20 21 24 28 31] five studies included participants with PD only,[19 23 27 29 30] two studies included mixed samples of PD (with or without dementia) or dementia only,[22 26] and one study included participants with HD.[25]

Disease stage was only reported in two studies,[23 29] both of which assessed PD severity using Hoehn and Yahr scale (H&Y), which defines broad categories of motor function in PD. The stages range from 0 to 5, with stage 0 indicating no signs of disease and stage 5 indicating the need for a wheelchair or an individual is bedbound without assistance. In Manor et al.[23] participants had a mean H&Y score of 2.2 and in Troche et al.[29] participants had a H&Y

score ranging from two to four. Site of disease onset in ALS was reported in three studies[18 21 31] with percentage of bulbar onset ranging from 26%[18] to 83%.[21] Where reported, duration of disease ranged from five years[25] to 11.8 years.[19]

Risk of bias within studies

All ratings were either for low or unclear risk of bias, with the exception of three high risk ratings for the selection bias domains for the non-randomised studies in Ayres et al.[19] and Wei et al.[30] and two high risk ratings for performance bias in Wills et al.[31] and Sheard et al.[27] due to the open labelled nature of the studies in which participants were not blinded (Supplementary Table 2). The studies receiving the greatest number of low risk of bias ratings (n = 5 for each) were Robbins et al.[26] and Troche et al.[29] The study by Cleary et al.[20] was a conference meeting abstract with limited reporting and so no further details were available to allow the critical appraisal of the methods of this study.

Outcomes and synthesis of results

Interventions targeting swallowing difficulties

Six interventions, reported in eight studies[19 20 22 23 25 26 29 30] were identified that targeted swallowing difficulties (see Table 2); these included:

(i) Chin-down posture or use of thickened liquids

Three studies[19 22 26] in patients with PD disease assessed the effectiveness of the chin-down posture in improving swallowing-related outcomes. The chin-down postural manoeuvre is performed by lowering the head with the intention of touching the chin with the neck or chest whilst swallowing. This manoeuvre promotes the major protection of the airways by

displacement of the epiglottis to a more protective position.[19] Ayres et al.[19] (n=24) compared the chin-down posture manoeuvre (intervention group 1) with a non-chin down posture group (intervention group 2) and a control group. The chin-down posture manoeuvre group received four weekly individual sessions of 30 minutes including training of chin-down manoeuvre with saliva and water. They were trained to perform the manoeuvre twice a day, swallowing saliva and during meals, throughout the week at home. An orientation group received four individual sessions of 30 minutes a week. In these sessions, doubts about the guidelines and treatment adherence were verified and instructions about feeding were performed; all instructions were given on a written document but the chin-down postural manoeuvre was not applied. The control group did not receive any intervention. The use of the chin-down postural manoeuvre resulted in significant improvements in clinically-evaluated symptoms of dysphagia when swallowing solid and liquid consistencies ($p < 0.001$ and $p = 0.022$ respectively) compared to the other two groups. However, assessment by Fiberoptic Endoscopic Evaluation of Swallowing (FEES) did not demonstrate differences between groups. Significant differences in symptom frequency and mental health domains of the SWAL-QOL were also observed ($p = 0.029$ and $p = 0.004$, respectively).

Two further studies, Logemann et al.[22] and Robbins et al.,[26] in addition to chin-down posture manoeuvre also assessed the use of nectar- and honey-thickened liquids (300 Centipoise) in improving swallowing difficulties. For the nectar and honey-thickened liquids, the patients were instructed to take the food from a spoon, hold the food in their mouths, and then swallow it in a head neutral position. For chin-down posture, patients were instructed to put their chins down to touch their chests or necks whilst swallowing thin liquid (15 Centipoise). Logemann et al.[22] (n=228) found that the use of honey-thickened liquids resulted in the lowest proportion of patients who aspirated (44%) compared with nectar-thickened liquids

(54%, $p < 0.001$) and the use of the chin-down posture (59%, $p < 0.0001$). Robbins et al.[26] (n=515) reported a similar pattern of aspiration rates in the honey-thickened (61%), nectar-thickened (65%) and chin-down posture (70%), intervention groups, although differences between the groups were non-significant. In addition, the proportion of patients reporting weight loss at three months follow-up was similar (2%) in the three groups. Overall, there is some evidence that the use of thickened liquids may reduce aspiration and that the chin-down posture may help to reduce dysphagia symptoms; however, the small number of studies precludes strong conclusions regarding the effectiveness of these interventions.

(ii) Respiratory muscle training

Two studies (one in PD[29] and one in HD[25]) reported on the effectiveness of respiratory muscle training. Troche et al.[29] (n=60) used a restorative treatment called expiratory muscle strength training (EMST) for swallowing dysfunction, which works by generating increased submental musculature force activation which in turn elevates the hyolaryngeal complex. The EMST treatment program uses a calibrated, one-way, spring-loaded valve to mechanically overload the expiratory and submental muscles. Troche et al.[29] assessed the effectiveness of EMST in PD with a sham device, which was identical to the EMST device except the pressure release valve was made to be non-functional by removing the spring. Participants in both groups were visited weekly during the four week training phase by a clinician to remind them how to properly use the device and then participants trained independently at home, completing five sets of five repetitions, five days per week. Improved swallow safety (measured by penetration-aspiration scores) was observed by the EMST intervention compared with the sham control group ($p = 0.001$). Hyolaryngeal function during swallowing also improved as a result of the intervention. However, there were no significant differences in improvements in swallowing quality of life between the groups. In Reyes et al.[25] (n=18)

the intervention and control group undertook home-based inspiratory and expiratory muscle training (five sets of five repetitions, six times a week for four months) but the intervention group had a progressively increased resistance (from 30% to 75% of each patient's maximum respiratory pressure), whereas the control group used a fixed resistance of nine centimetres of water throughout the training period. No substantive differences were found between the intervention and control groups for any of the measures of swallowing function or Swallowing Quality of Life at two or four month follow-up.

(iii) Lung volume recruitment intervention

Lung volume recruitment intervention (LVR) - a manual breath stacking technique to help patients cough with sufficient force to clear pulmonary secretions - was assessed in a single study in people with ALS[20] (n=29). The LVR intervention was reported to have a significant effect on peak cough flow compared to no treatment. However, this data was from a conference meeting abstract with limited reporting.

(iv) Video-assisted swallowing therapy

A single study[23] in participants with PD (n=42) assessed video-assisted swallowing therapy (VAST), a therapeutic approach based on the concept that a dynamic personalised video of swallowing will help the patient implement instructions. The video depicts the patient's swallowing function during a FEES session at baseline and then a second time while implementing the learned compensatory technique (repeated forceful swallow). The analysis of VAST was compared with conventional therapy (control) and the only difference between the two groups was the implementation of the video-assisted tool during each therapy session. VAST significantly improved food residue in the pharynx as assessed by FEES at baseline and immediately post therapy ($p < 0.05$). There were no significant differences observed

between groups on other measures assessed by FEES (e.g. bolus flow time, bolus location, penetration and aspiration). Dysphagia symptoms as measured by the Swallowing Disturbance Questionnaire were significantly improved in the VAST group compared with the control group immediately post-intervention and at one month follow-up ($p < 0.005$). The SWAL-QoL scores were significantly better in the VAST group compared with the control group for burden, eating desire, social functioning, mental health and symptom frequency ($p < 0.01$) with significant improvements observed between four weeks post-therapy and six months post-therapy. There was also a significantly greater improvement in the Pleasure of Eating score during the course of therapy in the VAST group compared with control group ($p < 0.05$). In addition, Swallowing Quality of Care scores were significantly better in the VAST group than the control group immediately post-treatment ($p < 0.05$).

(v) Swallowing management clinic with outpatient support

The effectiveness of a swallowing management clinic with outpatient support was assessed in one study in PD (n=217).[30] The intervention was a standardised out-of-hospital management intervention including long-term attention and overall management (establishment of a swallowing management clinic, swallowing archives, periodic re-examination with individualised intervention strategies), multi-media training combined with feedback to raise awareness and education, out-of-hospital rehabilitation training (swallowing skill training, oral muscle exercises, mis-inhalation protection, pronunciation, effective cough, pharynx cold stimulation and empty swallowing training), eating prescription (guidance on appropriate posture, amount per morsel, food property selection', compensatory strategies), and a web chat platform to monitor, prompt and educate patients and for patients to ask questions. The control group received face and tongue training and eating considerations but did not receive the out-of-hospital management intervention. The study reported increased

dysphagia recovery in the intervention group (68.3%) compared with the control group (17%) ($p < 0.01$). The mis-inhalation rate was also observed to be lower in the intervention group than in the control group ($p < 0.01$).

Behavioural change techniques (BCTs) and modes of delivery (MoDs) used in intervention studies targeting swallowing difficulties

The behavioural change techniques (BCTs) and modes of delivery (MoDs) were evaluated in all studies apart from the Cleary et al.[20] conference abstract which did not contain sufficient details to code BCTs or MODs.

A total of eleven different BCTs[13] were identified (Supplementary Table 3). The most frequently coded BCT was instruction on 'how to perform the behaviour',which was identified in a total of seven studies[19 22 23 25 26 29 30] reporting the use of the chin-down posture,[20 22 26] thickened liquids,[22 26] VAST,[23] respiratory muscle training[25 29] and swallowing management clinic with outpatient support.[30] The BCT of 'behavioural practice/rehearsal' was identified in four studies,[23 25 29 30] reporting the use of respiratory muscle training,[25 29] swallowing management clinic with outpatient support[30] and VAST.[23] 'Self-monitoring' was also identified in four studies[19 23 25 29] reporting the use of chin-down posture,[19] respiratory muscle training[25 29] and VAST.[23] 'Feedback on behaviour' was reported in two studies[29 30] reporting the use of respiratory muscle training[29] and swallowing management clinic with outpatient support.[30] Other BCTs were only reported in individual studies. There was no evidence to link specific BCTs to intervention effectiveness.

Nine different MoDs[14] were identified (Supplementary Table 4). The most commonly applied MoD was 'human, face-to-face', identified in a total of six studies[19 22 23 25 29 30] reporting the

use of chin-down posture,[19 22] thickened liquids,[22] respiratory muscle training,[25 29] swallowing management clinic with outpatient support[30] and VAST.[23] 'Somatic, liquid' was identified in the two studies on thickened liquids.[22 26] 'Somatic, unspecified' was also reported in the two studies on swallowing management clinic with outpatient support[30] and respiratory muscle training.[29] Other MoDs were either reported in individual studies or not reported. There was no evidence to link specific MoDs to intervention effectiveness.

Table 2

Key characteristics of studies testing interventions targeting swallowing problems.

Study, year	Diagnosis	Study design and sample size (N)	Intervention conditions	Control conditions	Outcome measures and assessments
(i) Chin-down posture and thickened liquids					
Ayres 2017[19]	PD	Non-RCT (N=32, analysed N=24)	Chin Down Posture Manoeuvre (CD) and written instructions regarding feeding	C1: no intervention C2: same as intervention but no CD manoeuvre training.	Clinical evaluation FEES SWAL-QOL Assessed at end of one-month intervention period
Logemann 2008[22]	PD	RCT (N=228)	1. Drink thin liquid in chin-down posture (CD) 2. Drink nectar-thickened liquid (NT) with no postural adjustment 3. Drink honey-thickened liquid (HT) with no postural adjustment	All participants completed all three interventions in a randomly assigned order.	Rates of aspiration assessed during intervention
Robbins 2008[26]	PD without D, PD with D, D	RCT (N=515) 504 followed until death or 3 months	1. Drink liquids in a chin-down posture (CD) 2. Drink nectar-thickened (NT) liquid in a head-neutral position 3. Drink honey-thickened (HT) liquid in a head-neutral position	Participants were randomly assigned to one of the three interventions	Rates of aspiration assessed during intervention Weight loss during 3 months follow-up

(ii) Respiratory muscle training					
Troche 2010[29]	PD	RCT (N=60)	Respiratory muscle training (EMST) .	Sham device	Swallow safety (PA score) Physiologic measures of swallow mechanism (Hyloid duration and displacement) SWAL-QOL Assessed at baseline and after 4 weeks of active treatment (post-treatment)
Reyes 2015[25]	HD	RCT (N=18)	Inspiratory and respiratory muscle training (EMST) – used a progressively increased resistance	Inspiratory and muscle training - same as intervention but used a fixed resistance of 9 cm water	Swallowing function (assessed by water swallowing test) SWAL-QOL Assessed at baseline, 2 and 4 months after training
(iii) Lung volume recruitment					
Cleary 2010[20]	ALS	Within-subjects-repeated measures cross-over design (N=29)	Lung Volume Recruitment (LVR)	No treatment	Peak cough flow measure Assessed at baseline, immediately and 30 minutes after treatment
(iv) Video-assisted swallowing therapy					
Manor 2013[23]	PD	RCT (N=42)	VAST plus conventional swallowing therapy	Conventional swallowing therapy	FEES SDQ

					SWAL-QOL SWAL-CARE POE Assessed at baseline, 1 and 6 months follow-up
(v) Swallowing management clinic with outpatient support					
Wei 2017[30]	PD	Non-RCT (N=217)	Swallowing management clinic with outpatient support	Standard care	Dysphagia rehabilitation efficiency Mis-inhalation incidence rate Assessed at 6 month follow-up

PA, penetration-aspiration; C, control group; CD, Chin Down Posture; EMST, Expiratory Muscle Strength Training; FEES, Fibreoptic Endoscopic Evaluation of Swallowing; HT, honey-thick liquids; I, intervention group; LVR, Lung Volume Recruitment; NT, nectar-thick liquid; IG2, intervention group 2; POE, Pleasure of Eating Scale; SDQ, Swallowing Disturbances Questionnaire; SWAL-CARE, Swallowing Quality of Care; SWAL-QOL, Swallowing Quality of Life; VAST; Video-assisted swallowing therapy

Intervention studies targeting dietary content

Six studies[18 21 24 27 28 31] were identified that reported on interventions targeting dietary content (see Table 3), of which four[18 24 27 31] reported interventions providing nutritional advice and support and two[21 28] reported interventions providing different supplements. A variety of methods were used to assess nutritional behaviour. Each included study tested a different intervention.

(i) Nutritional advice and support

First, Almeida et al.[18] (n=53) compared the use of a food pyramid tool adapted to the Brazilian population[32] with a control group in ALS participants. The food pyramid tool was used to deliver nutritional education to patients by providing guidelines to patients and caregivers during quarterly outpatient monitoring, nutritional counselling and periodic verification of anthropometric measurements and food intake. The tool also helped patients to monitor their own nutritional status. The control group were provided with general guidelines including changes in food consistency (i.e. texture) and dividing up the components of meals. There was an increase in the consumption of dairy products in the intervention group between baseline and three-month follow-up ($p < 0.05$), although consumption data were not reported for the control group. No statistical difference was found in BMI decline between the control and intervention group ($p = 0.76$) at three months follow-up.

Second, Morassutti et al.[24] (n=33) compared the use of a precise nutritional intervention protocol to monitor participants, with a control group in ALS participants. The estimation of recommended nutritional requirements (based on Harris-Benedict formula) and patients' diet history was used to prescribe standard diet. Consistency (i.e. texture) of food was recommended according to the severity of dysphagia to allow safe swallowing. When

patients were unable to orally receive adequate calorie intake for their needs from their diet, oral supplements were recommended and when oral feeding methods could not be used percutaneous endoscopic gastrostomy was recommended. The intervention group received nutritional intervention according to a fixed calendar. In the control group, participants received intervention according to the clinical condition of each patient and were monitored before the protocol was applied (i.e. when criteria for referral to a nutritionist were not yet determined nor was monitoring formalised or the work method standardised). The study found that higher proportions of patients in the intervention group took food by mouth and oral nutritional supplements, and a lower proportion received enteral nutrition, compared with the control group at 1, 6 and 12 months follow-up. In addition, weight loss was also lower in the intervention compared to the control group at all follow-ups.

Third, Wills et al.[31] (n=19) compared an e-health application (iPad or iPhone) or in-person (i.e. face-to-face) dietary counselling with standard care in patients with ALS. Participants in the in-person arm received dietary counselling at every in-person visit and biweekly telephone calls and/or email follow-ups between visits. Participants in the e-health arm received biweekly remote dietary counselling and monitoring of dietary intake using the E-health Application To Measure Outcomes REmotely (EAT MORE). The authors[30] found that both the in-person and e-health nutritional intervention groups had a higher calorie intake than standard care controls at three months follow-up. However, these differences were not significant at six months follow-up. The effect of the nutritional interventions on weight was not reported.

Fourth, Sheard et al.[27] (n=19) investigated the effect of individualised nutrition information given by a dietitian and weekly phone contact with standard care (patient received written

information only) in participants with PD. Both groups had four visits. Non-significant differences were found in Parkinson's Disease Questionnaire-39 scores between participants who received individualised nutritional advice from dietitian and weekly phone contact versus standard care at 12-weeks follow-up.

(ii) Provision of supplements

First, Dorst et al.[21] (n=26) compared the use of high fat or high carbohydrate oral food supplements in addition to normal food intake in people with ALS. Patients took 200 ml of the food supplement three times daily (3 x 200 ml) between their normal meals for 12 weeks. Both food supplements had 150 kcal per 100 ml. The food supplement with high fat content contained 35% fat, 50% carbohydrates, and 15% protein; the supplement with high carbohydrate content contained 0% fat, 89% carbohydrate, and 11% protein. It was found that the use of both high fat and high carbohydrate oral food supplements led to significant weight gain during the 12 weeks intervention period ($p = 0.012$ and $p = 0.0008$, respectively), with a greater effect observed in the group with high fat supplement, although the difference in weight gain between the two supplements was not statistically significant ($p = 0.37$). Non-significant differences between the groups were found for all other outcomes (e.g. cholesterol) apart from a greater increase in body fat in patients receiving the high fat versus the high carbohydrate oral food supplements ($p = 0.035$).

Second, Silva et al.[28] (n=16) compared the use of milk whey protein (containing 70% of milk serum protein and 30% modified starch) oral supplement with a control group using maltodextrin oral supplement. Nutritional supplementation was administered twice a day (morning and afternoon) for 16 consecutive weeks. Increases in weight and BMI were

observed for the group receiving milk whey proteins, whereas weight and BMI declined for the group receiving maltodextrin, but differences between the groups were non-significant.

Behavioural change techniques (BCTs) and modes of delivery (MoDs) used in intervention studies targeting dietary content

BCTs and MoDs were coded in all studies apart from the study by Dorst et al.[21] which contained insufficient detail to allow coding of BCTs and MODs. Supplementary Table 4 provides details of the BCTs applied in each intervention. Overall, the most commonly coded BCTs[13] across the studies was instruction on how to perform the behaviour, reported in four studies.[18 24 28 31] The BCT of credible source was reported in two studies.[27 31] A total of four other BCTs were reported in individual studies, including goal setting,[31] feedback on behaviour,[31] self-monitoring[31] and pharmacological support.[24]

Supplementary Table 5 provides details of MODs used in each intervention. The most frequently identified MoD[14] was human, face-to-face reported in three studies[24 27 31] and somatic, liquid reported in two studies.[21 28] A total of four other MoDs were reported in individual studies, including human, distance, audio call,[27] digital, phone, email,[31] digital, phone, app[31] and somatic (unspecified).[24] There was no evidence to link specific BCTs or MoDs to intervention effectiveness.

Table 3.

Key characteristics of studies testing interventions targeting dietary content

Study, Year	Diagnosis	Study design and sample size (N)	Intervention condition	Control condition	Outcome measures and assessment
(i) Nutrition advice and support					
Almeida 2016[18]	ALS	RCT (N=53)	Food pyramid tool (adapted to Brazilian population)	General guidelines, including changes in food consistency and dividing up components of meals	BMI Food intake (food frequency questionnaire) Assessed at time of referral and after three months
Morassutti 2012[24]	ALS	RCT (N=33)	Individualised nutritional intervention protocol and received nutritional intervention according to a fixed calendar	Nutritional intervention according to the clinical condition of each patient. No nutritional intervention protocol used	Weight Types of nutritional intervention received (standard diet, ONS, enternal feeding) Assessed at initial assessment, 1, 6 and 12 months follow-up
Wills 2017[31]	ALS	RCT (N=77, analysed N=71)	E-Health application OR In-person dietary counselling	Standard Care	BMI 24-hour recalls and 4-day food records Assessed at baseline, 3 and 6 months
Sheard 2014[27]	PD	RCT (N=19)	Individualised nutritional advice from dietitian and weekly phone contact	Standard Care with written information only	PDQ-39 Assessed at baseline, 4 and 12 weeks

(ii) Provision of supplements					
Dorst 2013[21]	ALS	RCT (N=26)	Supplement with high fat content	Supplement with high carbohydrate content	Body weight Blood tests (cholesterol, LDL, HDL and triglycerides) Fat mass (BIA) Assessed at baseline, 4 and 12 weeks during intervention
Silva 2010[28]	ALS	RCT (N=16)	Milk whey protein oral supplements set at 30% of the daily protein requirements	Maltodextrin oral supplements	Weight, BMI Assessed at baseline, 2 and 4 months

BIA, bioelectrical impedance analysis; BMI, body mass index; C, control; HDL, high density- lipoprotein; I, intervention; LDL, low-density-lipoprotein; NR, not reported; ONS, oral nutritional supplement; PDQ-39, Parkinson's disease Questionnaire-39

Discussion

In this systematic review, 14 studies[18-31] were identified that assessed interventions used to promote oral nutritional behaviour in people with NDMS. Of these, eight studies[19 20 22 23 25 26 29 30] reported on interventions used to assist with swallowing difficulties and six [18 21 24 27 28 31] reported on interventions targeting dietary content. Some positive findings were found for the effectiveness of interventions targeting swallowing-related difficulties in NDMS, including the use of chin-down posture, thickened liquids, respiratory muscle training, video-assisted swallowing theory and swallowing management clinics with outpatient support. However, some of the interventions assessed were based on single studies only, and even when interventions were evaluated in more than one study, evidence did not allow a definitive conclusion on effectiveness to be made. Some potentially promising evidence was also identified on interventions targeting dietary content in people with NDMS, although data were limited. Positive effects were observed for the use of an individualised nutritional intervention protocol, electronic health application and face-to-face dietary counselling, as well as well the provision of oral nutritional supplements. However, these results should be viewed with caution, as the interventions were only evaluated in single studies and in some cases the positive findings were not sustained at longer-term follow-up (6 months).[31] In addition, the studies testing the provision of oral nutritional supplements[21 28] had very small sample sizes which is likely to have precluded significant between-group differences due to low statistical power.

The identified interventions were also coded for relevant BCTs and MoDs to identify components within the intervention that may be associated with increased effectiveness. A limited range of BCTs were used in the interventions, with many of the BCTs only reported in one or two studies. Instruction on how to perform the behaviour was the most frequently

used BCT and was reported in all bar one of the coded studies. This is expected given that the interventions tested specific swallowing techniques or provided advice on ways to increase calorie intake (e.g. through food fortification or the use of nutritional supplements). Other frequently used BCTs included behavioural practice and self-monitoring. The most frequently employed MoD was face-to-face by a healthcare professional, although there were some instances of the use of digital technologies to deliver interventions. However, there was no evidence to link specific BCTs or MoDs to intervention effectiveness.

The current review dovetails with the recent ESPEN guidelines for clinical nutrition in neurology[34]. For example, in ALS, the guidelines highlight the importance of screening and monitoring for weight loss, screening for dysphagia and providing advice on modifying food texture and protecting airways. The guidelines also recommend increasing calorie intake to maintain or increase weight using oral nutritional behaviour (including the use of oral nutritional supplements) and, if patients' nutritional needs are not met, enteral feeding. However, the current review highlights that the evidence base for these recommendations, in terms of specific interventions that may be used to increase calorie intake and address swallowing problems, is small, weak and inconclusive.

In particular, the included evidence had a number of important limitations. First, overall, the included studies were heterogeneous in terms of population, intervention, comparators and outcomes. The heterogeneity between studies, combined with small number of included studies, small sample sizes and limited reporting did not allow the undertaking of any statistical analysis including computing effect sizes for specific BCTs and MoDs. Hence, uncertainty remains over which interventions were considered to be most effective. Second, it was not possible to determine which BCTs and MoDs were associated with the most

effective interventions. The reporting of the content of the interventions was often poor (i.e. lacked detail). As a result, it is possible that the interventions may have included other BCTs and MoDs that were not reported in the studies. Future studies should be encouraged to report intervention protocols in greater detail[33] to allow for the thorough identification of BCTs and MoDs. Third, most of the studies included in the systematic review included participants with PD, HD, and ALS. However, as there were relatively few studies of each disease it was not possible to assess whether the effectiveness of the interventions was moderated by disease type. As a result the transferability of this review to other NDMSs is questionable. Similarly, the study by Robbins et al.[25] included patients with PD, PD with dementia and dementia; yet patients with dementia may have different needs and risk and may respond differently to interventions than those without dementia. However, it was not possible to differentiate results for patients with different diagnoses. Fourth, our review only identified interventions targeting swallowing difficulties and dietary content, with no studies identified on interventions targeting other aspects of nutritional behaviour, such as the use of adapted cutlery. Fifth, the oral nutritional interventions targeting dietary content were heterogeneous in terms of content, duration, how they were delivered and by whom; moreover, usual care often included components of the intervention. Consequently, uncertainties therefore remain around the beneficial components of nutritional interventions. These and other limitations make it difficult to assess the true magnitude and direction of effect of nutritional interventions in people with NDMS.

The systematic review also had a number of strengths. First, most of the included studies were of moderate to good methodological quality and, as this systematic review is the first in this area, it can be used as a base for further research. A second strength of our review lies in the robust systematic reviewing methodology used; to minimise bias two reviewers

undertook the screening, data coding, data extraction and quality assessing of all the studies and mapping of BCTs and MoDs of all the interventions. In addition, a published search strategy (for reproducibility) has also been included.

Our review highlights the need for additional well-designed RCTs (with sufficient sample sizes) focusing on nutritional behaviours of interest (e.g. increased calorie intake) with good reporting of details (e.g. on intervention and comparator(s), effectiveness results and description of BCTs/MoDs). In addition, studies investigating other aspects of nutritional behaviour other than swallowing and dietary choices (e.g. ability to prepare meals) are necessary. Other key areas that require further investigation include the following: (1) the moderating effect of disease stage and/or severity of symptoms (i.e. dysphagia) on the effectiveness of the intervention to help identify the optimal time for introducing the intervention to achieve maximum benefit, (2) the use of long-term follow-up in studies to assess whether any benefits of the intervention are sustained over time, (3) the identification of the optimal intervention frequency, duration and content to attain most effective outcome, and (4) the exploration of acceptability, views and preferences of patients and professionals of different interventions. Furthermore, consideration needs to be given to where and by whom interventions should be delivered and how they could be implemented into current management strategies and services as this may require additional resources and training.

Conclusion

Despite the limited evidence on the various interventions, and especially specific intervention components, to promote oral nutritional behaviour these findings may nonetheless inform the development of more effective interventions and strategies to help people with NDMS to maintain or increase their weight. In particular, the provision of nutritional advice and

support shows some promise although further research, with larger samples, is needed to demonstrate which interventions, or intervention components, yield most benefit to patients.

Statement of Authorship

M.E, R.A, I.W, M.C, S.W, T.S, D.W, P.N, C.M made substantial contribution to the conceptualisation of the research; M.E, R.A, E.C, S.W, T.S, D.W, P.N, C.M acquired the funding; M.E, R.A, I.W, M.C, T.S, P.N made substantial contribution to the development of the methodology; M.E, R.A, I.W, N.Z, E.C, P.N undertook formal analysis; M.E, R.A, I.W, N.Z, E.C, M.C, D.B, G.H, P. N, C.D undertook the investigation; M.E, R.A, P.N, CD supervised; M.E, R.A, D.B, D.W, P.N, C.D were involved with project administration; M.E and R.A did visualization; M.E drafted the paper and all other authors critiqued the paper for important intellectual content.

Conflicts of interest

TS received grants from National Institute for Health Research (NIHR) under the Research for Patient Benefit (RfPB) programme, grants from Motor Neurone Disease Association of Great Britain and Northern Ireland (MNDA) under the Healthcare Research Grant scheme, outside the submitted work. SW is a home enteral feed clinical lead for the parenteral and enteral nutrition specialist group of the British Dietetic Association. M.E, R.A, I.W, N.Z, E.C, M.C, D.B, G.H, D.W, P.N and C.M declared no conflicts of interest.

Acknowledgements/ Funding sources

This project is funded by the National Institute for Health Research (NIHR) Programme Grants for Applied Research Programme (Grant Reference Number RP-PG-1016-20006) and supported by the NIHR Sheffield Biomedical Research Centre. The views expressed are

those of the authors and not necessarily those of the NIHR or the Department of Health and Social Care.

References

1. Crary MA, Groher ME. Dysphagia: clinical management in adults and children: Elsevier Health Sciences 2016.

2. Dupuis L, Pradat P-F, Ludolph AC, et al. Energy metabolism in amyotrophic lateral sclerosis. The Lancet Neurology 2011;10(1):75-82. doi: https://dx.doi.org/10.1016/S1474-4422(10)70224-6

3. Genton L, Viatte V, Janssens JP, et al. Nutritional state, energy intakes and energy expenditure of amyotrophic lateral sclerosis (ALS) patients. Clinical Nutrition (Edinburgh, Scotland) 2011;30(5):553-9. doi: https://dx.doi.org/10.1016/j.clnu.2011.06.004

4. Kalf JG, de Swart BJM, Bloem BR, et al. Prevalence of oropharyngeal dysphagia in Parkinson's disease: A meta-analysis. Parkinsonism and Related Disorders 2012;18(4):311-15. doi: http://dx.doi.org/10.1016/j.parkreldis.2011.11.006

5. Kasarskis EJ, Neville HE. Management of ALS: nutritional care. Neurology 1996;47(4 Suppl 2):118S-20S.

6. Pfeiffer RF. Gastrointestinal dysfunction in Parkinson's disease. The Lancet Neurology 2003;2(2):107-16.

7. Fereshtehnejad S-M, Ghazi L, Shafieesabet M, et al. Motor, psychiatric and fatigue features associated with nutritional status and its effects on quality of life in Parkinson's disease patients. PloS One 2014;9(3):e91153. doi: https://dx.doi.org/10.1371/journal.pone.0091153

8. Cumming K, Macleod AD, Myint PK, et al. Early weight loss in parkinsonism predicts poor outcomes: Evidence from an incident cohort study. Neurology 2017;89(22):2254-61. doi: https://dx.doi.org/10.1212/WNL.0000000000004691

9. Paganoni S, Deng J, Jaffa M, et al. Body mass index, not dyslipidemia, is an independent predictor of survival in amyotrophic lateral sclerosis. Muscle & Nerve 2011;44(1):20-24.

10. Stavroulakis T, Walsh T, Shaw PJ, et al. Gastrostomy use in motor neurone disease (MND): a review, meta-analysis and survey of current practice. Amyotrophic Lateral Sclerosis and Frontotemporal Degeneration 2013;14(2):96-104.

11. Barichella M, Cereda E, Pezzoli G. Major nutritional issues in the management of Parkinson's disease. Movement Disorders 2009;24(13):1881-92. doi: https://dx.doi.org/10.1002/mds.22705

12. Liberati A, Altman DG, Tetzlaff J, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. PLoS Medicine 2009;6(7):e1000100.

13. Michie S, Richardson M, Johnston M, et al. The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: building an international consensus for the reporting of behavior change interventions. Annals of Bbehavioral Medicine 2013;46(1):81-95.

14. Carey RJ, E. Williams, P. Evans, F. Horan, M. Johnston, M. West, R. Michie, S A taxonomy of modes of delivery of behaviour change interventions: development and evaluation The European Health Psychology Society Conference, Padua, Italy, 2017;19

15. Higgins JPT, Green S, eds. Cochrane handbook for systematic reviews of interventions version 5.1.0 The Cochrane Collaboration, 2011. [updated March 2011]. Available at: www cochrane-handbook org(Date of access: 01/03/2019)

16. Khan KS, Ter Riet G, Glanville J, et al. Undertaking systematic reviews of research on effectiveness: CRD's guidance for carrying out or commissioning reviews: NHS Centre for Reviews and Dissemination 2001.

17. Centre for Reviews and Dissemination (CRD). Systematic review: CRD's guidance for undertaking reviews in healthcare: University of York, York Publ. Services 2009.

18. Almeida CS, Stanich P, Salvioni CCS, et al. Assessment and nutrition education in patients with amyotrophic lateral sclerosis. Arquivos De Neuro-Psiquiatria 2016;74(11):902-08. doi: 10.1590/0004-282x20160145

19. Ayres A, Jotz GP, Rieder CRM, et al. Benefit from the Chin-Down Maneuver in the Swallowing Performance and Self-Perception of Parkinson's Disease Patients. Parkinsons Disease 2017 doi: 10.1155/2017/7460343

20. Cleary S, Misiaszek J, Wheeler S, et al. Using lung volume recruitment therapy to improve swallowing and airway protection for individuals with ALS. Amyotrophic Lateral Sclerosis 2010;11(SUPPL. 1):58-59. doi: http://dx.doi.org/10.3109/17482968.2010.519484

21. Dorst J, Cypionka J, Ludolph AC. High-caloric food supplements in the treatment of amyotrophic lateral sclerosis: a prospective interventional study. Amyotrophic Lateral Sclerosis & Frontotemporal Degeneration 2013;14(7-8):533-6. doi: https://dx.doi.org/10.3109/21678421.2013.823999

22. Logemann JA, Gensler G, Robbins J, et al. A randomized study of three interventions for aspiration of thin liquids in patients with dementia or Parkinson's disease. Journal of

Speech, Language, and Hearing Research 2008;51(1):173-83. doi: http://dx.doi.org/10.1044/1092-4388%282008/013%29

23. Manor Y, Mootanah R, Freud D, et al. Video-assisted swallowing therapy for patients with Parkinson's disease. Parkinsonism and Related Disorders 2013;19(2):207-11. doi: http://dx.doi.org/10.1016/j.parkreldis.2012.10.004

24. Morassutti I, Giometto M, Baruffi C, et al. Nutritional intervention for amyotrophic lateral sclerosis. Minerva Gastroenterologica e Dietologica 2012;58(3):253-60.

25. Reyes A, Cruickshank T, Nosaka K, et al. Respiratory muscle training on pulmonary and swallowing function in patients with Huntington's disease: a pilot randomised controlled trial. Clinical Rehabilitation 2015;29(10):961-73. doi: 10.1177/0269215514564087

26. Robbins J, Gensler G, Hind J, et al. Comparison of 2 interventions for liquid aspiration on pneumonia incidence: a randomized trial. Annals of Internal Medicine 2008; 148(7). http://cochranelibrary-wiley.com/o/cochrane/clcentral/articles/082/CN-00631082/frame.html

27. Sheard JM, Ash S, Mellick GD, et al. Improved nutritional status is related to improved quality of life in Parkinson's disease. BMC Neurology 2014;14:212. doi: https://dx.doi.org/10.1186/s12883-014-0212-1

28. Silva LBD, Mourao LF, Silva AA, et al. Effect of nutritional supplementation with milk whey proteins in amyotrophic lateral sclerosis patients. Arquivos De Neuro-Psiquiatria 2010;68(2):263-68. doi: 10.1590/s0004-282x2010000200021

29. Troche MS, Okun MS, Rosenbek JC, et al. Aspiration and swallowing in Parkinson disease and rehabilitation with EMST: A randomized trial. Neurology 2010;75(21):1912-19. doi: http://dx.doi.org/10.1212/WNL.0b013e3181fef115

30. Wei H, Sun D, Liu M. Implementation of a standardized out-of-hospital management method for Parkinson dysphagia. Revista da Associacao Medica Brasileira 2017;63(12):1076-81. doi: http://dx.doi.org/10.1590/1806-9282.63.12.1076

31. Wills AM, Garry J, Hubbard J, et al. Effects of dietary counseling on nutrient consumption from the electronic health application to measure outcomes remotely (EAT MORE) study. Amyotrophic Lateral Sclerosis and Frontotemporal Degeneration 2017;18(Supplement 2):300. doi: http://dx.doi.org/10.1080/21678421.2017.1374620/0020

32. Philippi ST. Pirâmide dos alimentos: fundamentos básicos da nutrição: Editora Manole 2008.

33. Hoffmann TC, Glasziou PP, Boutron I, et al. Better reporting of interventions: template for intervention description and replication (TIDieR) checklist and guide. BMJ 2014;348:g1687.

34. Burgos R, Breton I, Cereda JC, et al. ESPEN guideline clinical nutrition in neurology. Clinical Nutrition 2018;37:354-396.

Appendix 1

The HighCALS group: Ammar Al-Chalabi, Rachel Archer, Wendy Baird, Daniel Beever, Margaret Boddy, Mike Bradburn, Janet Cade, Mark Clowes, Elizabeth Coates, Cindy Cooper, Munira Essat, Gemma Hackney, Vanessa Halliday, Gillian Marsden, Christopher McDermott, Paul Norman, Ann Quinn, Pamela Shaw, Theocharis Stavroulakis, Martin Turner, David White, Sean White, Isobel Williams, Tracey Young and Nicolò Zarotti.

Appendix 2

Example search strategy (Medline)

Database: Ovid MEDLINE(R) Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE(R) Daily, Ovid MEDLINE and Versions(R) <1946 to May 09, 2018>

Search Strategy:

---

1 (optim* nutrition* or nutrition* support* or malnutrition or malnourish* or undernutrition or undernourish* or under-nutrition or under-nourish* or underweight or ((under or los* or maintain* or maintenan*) adj2 (weight or body mass or BMI))).mp. (162723)

2 (((food* or diet*) adj3 (enrich* or fortif*)) or ((protein* or carbohydrate* or fat or modular) adj3 supplement*)).mp. (23615)

3 dietary supplements/ or food, fortified/ (54757)

4 (((adapt* or modif*) adj2 (cutlery or kni* or fork* or spoon*)) or sip feed* or ONS or oral nutrition* supplement* or DEANNA or ((diet* or food or nutrition*) adj3 (fortif* or supplement*))).ti,ab. (52438)

5 (((dietetic or nutritional) adj2 (intervention* or treatment*)) or (modif* adj4 textur*) or (food* adj2 texture) or ((monitor* or manag* or safe* or assist* or help* or technique) adj3 (dysphag* or swallow*))).mp. (7587)

6 ((hypercalor* or hyper-calor* or (high or higher)) adj2 (calori* or carb* or prote*)).mp. (49112)

7 2 or 3 or 4 or 5 or 6 (152604)

8 exp motor neuron disease/ or als.ti,ab. or (pwALS or pwMND or lateral sclero* or motor neuron* disease* or MND or progressive muscular atrophy or progressive bulbar palsy or kennedy* disease or lou gehrig* disease).mp. (42532) - TIER 1

9 Parkinson Disease/ or parkinson*.ab. (102566)

10 Huntington Disease/ or hunting#on*.mp. (17545)

11 (progressive supranuclear palsy or progressive supra-nuclear palsy or PSP or Steele-Richardson-Olszewski syndrome or Guillian-barre syndrome).mp. (7033)

12 9 or 10 or 11 (121316) - TIER 2

13 exp Multiple Sclerosis/ or multiple sclerosis.mp. (73230)

14 (dementia or alzheimer*).mp. (204856)

15 13 or 14 (275386) - TIER 3

16 exp patient compliance/ or exp treatment refusal/ (78784)

17 exp Informed Consent/ (38804)

18 (((patient* or carer* or caregiver* or care-giver* or family or families or health* profession* or care* profession* or nurs* or staff or health visitor* or homecare) adj3 (attitude* or perception* or perspective* or opinion* or belief* or fear* or view* or behavio*)) or nutrition* behavio* or (behavio* adj2 chang*)).mp. (144608)

19 (compliance or compliant or comply or complies or adher* or fidelity or uptake or up-take or accept* or consent*).mp. (1184469)

20 16 or 17 or 18 or 19 (1311794)

21 (cost effective or effectiveness or efficacy or economic evaluation*).mp. (1085407)

22 (intervention* or randomi#ed controlled trial* or RCT* or cluster trial*).mp. (1362286)

23 (clinical trial* or cohort stud* or observational stud* or nonrandomi* or non-randomi* or control* group or control* trial* or control* stud* or prospective or retrospective).mp. (3135688)

24 randomized controlled trial.pt. or randomized.mp. or placebo.mp. (798860)

25 21 or 22 or 23 or 24 (4304755)

26 exp animals/ (21538001)

27 exp humans/ (17080409)

28 26 not 27 (4457592)

29 ((1 or 7) and 8) not 28 (566) - TIER 1

30 29 and 25 (252) - TIER 1 (intervention studies)

31 ((1 or 7) and 12) not 28 (912) - TIER 2

32 31 and 25 (340) - TIER 2 (intervention studies)

33 ((1 or 7) and 15 and 20) not 28 (263)

34 ((2 or 3 or 4 or 5 or 6) and 15) not 28 (1603)

35 33 or 34 (1735) - TIER 3

36 35 and 25 (830) - TIER 3 (intervention studies)

37 29 or 31 or 35 (2977) - TOTAL WP2.1

38 30 or 32 or 36 (1317) - TOTAL WP2.2

Appendix 3

Definitions of identified Behaviour Change Techniques (Michie et al., 2013)

1.3 Goal setting

'Set or agree on a goal defined in terms of a positive outcome of wanted behavior'

2.1 Monitoring of behaviour by others without feedback

'Observe or record behavior with the person's knowledge as part of a behavior change *strategy'*

2.2 Feedback on behaviour

'Monitor and provide informative or evaluative feedback on performance of the behavior'

2.3 Self-monitoring

*'Establish a method for the person to monitor and record their behavior(s) as par*t of a *behavior change strategy'*

2.6 Biofeedback

'Provide feedback about the body (e.g. physiological or biochemical state) using an external monitoring device as part of a behavior change strategy'

4.1 Instruction on how to perform the behaviour

'Advise or agree on how to perform the behavior (includes 'Skills training')'

5.1 Information about consequences

'Provide information (e.g. written, verbal, visual) about health consequences of performing the behavior'

6.1 Demonstration of the behaviour

'Provide an observable sample of the performance of the behaviour, directly in person or *indirectly e.g. via film, pictures, for the person to aspire to or imitate'*

7.1 Prompts /cues

*'Introduce or define environmental or social stimulus with the purpose of prompt*ing or cueing the behavior'

8.1 Behavioural practice / rehearsal

'Prompt practice or rehearsal of the performance of the behavior one or more times in a context or at a time when the performance may not be necessary, in order to increase habit *and skill'*

8.7 Graded tasks

'Set easy-to-perform tasks, making them increasingly difficult, but achievable, until behavior *is performed'*

9.1 Credible source

'Present verbal or visual communication from a credible source in favour of or against the behavior'

11.1 Pharmacological support

'Provide, or encourage the use of or adherence to, drugs to facilitate behavior change'

Appendix 4

Definitions of identified Modes of Delivery (Carey et al., 2017)

01.01 Human, Face-to-face

'Delivery through human contact in which the participant meets a person in real-time, face to face'

01.02 Human, distance (unspecified)

'Delivery through human contact in which the participant has contact with a person at a distance'

01.02.01 Human, distance, audio call

'Delivery through a telephone call involving audio/voice only'

01.02.03 Human, distance, text message

'Delivery through a written message sent via SMS from a person (i.e. as opposed to automated SMS)'

02 Printed material (unspecified)

'Delivery through information produced on paper'

03 Digital (unspecified)

'Delivery through a form of digital technology, including computer, smartphone, tablets, television, and wearable or environmental devices'

03.01.01 Digital, Phone, Email

'Delivery through a message sent via electronic messenger to a specific email address'

03.01.06 Digital, Phone, App

'Delivery through a purpose-built stand-alone piece of software designed for a particular *purpose'*

03.02 Digital, computer /TV

'Delivery through a computing device (desktop/ laptop/tablet) or television set'

04 Somatic (unspecified)

'Delivery through a device designed to act within the body'

04.05 Somatic, liquid

'Delivery through a fluid substance'

Supplementary Table 1

Additional patient and study characteristics.

Study, Year Funding	Setting and Location	Population Characteristics				
		Mean age, years (SD)	Sex (Female %)	Diagnosis	Diagnostic criteria	Mean disease duration, years (SD)
Studies targeting swallowing difficulties						
Ayres 2017[19] NR	PD and Movement Disorders clinic, Brazil	I: 62.0 (11.5) C1: 62.8 (6.2), C2: 64.5 (5.6)	I: 20% C1: 25%, C2: 33.3%	PD	UK PD Brain Bank Criteria	I: 10.7 (4.7) C1: 11.8 (8.0) C2: 8.8 (6.0)
Logemann 2008[22] NR	Acute-care hospitals and sub-acute residential facilities, USA	NR	NR	PD	Diagnosis by physician	NR
Robbins 2008[26] Various funders[a]	Acute-care hospitals and sub-acute residential facilities, USA	Median: 81	30%	PD without D 30%; PD with D 20%; D 50%	Diagnosis by physician	NR
Troche 2010[29] Various funders[b]	Academic centre / outpatient clinic, USA	I: 66.7 (8.9) C: 68.5 (10.3)	I: 16.7% C: 26.7%	PD	UK PD Brain Bank Criteria	NR
Reyes 2015[25] No funding received	NR, Australia	I: 56 (10.2) C: 50 (9.2)	I: 33% C: 44%	HD	Positive genetic test, clinically verified disease expression	I: 5 (2.6) C: 6 (2.0)
Cleary 2010[20] (abstract) NR	NR, Canada	NR	NR	ALS	NR	NR

Manor 2013[23] NR	Movement Disorders Unit, Israel	I: 67.66 (8.26) C: 69.86 (9.7)	43%	PD	UK PD Brain Bank Criteria	I: 7.43 (4.66) C: 8.76 (5.67)
Wei 2017[30] NR	Outpatient clinic, China	I: 71.4 (12.7) C: 69.3 (11.3)	I: 39.4% C: 41%	PD	UK PD Brain Bank Criteria	NR
Studies targeting dietary content						
Almeida 2016[18] NR	Outpatient clinic, Brazil	I: 56.8 (10.5) C: 54 (10.5)	I: 48.60 % C: 27.80%	ALS	El Escorial Criteria	I:360 days (NR) C: 315 days(NR)
Morassutti 2012[24] NR	Outpatient clinic, Italy	I: 67.5 (9.8) C: 69.8 (6.4)	I: 25% C: 52%	ALS	NR	I: 448 days (305) C: 616 days (775)
Wills 2017[31] (abstract) ALS Association	General hospital ALS clinic, USA	NR	NR	ALS	NR	NR
Sheard 2014[27] NR	Community-dwelling patients, Australia	Median (range): 69 (35-84)	NR	PD	Determined by participants' physician or neurologist and self-reported by participant	Median (range): 7.0 (1.5-26.5)
Silva 2010[28] Funding[d]	Neuromuscular outpatient clinic, Brazil	53 (range 32-69)	12.5%	ALS	El Escorial Criteria	2 (1)
Dorst 2013[21] Funding[c]	NR, Germany	Median (range): I: 66.5 (43-80) C: 58.5 (44-77)	42.3%	ALS	Revised El Escorial Criteria	Median (range) I: 18.5 months (2-33) C: 13.5 months (1-39)

Supplementary Table 2

Risk of bias summary: Judgements of risk of bias for each included study.

Author, year	Methodological quality assessment						
	Selection bias		Performance bias	Detection bias	Attrition bias	Reporting bias	
	Random sequence generation (selection bias)	Allocation of treatment concealed	Blinding of participants and personnel	Blinding of outcome assessment	Incomplete outcome data	Selective reporting	Other biases (e.g. commercial funding)
Ayres 2017[19]	H	U	L	U	U	L	L
Logemann 2008[22]	U	U	L	U	L	U	L
Manor 2013[23]	U	U	L	L	L	U	L
Reyes 2015[25]	L	L	U	U	L	U	L
Robbins 2008[26]	L	L	L	U	L	U	L
Troche 2010[29]	U	U	L	L	L	L	L
Wei 2017[30]	H	H	U	U	L	U	L

Almeida 2016[18]	U	U	U	U	L	U	L
Morassutti 2012[24]	U	U	U	U	L	U	L
Wills 2017[31]	L	U	H	U	U	U	L
Sheard 2014[27]	L	L	H	U	L	L	L
Dorst 2013[21]	U	U	L	U	U	U	L
Silva 2010[28]	U	U	L	U	L	U	L
L: low risk of bias; H: high risk of bias; U: unclear risk of bias							

Supplementary Table 3

Behaviour change techniques (BCTs) applied in intervention studies addressing swallowing difficulties (Michie et al.).[13]

Study	Population	Behaviour Change Technique											
		Monitoring of behaviour by others without feedback	Feedback on behaviour	Self-monitoring	Biofeedback	Instruction on how to perform the behaviour	Information about consequences	Demonstration of the behaviour	Prompts /cues	Behavioural practice / rehearsal	Graded tasks	Credible source	Insufficient detail to code
		2.1	2.2	2.3	2.6	4.1	5.1	6.1	7.1	8.1	8.7	9.1	
Ayres[19] 2017	PD			X		X							
Logemann 2008[22]	PD+D					X							
Robbins 2008[26]	PD+D	X				X							
Troche 2010[29]	PD		X	X		X				X			
Reyes 2015[25]	HD			X		X			X	X	X		
Cleary 2010[20]	ALS												X
Manor 2013[23]	PD			X	X	X				X		X	
Wei 2017[30]	PD		X			X	X	X		X			
Total	N/A	1	2	4	1	7	1	1	1	4	1	1	0

ALS, Amyotrophic Lateral Sclerosis; D, dementia; HD, Huntington's Disease; N/A, not applicable; PD, Parkinson's disease; PD+D, Parkinson's disease with dementia

Supplementary Table 4

Modes of delivery (MoDs) applied in intervention studies addressing swallowing difficulties (Carey et al., 2017).[14]

Study	Population	Mode of delivery											
		Human, Face-to-face	Human, distance (unspecified)	Human, distance, audio call	Human, distance, text message	Printed material (unspecified)	Digital (unspecified)	Digital, Phone, Email	Digital, Phone, App	Digital, computer /TV	Somatic (unspecified)	Somatic, liquid	Insufficient detail to code
		01.01	01.02	01.02.01	01.02.03	02	03	03.01.01	03.01.06	03.02	04	04.05	
Ayres 2017[19]	PD	X				X							
Logemann 2008[22]	PD+D	X										X	
Robbins 2008[26]	PD+D											X	
Troche 2010[29]	PD	X									X		
Reyes 2015[25]	HD	X		X	X								
Cleary 2010[20]	ALS												X
Manor 2013[23]	PD	X								X			
Wei 2017[30]	PD	X	X				X				X		
Total	-	6	1	1	1	1	1	0	0	1	2	2	1

ALS, Amyotrophic Lateral Sclerosis; D, dementia; HD, Huntington's Disease; N/A, not applicable; PD, Parkinson's disease; PD+D, Parkinson's disease with dementia

Supplementary Table 5

Behaviour change techniques (BCTs) applied in intervention studies targeting dietary content (Michie et al., 2013).[13]

Study	Population	Behaviour Change Technique													
		Goal setting	Monitoring of behaviour by others without feedback	Feedback on behaviour	Self-monitoring	Biofeedback	Instruction on how to perform the behaviour	Information about consequences	Demonstration of the behaviour	Prompts /cues	Behavioural practice / rehearsal	Graded tasks	Credible source	Pharmacological support	Insufficient detail to code
		1.3	2.1	2.2	2.3	2.6	4.1	5.1	6.1	7.1	8.1	8.7	9.1	11.1	
Almeida 2016[18]	ALS						X								
Morassutti 2012[24]	ALS						X							X	
Wills 2017[31]	ALS	X		X	X		X						X		
Sheard 2014[27]	PD												X		
Dorst 2013[21]	ALS														X
Silva 2010[28]	ALS						X								
Total	6	1	0	1	1	0	4	0	0	0	0	0	2	1	1

ALS, Amyotrophic Lateral Sclerosis; D, dementia; HD, Huntington's Disease; N/A, not applicable; PD, Parkinson's disease; PD+D, Parkinson's disease with dementia

Supplementary Table 6

Modes of delivery (MoDs) applied in intervention studies targeting dietary content (Carey et al., 2017).[14]

Study	Population	Mode of delivery											
		Human, Face-to-face	Human, distance (unspecified)	Human, distance, audio call	Human, distance, text message	Printed material (unspecified)	Digital (unspecified)	Digital, Phone, Email	Digital, Phone, App	Digital, computer /TV	Somatic (unspecified)	Somatic, liquid	Insufficient detail to code
		01.01	01.02	01.02.01	01.02.03	02	03	03.01.01	03.01.06	03.02	04	04.05	
Almeida 2016[18]	ALS												X
Morassutti 2012[24]	ALS	X									X		
Wills 2017[31]	ALS	X						X	X				
Sheard 2014[27]	PD	X		X									
Dorst 2013[21]	ALS											X	
Silva 2010[28]	ALS											X	
Total		3	0	1	0	0	0	1	1	0	1	2	1

ALS, Amyotrophic Lateral Sclerosis; D, dementia; HD, Huntington's Disease; N/A, not applicable; PD, Parkinson's disease; PD+D, Parkinson's disease with dementia