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A systematic review of behavioral techniques used in nutrition and weight loss interventions among adults with mobility impairing neurological and musculoskeletal conditions

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Abstract

Obesity is a common comorbidity in adults with mobility impairing neurological and musculoskeletal conditions, such as stroke and arthritis. The interaction between mobility impairments and environmental factors often compromises motivation and ability to engage in healthy behaviors. Such difficulties to engage in healthy behaviors can result in energy imbalance, weight gain, and a cycle of functional declines; i.e., obesity can exacerbate mobility impairments and symptoms and increase the likelihood of other comorbid conditions, all of which make it more difficult to engage in healthy behaviors. To help disrupt this cycle, there is a need to identify strategies to optimize energy balance. Thus, this review summarizes clinical trials of nutrition and weight loss interventions in adults with mobility impairing conditions. Although adults with osteoarthritis were represented in large rigorous clinical trials, adults with neurological conditions were typically represented in small feasibility studies characterized by a small number of participants, a short-term follow-up, and high attrition rates. Studies varied greatly in outcome measures, description and implementation of the interventions, and the strategies used to promote behavior change. Nutrition and weight loss research in adults with mobility impairing conditions is still in its formative stages and there is a substantial need to conduct randomized controlled trials.

Keywords

Disability; Nutrition; Nervous System Diseases; Musculoskeletal Diseases

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Adults with mobility impairing neurological and musculoskeletal conditions, such as stroke and arthritis, are approximately two to four times more likely to be obese compared to adults without disabilities (1-3). The reciprocal relationship between obesity and impairments in neurological and musculoskeletal systems may help to explain the increased likelihood of obesity. Obesity is a risk factor in the diagnosis of several mobility impairing neurological and musculoskeletal conditions (4, 5). Furthermore, neurological and musculoskeletal impairments make it difficult to engage in healthy behaviors to achieve energy balance and prevent weight gain (1, 6). Regardless of whether obesity is a cause or a consequence of a neurological or musculoskeletal condition, it can initiate and accelerate a cycle of preventable functional declines; i.e., obesity can exacerbate mobility impairments and symptoms, as well as increase the likelihood of other comorbid conditions, such as diabetes and cardiovascular disease, all of which can make it more difficult to engage in healthy behaviors (7-10). Thus, there is a need to optimize energy balance in adults with mobility impairing neurological and musculoskeletal conditions to avoid and disrupt the cycle of preventable functional declines.

Obesity may accelerate disease processes and accentuate mobility impairments among adults with neurological and musculoskeletal conditions. Obesity is a pro-inflammatory state that might exacerbate inflammatory disease processes (11). For example, adipokines, which are cytokines secreted by adipose tissue, are associated with the pathogenesis of rheumatoid arthritis and multiple sclerosis (12-15). Obesity may also accentuate mobility impairments by increasing joint loads and pain as well as restricting range of motion (7). In a research sample of women with disabling neurological and musculoskeletal conditions, Nosek et al. (16) found that obesity was a prevalent problem and obesity was associated with disability severity and several comorbid conditions.

The interaction between obesity, mobility impairments, and environmental factors may also increase participation restrictions in life roles and can compromise confidence, motivation, and ability to engage in healthy behaviors (17). For example, the built environment, equipment, and polices of many recreational centers create accessibility barriers for adults with mobility impairments to engage in community-based exercise programs (18). Adults with mobility impairing conditions experience discrimination, restricted nutritional autonomy, and can have negative views about their body image, all of which may be compounded by obesity and lead to decreased confidence and ability to participate in life roles and healthy behaviors (19-24). In a qualitative study, Pain and Wiles (25) found that people with disabilities who were obese often felt discriminated against and experienced problems obtaining appropriate mobility devices and accessing community services.

Although adults with mobility impairing conditions need access to health promotion and wellness services, they often have limited opportunities to receive such services (17, 26-28). Physical, occupational, and dietary therapy is typically not a reimbursable healthcare service unless it is deemed medically necessary (29, 30). Healthcare services with the goal of tertiary prevention and health education are not readily accessible. Furthermore, adults with mobility impairing conditions often experience many barriers in accessing government programs that can disseminate relevant and appropriate health education (27, 31, 32). Difficulties in obtaining expert advice may make adults with mobility impairing conditions

susceptible to misinformation claiming that a particular diet can cure or reduce symptom severity.

Given the need to support adults with mobility impairing conditions in achieving energy balance, it is important to review the existing research literature. Several recent review articles summarize health behavior interventions in adults with disabilities (33-37). However, these reviews typically focus on physical activity and/or the benefits of engaging in a particular health behavior; e.g., describing the benefits of exercise rather than strategies used to promote exercise adherence. Furthermore, many reviews are disease-specific and there are concerns about developing behavior change interventions independently of each other rather than building effective intervention strategies (38). Thus, there is a need to identify and describe empirically-tested behavior change techniques to support healthy eating habits and weight management across adults with different disabling conditions. Such a review may facilitate researchers and clinicians to utilize these techniques in clinical practice or to test and refine in research.

Therefore, the purpose of this review was to identify and summarize clinical trials of nutrition and weight loss interventions in adults with neurological and musculoskeletal conditions that characteristically result in mobility impairments. Specifically, we summarize the outcome measures used in these clinical trials and describe the delivery format and behavior change techniques used in the evaluated intervention. Describing the behavior change techniques used in nutrition and weight loss interventions is an important first step in understanding the “active ingredients” that produce the desired behavioral changes and resulting functional and quality of life outcomes. Because there are several reviews on physical activity interventions, we restricted our review to studies that evaluated behavior change interventions with a nutritional education component and included weight loss as an outcome measure.

Methods

Search strategies, study selection, and result reporting are described below according to PRISMA (39). We used Coventry Aberdeen LOndon – REfined (CALO-RE) taxonomy to describe the behavior change techniques used in the interventions (40). The taxonomy defines 40 behavior change techniques (e.g., goal-setting, using a role model, and enlisting social support) commonly used in intervention research (41). The CALO-RE is based on the Abraham and Michie's taxonomy, which was found to have good consistency between coders and between intervention manuals and research articles (41).

Eligibility criteria

We applied the following inclusion criteria: (a) clinical trials of interventions that incorporated educational topics on nutrition; (b) the study included community-dwelling adults with chronic neurological or musculoskeletal conditions that characteristically result in lower-extremity mobility impairments (e.g., multiple sclerosis, stroke, spinal cord injury, arthritis, lupus, cerebral palsy, and spina bifida); (c) body weight was used as an outcome measure; (d) the study was described in the English language and published between 1980 and 2013.

Exclusion criteria were: (a) case studies or studies with less than 11 research participants, conference proceedings and abstracts, review articles that described ongoing research, observational/secondary data analysis studies that identify risk factors for disease, or studies exploring body mass index as a moderator of an intervention not focused on nutrition or weight loss; (b) medications, supplements, gastric tube feeding, or surgical interventions; (c) interventions designed to promote weight gain or prevent sarcopenia; (d) patients living in a long-term care facility or the study had a primary inclusion criterion of childhood age or having a diagnosis of cardiovascular disease, idiopathic/non-specific signs and symptoms (e.g., chronic pain), developmental disability not characterized by mobility impairments (e.g., excluding autism, intellectual disability, and Down syndrome, while including spina bifida and cerebral palsy), cancer, endocrine disease, mental health disorders, epilepsy, or Alzheimer's disease; (e) inadequate description of how the intervention promoted behavior change (i.e., operationally defined as coding at least two behavior change techniques from the CALO-RE taxonomy, which was intended to exclude interventions that were coded as using only the behavior change technique of instruction).

Information sources & search

We used multiple search strategies to identify studies. We first searched PubMed, Scopus, CINHAL, and PsycINFO using the following MeSH and/or subject terms: disabilities, physical conditions, musculoskeletal conditions, and nervous system conditions. We then combined these terms with the following MeSH and/or subject terms: diet, overweight, nutrition, eating behavior, body weight, nutrition therapy, nutrition support, nutritional status, nutrition assessment, weight reduction programs, weight control, obesity, weight loss, weight gain, and appetite. The search was limited to English and human adults ≥ 18 years of age. An additional search in Google Scholar and PubMed was performed by using the terms nutrition, weight, intervention, or education and combing them with the following search phrases and names of specific conditions: mobility, autoimmune disease, neuromuscular, arthritis, cerebral palsy, amputation, fracture, fibromyalgia, spina bifida, spinal cord injury, traumatic brain injury, polio, stroke, lupus, muscular dystrophy, multiple sclerosis, or Parkinson. We also searched the reference list of relevant review articles and the following journals were hand-searched: Journal of Nutrition, Journal of the Academy of Nutrition and Dietetics, British Journal of Nutrition, Disability Studies Quarterly, Disability and Health Journal, and American Journal of Preventive Medicine.

Study selection

For all retrieved studies, citations and abstracts were downloaded to EndNote and duplications were removed. The search procedure was divided into two phases: (1) title and abstract review and (2) full-text article review. For the first phase, we scanned titles and abstracts in each database to identify any potential study that could meet inclusion-exclusion criteria. After this preliminary search, we scanned the abstracts of articles to exclude reviews, conference proceedings, case studies, studies published before 1980, and studies on children, healthy adults, and individuals who did not have mobility impairing conditions as defined above. For the second phase of review, we scanned the articles in detail, coded behavior change techniques, and excluded studies that did not meet any remaining criteria.

Data collection process, data items, & synthesis

For the remaining pool of articles, sample characteristics (e.g., gender, race, education, and disability level), type of research design, outcome measures, and intervention characteristics (e.g., length of intervention, number of contacts, delivery format, guiding intervention theory, and/or framework) were extracted from the articles. By using simple pooling across studies, mean amount of weight loss and other characteristics of the research sample and intervention were calculated (e.g., mean estimates were not weighted by sample size). The first author and a graduate assistant extracted all data and coded behavior change techniques independently. Behavior change techniques were compared and tallied across studies. Disagreements in coding were discussed until consensus was reached.

Results

Study selection

We had an initial pool of 914 articles. Of these, we excluded 350 articles during the first phase of review (see Figure 1). Many articles were excluded due to being literature reviews, observational studies on risk factors for diseases, or did not include adults with mobility impairing neurological and musculoskeletal conditions. In the second phase of review, we excluded 475 articles, as they did not describe the implementation of an intervention, or were medication, surgical, or supplementation interventions, or focused on gastric tube feeding. An additional 48 articles were excluded for not providing enough detail on how behavior change was encouraged. The remaining 41 articles described 25 interventions; 16 of the articles described a secondary/process evaluation of the intervention.

Study characteristics

Table 1 provides a summary of the characteristics of the 25 research samples. The 25 research samples had 2490 community-dwelling adults with neurological and musculoskeletal conditions; 65% were female and the mean age was 56.5 years. Most studies had research samples (n=20) with a mean age of greater than 50 and five research samples had a mean age greater than 65. Twelve studies reported on the race/ethnicity (two studies > 80% racial minorities and eight studies < 30% racial minorities). There were 165 adults with neurological conditions (stroke, n=44; spinal cord injury, n=53; multiple sclerosis, n=37; polio, n=11; spina bifida, n=13; cerebral palsy, n=7) and 1643 adults with osteoarthritis, 505 adults with rheumatoid arthritis, 125 adults with fibromyalgia, and 41 adults with lupus.

There was little consistency on how health and function were characterized among the different research samples. However, some characteristics can be derived from study criteria. For example, seven studies excluded individuals for not being able to walk, and nine studies excluded individuals because their disease status was assessed as being too severe. Twelve studies tried to avoid ceiling effects by excluding individuals whose disease status or symptom impact was assessed as being only minor. Fifteen research studies had a criterion of being overweight or obese, (i.e., body mass index ≥ 25).

Research design and outcomes—Seventeen interventions were evaluated using a randomized controlled trial, while two other trials used a control group but did not randomize participants. Six interventions were evaluated using a pre-posttest design without a control group. One intervention was reported as being assessed using a double-blind research design, and ten interventions were reported as being assessed with a single-blind research design. Ten studies conducted a power analysis to determine the appropriate sample size, and seven studies conducting an intent-to-treat analysis. Mean attrition rate across all studies was 17.3%, with six studies reporting attrition rates greater than 25%.

The timing of when outcome measures were administered in relation to the first pretest assessment varied greatly. The first posttest assessment ranged from 3 weeks to 36 weeks (average 15 weeks) after the first pretest assessment. Thirteen studies included more than two posttest assessments. The second posttest assessment ranged from 12 weeks to 104 weeks (average 38 weeks) after the first pretest assessment. Five studies included assessment time points after intervention contacts had completely ceased.

Synthesis of results

Mean weight loss across interventions (n=23) was − 4.11 kg (two studies reported changes in BMI only). Nine studies included measures of percent body fat using dual-energy x-ray absorptiometry, skin fold calipers, or air displacement plethysmography. Outcome measures used to examine the potential beneficial effects of weight loss or a particular type of diet included patient-reported physical function (n=18), biomarkers (n=18), pain (n=17), engagement in healthy behaviors (n=16), patient-reported mental health (n=13), and provider-reported/objective outcomes of physical function (n=11). Fewer studies used outcome measures of social function (n=8), fatigue (n=7), and objective cognitive assessments (n=1). Only one study examined cost-effectiveness.

Intervention effects included statistically significant improvements across time or between groups in weight (n=21), patient-reported physical function (n=17), pain (n=16), biomarkers (n=14), engagement in healthy behaviors (n=12), and provider-reported/objective measures of physical function (n=7). Fewer studies reported statistically significant improvements in mental function (n=7), fatigue (n=5), and social function (n=6). Three studies reported that participants experienced adverse events serious enough to cause them to withdraw from the study. Twelve studies conducted analyses to identify mechanisms of action (i.e., explaining changes in outcomes or identifying sub-groups that responded differently to the intervention); two studies explored mechanisms of behavior change (e.g., exploring changes in self-efficacy); 11 studies explored mechanisms for improving impairments in body functions and structures (e.g., symptoms, body weight, biomarkers, etc.), and three studies explored mechanisms for improving function in daily activities.

Description of intervention—Nine interventions included only topics on nutrition; sixteen interventions included topics on nutrition and physical activity, and seven interventions included topics on symptom self-management. The most common delivery formats were face-to-face contacts (n=23) either in a group (n=17) or one-to-one instruction (n=10), and some using both forms of contact (n=7). Two interventions primarily used

distance education approaches, i.e., phone. Five interventions used a combination of distance education approaches and face-to-face contact. The length of intervention ranged from 4 to 72 weeks (including follow-up visits). The number of contacts the participants had with the interventionists ranged from 3 to 216 contacts. One intervention modified/tailored the number of contacts based on the participants' needs, and one intervention had an email/call in-service to answer participants' questions when needed. The most common health professionals that delivered the interventions were registered dieticians/nutritionists (n=15), followed by exercise physiologists (n=10), non-licensed education specialists (n=7), psychologists (n=4), and physicians (n=3).

Behavior change techniques—Table 2 summarizes the frequency counts of the behavior change techniques used across interventions. Six interventions were described as being based on a behavior change theory (e.g., social cognitive theory). The number of behavior change techniques used within a single intervention ranged from 2 to 17 techniques, with 14 interventions incorporating five or more behavior change techniques. The most common behavior change technique employed was presenting instructive information (n=25), followed by self-monitoring of behavior (n=21), modeling or demonstrating the behavior (n=13), presenting feedback about performance (n=13), modeling (n=13), problem solving/barrier identification (n=12), self-monitoring of outcomes (n=10), and restructuring the environment (n=9). Action planning (n=1), time management (n=0), prompting social comparisons (n=1), communication skills (n=2), and rewarding participants based on effort (n=0) or success (n=1) were infrequently applied behavior change techniques.

Discussion

Summary of evidence

Although adults with knee osteoarthritis were represented in large rigorous clinical trials (42-56), adults with systemic musculoskeletal conditions and neurological conditions were represented in smaller feasibility studies. These studies were typically conducted in a small number of participants, had a short-term follow-up, and were limited by attrition rates or non-compliers. Only two studies explored mechanisms of behavior change, and intervention descriptions often lacked sufficient detail to implement the intervention within clinical practice or improve upon it in research. Thus, our review highlights a need for fully-powered randomized controlled trials that examine and identify clearly-described and theoretically-based nutrition and weight loss interventions in adults with mobility impairing neurological and musculoskeletal conditions.

Delivery formats, intervention topics, outcome measures, and the combination of behavior change techniques implemented varied across studies depending on the research paradigm used. Several included interventions (n=11) were developed and tested using a traditional biomedical research paradigm. In such biomedical studies, participants were asked to adhere to a particular diet and/or exercise program using two or three behavior change techniques, and the intervention was evaluated with outcomes of disease severity and physical function. Some interventions were developed and tested using a patient-centered, biopsychosocial

paradigm (45, 62, 72, 73, 77). In such biopsychosocial studies, participants collaborated with the interventionist to develop individualized diet and/or exercise programs employing multiple behavior change techniques, and the intervention was evaluated with outcomes of disease severity as well as physical, mental, and/or social function. Below we summarize findings in weight loss outcomes and the similarities and differences across the included studies in their research design and intervention format and dose as well as provide suggestions for future research.

Weight loss outcomes

Our findings that 21 studies reported statistically significant improvement in weight loss across time or between groups and that average weight loss across interventions was -4.11 kg should be interpreted with caution. Small sample sizes, high attrition rates, failure to conduct intent-to-treat analyses, maturation, and selection effects could have all been possible threats to validity (83). Nonetheless, given the higher rates of inactivity and increased barriers for eating healthy among adults with disabling conditions, it is possible that small improvements in lifestyle behaviors could result in significant short-term weight loss. However, research in the general population indicates that including only short-term follow-ups in weight loss studies can be misleading and that weight gain is likely once intervention contacts cease (84, 85).

Few included studies incorporated comprehensive measures of body composition. Measurements of lean body mass and percent body fat might be particularly important to include in studies of weight loss interventions among adults with neurological and musculoskeletal conditions. Such measures are needed to help explain findings of the obesity paradox in observational studies (86) and further examine whether weight loss and associated declines in muscle mass results in decreased physical function among adults with disabling conditions who may already have problems with sarcopenia. Furthermore, using percent body fat as a study inclusion criterion rather than body mass index may be more suitable in populations with muscle atrophy (17). Whether it is appropriate to use weight loss as a primary outcome in clinical trials rather than the desired outcome of increased muscle mass and decreased percent body fat needs to be explored among adults with mobility impairing neurological and musculoskeletal conditions.

Research design

Participants—More studies in our review focused on adults with musculoskeletal conditions than on adults with neurological conditions. In particular, 86% of the included research samples (n= 2,490) were in adults with arthritis. Perhaps this is because several observational studies indicate that obesity is associated with pain severity (87), whereas the adverse effects of obesity in adults with neurological conditions are not as well documented. Nonetheless, adults with multiple sclerosis, for example, have a similar life expectancy as the general population and therefore have a similar need to reduce cardiovascular risks as the general population (88). Stroke survivors, for example, have a substantial risk for a secondary stroke and therefore have a need to lose weight to reduce that risk (89). Thus, there is a need to develop and test nutrition and weight loss interventions in adults with neurological conditions. We further note that only one study (74) in this review included

participants with different disabling conditions, which may help facilitate the translation of the intervention into healthcare systems (90). Thus, there is a need to examine weight loss interventions that include adults with different disabling conditions.

Outcomes in response to diet and weight loss—The most common outcomes that were incorporated to examine the possible beneficial effects of weight loss or a particular diet were indicators of physical function and pain severity and biomarkers. Few studies incorporated comprehensive outcome measures of social function or participation in life roles, which is arguably the most important outcome for adults with disabling conditions (91). The effects of weight loss or a particular diet on symptom severity, physical function, and social function and underlying biological mechanisms of improvement are important relationships to identify and merit further research. Fortunately, there are a growing number of research studies that are using animal models to understand the biological mechanisms between nutrition and disease processes, which might facilitate translational nutrition and weight loss research in adults with neurological and musculoskeletal conditions (92-94).

Types of Interventions

Nutrition interventions—Nine studies included in our review explored the efficacy of a particular diet to reduce symptom severity and improve function. The specific diets examined varied based on the etiology and pathology of the disabling condition. For example, studies in patients with arthritic conditions focused on anti-inflammatory and vegetarian diets. These studies took a traditional biomedical approach to prescribing the diet program and often were vague in describing the strategies used to promote adherence (59, 64, 65, 67, 69, 79, 80). Furthermore, most of the studies that examined a particular type of diet were initially excluded for lack of detail on how behavior change was encouraged. To reduce attrition and encourage adherence, future research should use a biopsychosocial research paradigm to develop interventions that strike a balance between prescribing the diet as intended and accommodating food preferences and individual circumstances. Behavior change theories could be used to guide the selection of strategies to facilitate adherence. Such research is needed for generating evidence-based guidelines on recommending a specific diet to slow disease progression or reduce symptom severity.

Weight loss interventions—Studies in this review that evaluated weight loss interventions (n=16), often with the goal of examining the effects of weight loss on symptom severity and function, varied in degree of patient-centeredness and consideration for food preferences and individual circumstances. Some studies prescribed a very regimented/structured diet that focused on caloric restriction. Although some of these diets were reported as being efficacious on reducing symptom severity and/or improving mobility (52-54, 58, 63), it is unclear whether individuals can adhere to the diet in the long-term. Frequent intervention contacts over a long period is likely needed to promote adherence, which might be cost prohibitive.

Alternatively, there were patient-centered weight loss interventions that incorporated multiple behavior change techniques or were developed with the input of stakeholders (e.g., patients and caregivers) to reduce accessibility barriers (43, 73, 75, 78, 81). Research

participants received guidelines to reduce caloric intake that took into account individual circumstances, such as food and physical activity preferences and functional status. Nonetheless, many of these studies appeared to take a “shotgun” approach to implementing behavior change techniques, i.e., implementing multiple techniques with the goal of addressing at least some of the participants' needs (95). Applying the multiphase optimization strategy (MOST) (96) could reduce the need for using the shotgun approach. MOST is a framework to develop multicomponent behavior change interventions by comparing each component of the intervention in a randomized controlled factorial research design.

Health promotion and wellness interventions—Three of the included studies were framed as evaluating health promotion or wellness interventions (60, 70, 72). Rimmer et al. (72) described implementing a health-promotion intervention that included a range of topics from nutrition and physical activity to self-care and stress management. Radomski et al. (70) described implementing both a wellness and weight management program for adults with spinal cord injury. Future research will need to explore how to best frame interventions for adults with disabling conditions. Although theoretical differences between weight loss, wellness, and self-management interventions exist, these interventions typically encourage engagement in healthy behaviors associated with achieving energy balance. Nonetheless, how the intervention is framed may have implications for the types of participants that are enrolled in the study and how many respond positively to the intervention. For example, an individual might be inclined to participate in a study with an emphasis on achieving wellness or promoting the idea of being “healthy at every size” but not in a study with emphasis on achieving weight loss (97). Future research should compare the effectiveness of how interventions are framed in relation to participants' psychosocial characteristics.

Intervention format and strategies

Dosing—The lengths of the intervention and number of contacts with the interventionist varied greatly across the studies. Thus, research will need to establish optimal dosing that is cost-effective and promotes long-term behavior change. Optimal dosing might be dependent on the characteristics of the participants. For instance, those with more functional limitations and/or who experience more barriers to healthy behavior engagement might benefit from more frequent contacts with the interventionist. A systematic review of weight loss interventions in the general population indicates that a greater number of contacts are associated with better outcomes, but the identification of an optimal, cost-effective number of contacts remains elusive (98).

Delivery format—Interventions were typically delivered by a licensed health professional face-to-face either in-group or one-to-one visits. A group format might offer opportunities for participants to interact with each other and provide each other with support and advice, while a one-to-one format could afford opportunities to better tailor information to the participants' needs, preferences, and unique barriers (99). Some studies included both one-to-one and group instruction (43, 52, 79), which provides opportunities for both group interactions and individual tailoring of information. Only two of the interventions focused on using distance learning strategies (e.g., phone) to promote behavior change (58, 73).

Given that people with disabling conditions often cite costs and transportation difficulties as major barriers to accessing health and wellness services (100), future research should examine low-cost distance learning approaches.

Behavior change techniques—The most common combination of behavior change techniques applied in the included interventions was instruction and self-monitoring. Dombrowski et al. (101) found in a review of weight loss interventions among adults with heart failure, breast cancer, binge eating disorder, coronary heart disease, and cardiovascular disease that instruction and self-monitoring were associated with better adherence outcomes. Instruction and self-monitoring might be two techniques to address the "how to adhere" question that adults with disabling conditions frequently ask. Research indicates that adults with disabling conditions often express concerns about not knowing how to engage in healthy behaviors on a regular basis (20, 100). Thus, instruction and self-monitoring might be strategies for initiating behavior change.

Surprisingly, few of the included interventions incorporated the behavior change techniques of training in communication skills, emotional regulation, time management, and action planning. These behavior change techniques seem to be particularly relevant to adults with disabling conditions. Lorig et al. (102) note that communication skills, emotional regulation, and action planning (i.e., setting goals and anticipating and planning to overcome barriers) are necessary skills to develop to effectively self-manage chronic conditions. Being unable to communicate needs to caregivers, ineffectively coping with emotions, and poor problem-solving skills may also contribute to obesity (103, 104). Thus, the utility of incorporating Lorig et al.'s framework into weight loss interventions for adults with disabling conditions should be explored.

Limitations

Limitations to this review include the inability to code interventions using the actual intervention manuals of each study, and not conducting a meta-analysis. Because we felt that it would not be possible to obtain all intervention manuals for the included studies (e.g., authors may not have developed a manual or their unwillingness to share their manual), we decided not to code intervention manuals. We felt there would have been inconsistencies between coding of interventions that had a manual and those that did not, which would make comparisons across interventions difficult. Because we did not code intervention manuals, there may have been strategies implemented in the interventions that we did not code, or the authors may not have been explicit. We decided not to conduct a meta-analysis because many of the included studies were not randomized controlled trials and had high attrition rates, leading to biases or inflations in effect size calculations. Conducting a meta-analysis with only the randomized controlled trials that had minimal risk of bias would have restricted our review primarily to adults with arthritis, which was not the intended purpose of this review. Furthermore, we excluded many articles for not providing enough detail about the intervention. An un-biased estimate of weight loss across randomized controlled trials in adults with mobility impairing conditions would need to consider these articles for inclusion. We also decided not to conduct a quantitative or qualitative assessment of risk in accordance with PRISMA guidelines because it was clear that many of the included articles

described pilot studies to demonstrate feasibility for subsequent studies that focus on minimizing threats to validity.

Conclusions

In order to address the obesity epidemic, it will be important to target those that are most at risk for obesity - adults with disabling conditions. The aging baby boomer generation and the increasing rates of obesity in young adulthood will substantially escalate the proportion of the population with disabling conditions (1-3, 24). Thus, there is an urgent need not only to support healthy young adults in achieving energy balance (i.e., primary prevention), but also support adults with disabling conditions to achieve energy balance and maintain healthy lifestyle habits (i.e., tertiary prevention). However, compared to research on weight loss interventions in the general population, research on weight loss interventions in adults with mobility impairing neurological and musculoskeletal conditions is still in its formative stages.

Indeed, there is a substantial need to draw upon strategies developed for weight loss interventions in the general public and examine their effectiveness and relevance in adults with mobility impairing conditions. Too often, rehabilitation research in adults with mobility impairing conditions focuses only on exercise and increasing physical activity levels, which is consistent with the medical model of disability. However, preventing and treating obesity will require changing nutritional habits. Rehabilitation professionals frequently interact with adults with mobility impairing conditions and thus have many opportunities to not only promote exercise adherence, but also, at the very least, begin the discussion about eating healthy while living with a mobility impairment.

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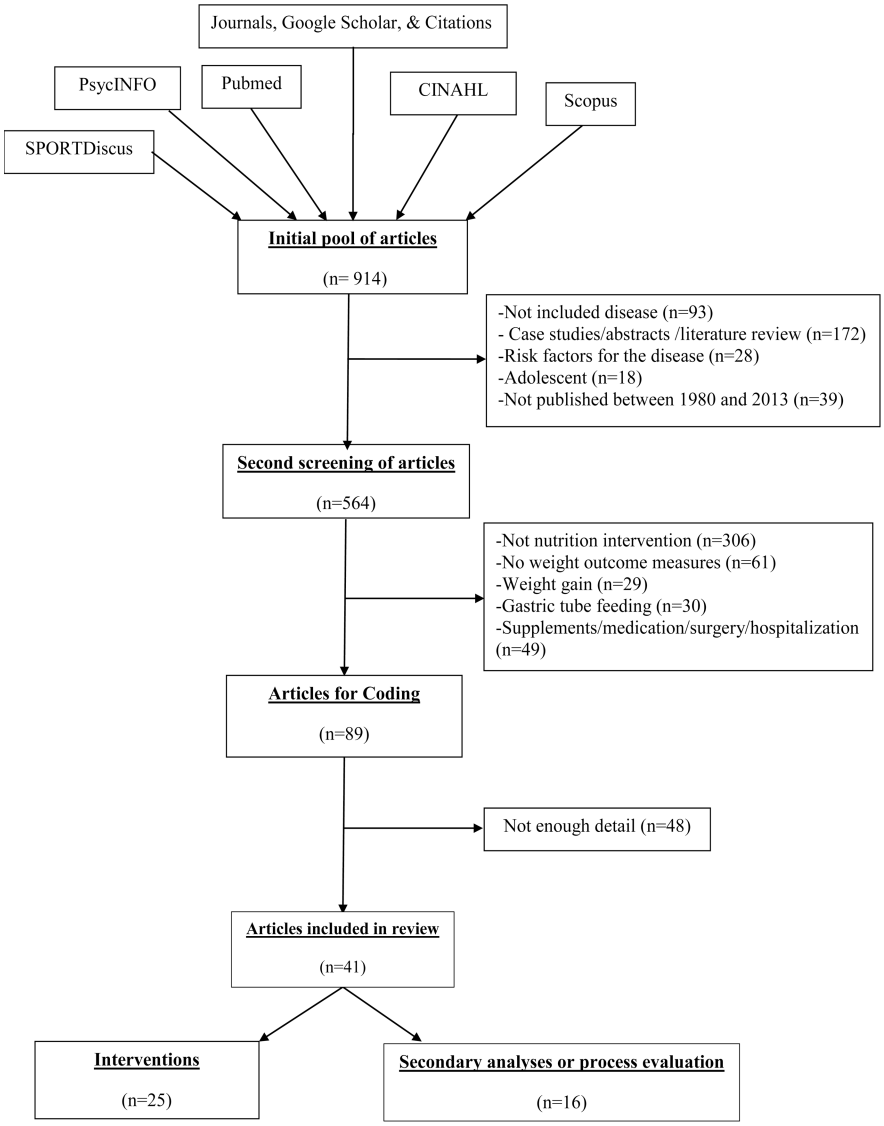

Figure 1. Flow of research articles

Table 1

Summary of included studies and intervention evaluated

	N	Condition	Age	Design	Intervention type	Intervention Format	#BCT	Main benefits/conclusions
ADAPT trial (42-51)	316	OA	69	RCT	WL	Group, one-to-one, phone	12	Weight loss, physical function, OA symptoms, cost-effective
PACT trial (52-54)	87	OA	70	RCT	WL	Group, one-to-one	9	Weight loss, physical function
IDEA trial (55, 56)	454	OA	66	RCT	WL	Group, one-to-one, phone	13	Weight loss, reduced inflammation
Chen (57)	16	SCI	44	Pre/post	WL	Group	11	Weight loss
Davies (58)	23	Lupus	46	RCT	WL	Phone	3	Weight loss, fatigue
Hansen (59)	109	RA	57	RCT	Nutri: Anti-inflam	Face-to-face	3	Symptoms
Hoffman (60)	11	Polio	54	NRCT	Wellness	Group	4	Diet
John (61, 62)	110	RA	61	RCT	Risk reduction	Group	17	Reduce cardiovascular risk
Martin (63)	48	OA	61	Pre/post	WL	Group	2	Weight loss, physical function, pain
McDougal (64)	24	RA	56	Pre/post	Nutri: Vegan	Face-to-face	3	Symptoms, diet
McKellar (65)	130	RA	54	NRCT	Nutri: Med	Group	3	Symptoms, diet
Messier (66)	24	OA	68	RCT	WL	Group, one-to-one	6	Weight loss, symptoms, gait
Nenonen (67)	43	RA	52	RCT	Nutri: Vegan	Face-to-face	4	Symptoms
Paans (68)	35	OA	57	Pre/post	WL	Group, one-to-one, phone	12	Physical function, pain
Panush (69)	33	RA	55	RCT	Nutri: Anti-inflam	One-to-one	5	No effect
Radomski (70)	13	SCI	53	Pre/post	Wellness & WL	Group, one-to-one	6	Feasible, Goal Attainment Scaling
Ravaud (71)	336	OA	64	RCT	WL	One-to-one	4	Weight loss, symptoms
Rimmer (72)	35	Stroke	53	RCT	Wellness	Group	9	Weight loss, QOL, physical function
Rimmer (73)	102	Cross	47	RCT	WL	Phone	11	Weight loss
Senna (74)	83	Fibro	46	RCT	WL	Face-to-face	3	Weight loss, QOL, symptoms
Shah (75-77)	17	Lupus	45	RCT	WL	Group, phone	12	Weight loss, diet, and QOL
Shapiro (78)	42	Fibro	54	Pre/post	WL	Group	4	Weight loss, QOL, symptoms
Skoldstam (79, 80)	56	RA	58	RCT	Nutri: Med	Group, one-to-one, phone	4	Symptoms, physical function, vitality
Somers (81)	232	OA	58	RCT	WL	Group, phone	13	Weight loss, physical function, symptoms
Wolf (82)	111	OA	68	RCT	WL	Group	8	Weight loss

Key: OA = osteoarthritis; RA = Rheumatoid arthritis; SCI = spinal cord injury; RCT = Randomized Controlled Trial; NRCT = Non-randomized Controlled Trial; WL= weight loss; Nutri = nutrition; Anti-inflam = Anti-inflammatory; Med = Mediterranean; #BCT = Number of behavior change techniques used in the intervention; QOL = quality of life

Table 2

Frequency of behavior change technique used across all included interventions

Behavior change technique	Frequency
Instruction	25
Self-monitoring of behavior	21
Modeling (showing)	13
Feedback about performance	13
Problem solving/barrier identification	12
Self-monitoring of outcomes	10
Environmental restructuring	9
Relapse prevention	8
Follow-up prompts	7
Outcome goal setting	7
Process goal setting	7
Training in emotional management	7
Information about general consequences	6
Galvanize social support	6