Nutritional Interventions in Heart Failure: A Systematic Review of the Literature

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ABSTRACT

Background: Heart failure (HF) is a major health care burden and there is a growing need to develop strategies to maintain health and sustain quality of life in persons with HF. The purpose of this review is to critically appraise the components of nutrition interventions and to establish an evidence base for future advances in HF nutrition research and practice.

Methods and Results: Cinahl, Pubmed, and Embase were searched to identify articles published from 2005 to 2015. A total of 17 randomized controlled trials were included in this review. Results were divided into 2 categories of nutrition-related interventions: (1) educational and (2) prescriptive. Educational interventions improved patient outcomes such as adherence to dietary restriction in urine sodium levels and self-reported diet recall. Educational and prescriptive interventions resulted in decreased readmission rates and patient deterioration. Adherence measurement was subjective in many studies. Evidence showed that a normal-sodium diet and 1-liter fluid restriction along with high diuretic dosing enhanced B-type natriuretic peptide, aldosterone, tumor necrosis factor α, and interleukin-6 markers.

Conclusions: Educational nutrition interventions positively affect patient clinical outcomes. Although clinical practice guidelines support a low-sodium diet and fluid restriction, research findings have revealed that a low-sodium diet may be harmful. Future research should examine the role of macronutrients, food quality, and energy balance in HF nutrition. (*J Cardiac Fail 2015;21:989–999*)

Key Words: Diet, sodium restriction, fluid restriction.

Heart failure (HF) is an international public health concern with increasing prevalence and direct health costs. Currently >5 million people in the United States and an estimated 23 million people worldwide are living with HF.[1] By 2030 an estimated 8 million people or 1 out of 33 individuals will have HF in the United States, and medical costs are expected to more than double.[2] Within the context of rapidly developing health care technologies that prolong the lives of persons with HF, there is a growing need to develop strategies to maintain health and sustain quality of life.

There are 6 nutrients that are essential to nutrition: carbohydrates, fats, proteins, water, vitamins, and minerals (including sodium).[3–5] Adequate nutrition is particularly important for persons with HF because the risk for developing electrolyte imbalance and vitamin and micronutrient deficiencies increase with the use of diuretics.

Behavior change to modify nutrition is challenging for persons with HF to accomplish because they are frequently managing multiple comorbidities and organ failure.[6,7] Adding to the challenges of adherence, there is conflicting evidence to support optimal HF nutrition, particularly sodium and fluid intake.[8] A recent meta-analysis examined evidence regarding sodium intake and mortality, and found low-sodium restrictions to increase overall mortality rates in general cardiac disease populations.[9] Much of the evidence related to HF nutrition is based on observational studies. The evidence from trials testing nutritional

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interventions in HF has not been summarized in the literature to date. The purpose of the present review is to summarize the current evidence and provide insight for future innovations in HF nutrition research and practice.

Methods

To identify the latest literature, we searched Cinahl, Pubmed, and Embase for studies published from 2005 to July 2015 on nutrition and HF as exemplified by the following Pubmed search strategy: ((“Diet”[Mesh] OR “Nutrition Therapy”[Mesh] OR “Thirst” [Mesh] OR “Sodium Chloride, Dietary”[Mesh] OR “Sodium, Dietary”[Mesh] OR “salt”[Title/Abstract] OR “thirst”[Title/Abstract] OR nutri*[Title/Abstract] OR diet*[Title/Abstract]) AND (“Heart Failure”[Mesh] OR “heart failure”[Title/Abstract] OR “CHF” [Title/Abstract] OR “HF”[Title/Abstract])).

The searches returned 1,045 studies. In addition to the search terms, studies were included if they were written in English, human research, nutrition and nutritional supplement (ie, protein shakes) interventional studies, adults, and left-sided HF. Studies were excluded if they reported on pharmaceutical or vitamin supplement intervention. Several studies mentioned dietary education as part of a self-care intervention but did not elaborate on what the dietary education provided or did not measure nutrition-related outcomes and were therefore excluded (Fig. 1). Titles, abstracts, and full text were reviewed by ≥2 independent reviewers to determine eligibility (D.B. and J.A.: 68% agreement; A.X. and A.C.: 73% agreement). A 3rd reviewer (M.A.) reconciled disagreements. After full text review, 17 studies met the criteria. After discussing the studies, the reviewers divided the studies into 2 categories: education-based interventions and prescriptive nutrition interventions (Tables 1 and 2). Though not mutually exclusive categories, studies that examined knowledge-related factors and

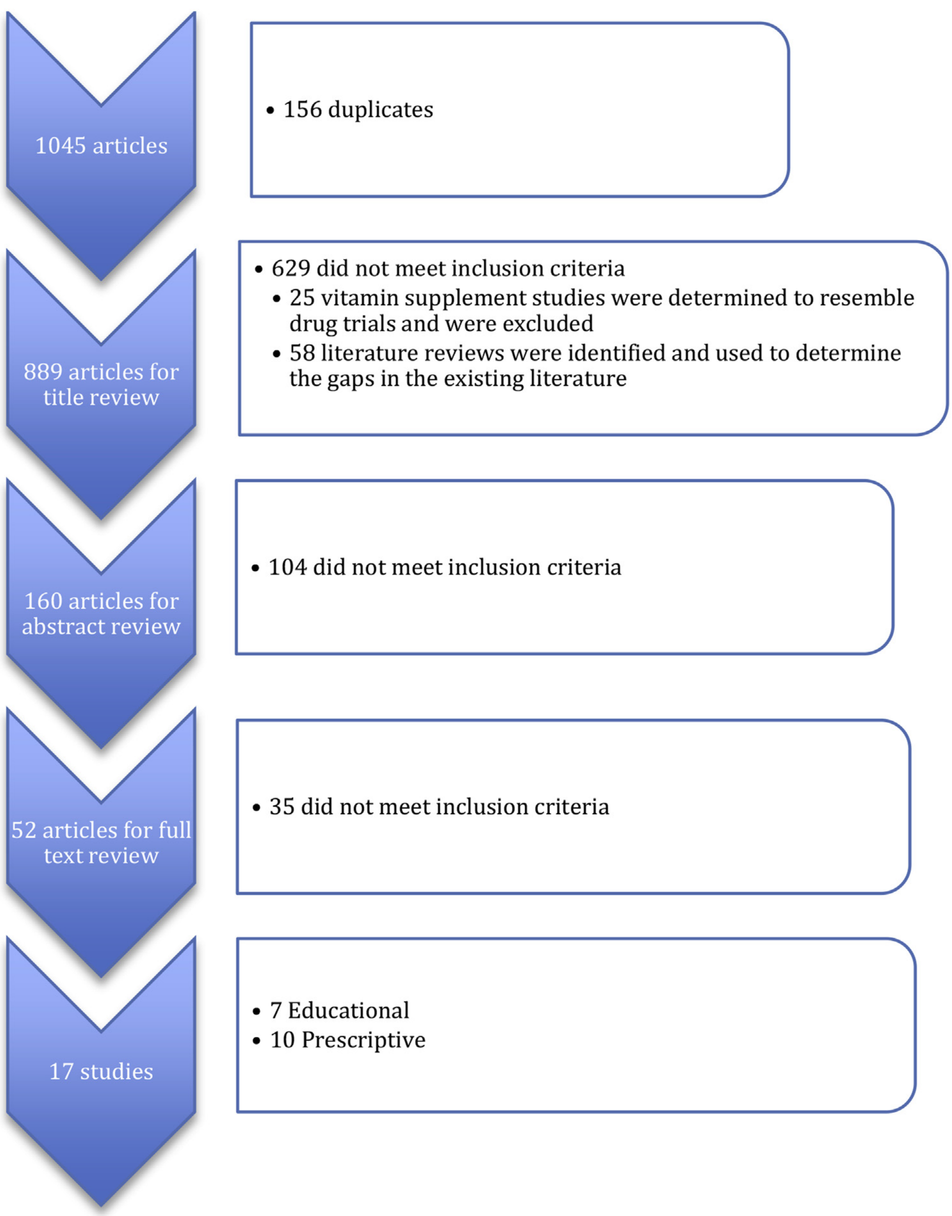

Fig. 1. Article selection.

included education in their purpose statement were categorized as educational interventions. We defined prescriptive nutritional interventions as those that required a particular dietary intake, dietary sodium, and/or fluid consumption regimen for participants without an emphasis on education.

Results

Populations Studied

Of the 17 studies included in this review, 7 studies focused on educational interventions to improve nutritional knowledge and compliance with dietary recommendations in patients with HF and 10 studies were prescriptive nutritional interventions (Tables 1 and 2) All of the studies were randomized controlled trials (RCT); 7 were conducted in North America, 7 in Europe, and 3 in South America. Sample populations of these studies are reflective of the demographics of the country, and only studies from Brazil, Canada, and the United States reported racial diversity. Mean ages ranged from 51 years[10] to 75 years.[11] Overall, women were underrepresented in the samples, ranging from 15%[12] to 65%[11] with most of the studies including <40% women. One trial included decompensated patients with HF, and the remaining studies included compensated or stable patients with HF.[19] There was 1 study including patients with HF with left ventricular assist devices (LVADs); that study was included because there are scant data available supporting a difference in dietary restrictions between patients diagnosed with HF with and without an LVAD.[14] Sample sizes varied among studies; most studies had 40−100 participants. The largest educational RCT was the DIAL trial with 1,518 participants; the largest prescriptive RCT was by Paterna et al with 410 participants.[15,18] Two studies addressed power analysis.[10,11] Finally, 2 studies used a family or dyadic approach for the intervention.[11,12]

Follow-Up

The duration of the studies and interventional time points varied, ranging from 14 days to 36 months. Most patients were contacted 4−6 weeks from baseline and were followed for ≥6 months. Four of the studies provided longer follow-up ranging from 8 to 57 months.[11,14,15,20] Ferrante et al followed patients for a total of 3 years after completion of the trial.[15]

Dietary Restrictions to Improve Nutrition in Heart Failure

There was a common focus on sodium in HF nutrition RCTs and practice. Studies included in this review referred to nutrition as "dietary" and "nutrition teaching" as well as "dietary self-care." These terms were used broadly to cover a very narrow educational focus on teaching a low-sodium diet and food selection. The educational studies provided different parameters to define sodium-restricted or low-sodium diets, most ranging from 2 g/d to 3 g/d. Prescriptive nutritional interventions tested the range of sodium dosing, with sodium restrictions ranging from 0.8 g/d to 5 g/d (Tables 3 and 4).

Beyond sodium, fluid restriction was a key component of prescriptive nutritional studies but not mentioned in studies describing educational interventions. The widest restriction difference between comparison groups was seen in the study by Badin Aliti et al, with the least restrictive (specified) fluid allowance being 2.5 L/d and the most restrictive being 0.8 L/d.[19]

Quality of food selection and nutrient balance were addressed in few of the intervention studies. Nutritional drinks were examined as simple interventions to improve nutrient balance for persons living with HF.[17,21] Also, 3 studies examined calorie/energy balance. Dunbar et al focused on food choices, diet planning, and managing the often-conflicting recommendations for diet with multiple comorbidities, especially diabetes.[10] Donner Alves et al and Kugler et al also included instruction on food groups and nutrients.[13,14] Although many studies used food diaries, most of these studies examined only quantity of sodium, not the source of sodium or change in quality of food choices.

Strategies Used to Change Behavior

Seven studies demonstrated that intense HF education improved compliance with dietary restrictions in an HF population. The control group in 5 studies received written HF education materials that highlighted basic therapeutic life style changes, including daily weights and sodium and fluid restrictions.[10,11,13,14,16] The intervention groups routinely received the same written materials along with either face-to-face counseling or telephone education sessions. Table 3 describes the general strategies used by educational RCTs. All of the studies used multiple strategies; the most common strategies were the use of nurses and dietitians to lead educational sessions, use of study-developed materials, and delivery of individualized patient-specific sessions. No study provided examples of individualized sessions, and therefore it is difficult to understand how this variability may have affected results.

Educational sessions that were held face to face were common and ranged from 30 minutes to 2 hours. Two studies described the educational focus as a "low-sodium diet" and did not mention providing a numeric goal for sodium consumption.[14,15] The Heart Failure Society of America and American Heart Association have online resources available for patient education that were used in 4 out of 7 studies. Only 2 studies published their study protocol or made their study materials publicly available.[22,23] The least commonly used strategies were the involvement of family in the designed intervention and the use of food diary review.[11]

Among prescriptive nutritional interventions, the approach to assist participants to understand how to follow the prescribed sodium/fluid/diet dosing varied. Most used a single handout on how to reduce sodium/fluid consumption, some used standardized diet plans for the participants to

Table 1. Educational Intervention Studies

Study	Sample, Demographics, and HF Characteristics	Design	Measures, Follow-Up, and Time Points	Key Findings
Dunbar,[10] 2014, USA	n = 65; control: n = 19; intervention: n = 46. Female 32.8%. African American 60.7%; white and other 39.3%. Mean age 58 y. NYHA I 31.7%, II 56.7%, III 11.7%	RCT (1:2 randomization ratio) Control, usual care (UC): 2 brochures Intervention, UC + intervention: 1. Two 45-min individual education and counseling sessions 2. Nurse-led (using flip charts and script); content: dietary Na, carbohydrates, fat content charts, common and fast foods, quick nutrition reference guides and suggested snacks, restaurant tips, and sample meal plans with recipes	Measure: Summary of Diabetes Self-Care Activities (SDSCA).* Follow-up: questionnaires sent via mail; follow-up with nurse during HF clinic visits. Time points: baseline and 30 and 90 d. Sodium: 2−3 g as defined by HFSA	1. Increases in SDSCA General Diet scores for intervention group from baseline to 30 d (*P* = .05) 2. Decreases in SDSCA General Diet scores for UC group from 30 to 90 d (*P* = .05)
Dunbar,[11] 2013, USA	n = 117 dyads; control: n = 38 dyads; patient family education (PFE): n = 42; family partnership intervention (FPI): n = 37. Female 37%. African American 42%, white 58%. Mean age 56 y. Family/partner: spouse 52.6%, child 22.4%, other 25%. NYHA II 72.6%, III 11.7%	RCT (3 groups) Control: UC + informational brochure covering HF self-care Interventions: 1. PFE + 2-h family partnership training 2. FPI: 2 2-h sessions of nurse-led training in 1st 2 mo.	Measures: 3-d food record, 24-h urine Na. Follow-up: telephone follow-up (PFE) and study newsletter (FPI). Time points: baseline and 4 and 8 mo. Sodium: urine Na ≤2,500 mg/d.	1. Higher adherence to low-Na diet (≤2,500 mg/d) found in PFE and FPI compared with UC group (*P* = .016) 2. Lower 24-h urinary Na in PFE and FPI at 4-mo follow-up compared with UC group (*P* = .018)
Welsh,[12] 2013, USA	n = 52; control: n = 25; intervention: n = 27. Female 46.2%. White 75%, other 25%. Mean age: control 59 y, intervention 53 y. NYHA II 48.1%, III or IV 51.9%.	RCT (repeated measures) Control: UC, no specific diet instructions Intervention: 1. Six weekly education sessions 2. Low-Na education materials	Measures: 3-d food diary, Dietary Sodium Restriction Questionnaire (DSRQ).* Follow-up: home visit or telephone calls over 6-wk period. Time points: baseline, 6 wk, and 6 mo. Sodium: 2 g as defined by HFSA.	1. Dietary Na intake did not differ between UC and intervention groups at 6 wk 2. Lower dietary Na intake in intervention group at 6 mo (*P* = .01) 3. Attitudes toward low-Na diet improved in intervention group at 6 wk (*P* < .01)
Donner Alves,[20] 2012, Brazil	n = 46; control: n = 23; intervention: n = 23. Female 30%. Race not specified. Mean age 58 y. NYHA I−III.	RCT Control, UC: 1. MD and nurse session 2. Nutritionist session Intervention: 1. UC + diet education focused on relationship between HF and diet 2. Low Na (2−3 g/d) and cholesterol 3. Macro- and micronutrients	Measures: Nutrition Knowledge Questionnaire,† 24-h urine, 24-h diet recall. Follow-up: HF clinic visits. Time points: baseline, 6 wk, and 6 mo. Sodium: 2−3 g/d as defined by AHA, individualized to disease severity.	1. Reduction in Na intake as reported by 24-h recall in intervention group (*P* = .017) 2. No significant difference in urinary Na excretion between groups 3. Reduced calorie intake in intervention group (*P* = .034)
Kugler,[14] 2012, Germany	n = 70; control: n = 36; intervention: n = 34. Female 15%. Race not specified. Mean age 52 y. Outpatients with LVADs: mean 44 days after implantation, 55% Heartmate II, 45% Heartware.	RCT Control: standardized UC for healthy diet, BMI target, regular exercise and reasons to seek psychosocial support Intervention: dietary counseling with follow-up every 2 wk, physical rehabilitation, and psychosocial support counseling	Measures: BMI, exercise tolerance. Follow-up: outpatient visits. Time points: baseline, 6 wk, and 6, 12, and 18 mo. Sodium/fluid parameters not defined.	1. Both groups increased exercise tolerance; no significant difference between groups, though trend toward significance in intervention group 2. Nutritional management effects on BMI after 18 mo showed significant increase in BMI in control group compared with intervention group (*P* < .02)

Ferrante,[15] 2010, Argentina	n = 1,518; control: n = 758; intervention: n = 760. Female 29%. Race not specified. Mean age 65 y. LVEF ≥40%: 20.5%; <40%: 79.5%.	RCT Control: UC Intervention: 1. Handbook: nutrition, exercise, weight and symptom monitoring 2. Nurse-led telephone call	Measures: diet compliance, hospital readmissions, weight control, mortality. Follow-up: individualized nurse-led telephone follow-up over 16–57 mo. Time points: Participants received calls every 14 d, then frequency could change after 4th phone call based on individualized needs and severity of case. Sodium/fluid parameters not defined.	1. HF-related death and HF hospitalization occurred less in intervention compared with control group ($P = .026$) 2. Improved diet compliance in 40% of intervention group 3. Improved daily weight control in 34.9% of intervention group 4. Nurse-based telephone intervention was associated with decreased hospitalizations for patients with chronic HF 1 and 3 years after intervention stopped
Arcand,[16] 2005, Canada	n = 47; control: n = 23; intervention: n = 24. Female 61%. Race not specified. Mean age 59 y. Mean LVEF 22.5%.	RCT Control: 1. Prescribed 2 g/day Na diet 2. Self-help nutritional literature Intervention: 1. Prescribed 2 g/d Na diet 2. Two counseling sessions with nutritionist	Measure: 3-day food record. Follow-up: sessions with nutritionist. Time points: baseline and 3 mo. Sodium: 2 g/d	Decreased Na intake over 3 mo for intervention group ($P < .05$)

HF, heart failure; NYHA, New York Heart Association functional class; RCT, randomized controlled trial; HFSA, Heart Failure Society of America; AHA, American Heart Association; LVAD, left ventricular assist device; BMI, body mass index.
*Has established reliability.[15,17]
†Has established validity.[20]

follow,[18,24,25] and 1 study used a face-to-face session approach acknowledging the importance of social networks and culture on food choices.[26] Philipson et al explained in the most detail the protocol they used to support participants to maintain the dose required for each study group.[26] One study had tighter control over intake, because patients were hospitalized.[19]

Control groups in education interventions and intervention groups in prescriptive nutritional trials (except Philipson et al[26]) used similar methods to give general instructions through the use of general HF education pamphlets. Because improved outcomes were noted in the educational intervention groups, it is possible that prescribed nutrition trials would see different results if more attention was given to support participants to achieve the desired nutritional dosing through the use of additional education strategies.

Adherence Measurement Could Be Improved

Urinary sodium has been acknowledged as the criterion-standard measure of sodium consumption.[27] However, despite underreporting of sodium in food-recall methods documented in earlier work, many studies used this method of assessing sodium consumption. Use of a 3-day food diary,[10,12,16,28] 24-hour diet recall,[13,20,21] and urine sodium[11,13,26] measurement were used in the trials. Most of the prescriptive studies also collected serum for laboratory tests and assessed serum sodium.

Alternate approaches to measuring adherence were also used in 4 studies. Albert et al developed and assessed reliability of the Fluid Restriction Behaviors Scale, an instrument to measure adherence to fluid restriction (Cronbach alpha 0.83–0.85).[29] Three studies reported distributing standardized diets as part of the prescriptive regimen.[18,24,25] Participants were to prepare the foods as described and to report any deviations in a food diary. Additionally, physicians or dietitians called the participants weekly to provide additional assistance with and assessment of adherence.

Adherence was an outcome variable for most educational interventions, but for prescriptive interventions the measure of adherence was used as a process measure to determine if a participant actually followed their prescribed regimen. It was difficult to determine how the data for participants with poor adherence was used. It is unclear if studies used a cutoff threshold level of adherence to include patient data (depending on the study design) or used another approach.

Outcomes of Educational and Prescriptive Nutritional Interventions

Educational interventions resulted in significant improvement in urine sodium excretion,[11,12] self-reported sodium intake[11–13,15] and daily weight monitoring.[14,15] One study reported that participants experienced challenges in obtaining urine sodium which may have limited the ability to detect the effect of the intervention.[20]

Table 2. Prescriptive Nutritional Interventions

Study	Sample, Demographics, and HF Characteristics	Design	Measures, Follow-Up, and Time Points	Key Findings
Biddle,[34] 2015, USA	n = 40; control: n = 18; intervention: n = 22. Female 43%. Race not specified. Mean age 65 y. NYHA II 70%, III 30%.	RCT Control: usual diet Intervention: 11.5-oz can of V8 juice per day + usual diet	Measures: 24-h dietary recalls, blood uric acid, CRP, BNP, lycopene. Time points: baseline, 1 mo.	1. No differences between intervention and control groups in uric acid, BNP, CRP, or Na levels 2. In intervention group CRP levels decreased in women but not men 3. Plasma lycopene levels increased significantly in intervention compared with control group ($P = .02$)
Colin-Ramirez,[35] 2015, Canada	n = 38; control: n = 19; intervention: n = 19. Female 53%. White 95%, other 5%. Mean age 65.5 y. NYHA II 90%, III 10%.	RCT Intervention: Group 1: moderate Na (100 mmol, 2,300 mg/d) Group 2: low Na (65 mmol, 1,500 mg/d)	Measures: 3-d food record for previous week, serum labs, plasma BNP. Follow-up: research dietitian call monthly. Time points: baseline and 3 and 6 mo.	1. Between baseline and 6 mo, Na intake did not significantly differ between groups 2. Median BNP levels decreased at 6 mo for low-Na diet group, but no significant difference in BNP levels between groups
Albert,[29] 2013, USA	n = 46; control: n = 26; intervention: n = 20. Female 39%. White 50.8%, other 49.2%. Mean age 63 y. NYHA I 2%, II 13%, III 61%, IV 24%.	RCT Control: usual care, often a 2,000-mL/d fluid restriction Intervention: 1,000-mL/d fluid restriction for 60 d after discharge	Measures: thirst, adherence to dietary and fluid restrictions, all-cause mortality, HF hospitalization. Follow-up: Reminder telephone call and telephone interview. Time points: 60-d follow-up.	1. Higher self-reported adherence to Na-restricted diet reported in intervention compared with control group (55% vs 3%) 2. HF emergency room visits were numerically but not significantly higher in usual care compared with 1-L/d group 3. Developed and tested reliability of Fluid Adherence Behaviors Scale (Cronbach alpha 0.825−0.85)
Badin Aliti,[19] 2013, Brazil	n = 75; control: n = 37; intervention: n = 38. Female 31%. White 84%, other 16%. Mean age 60 y. Hospitalized for HF admission; NYHA III 47%, IV, 45%; mean LVEF 26%.	RCT Control: 1. Standard hospital diet 2. Liberal fluid (≥2.5 L/d) and dietary Na (3−5 g/d) Intervention: 1. Fluid restriction (≤800 mL/d) 2. Dietary Na restriction (≤800 mg/d)	Measures: serum labs, perceived thirst, readmission. Follow-up: nurse-led admission and follow-up exams during hospitalizations. Time points: admission, 3 d into hospital stay, and 30 d after discharge.	1. Significantly worse thirst in the intervention group ($P = .01$) at 3-d follow-up 2. Restricting dietary Na leads to activation of the antidiuretic and antinatriuretic systems 3. No significant difference in readmissions between groups
Philipson,[20] 2013, Sweden	n = 97; control: n = 48; intervention: n = 49. Female 38%. Race not specified. Mean age 75 y. NYHA II 24%, III 74%, IV 0%.	RCT Control: dietitian or nurse-led session with brief information to decrease salt and fluid intake Intervention: individualized dietary support from and RD or RN, fluid restriction (≤1,500 mL/d), dietary Na restriction (≤5 g/d)	Measures: NYHA, thirst, weight, 24-h recall, HF hospitalization. Follow-up: During HF clinic visits and telephone calls by RD and RN. Time points: baseline, follow-up after 4 wk by nurse, every 2−3 wk for 12 wk by RD or RN, 12 wk and follow-up in 10−12 mo.	1. At the composite end point, there were significant improvements in NYHA and leg edema in intervention group (51% vs 16%; $P < .001$). 2. A significant difference in the numbers of improved patients in intervention group and deteriorated patients in control groups ($P < .001$). 3. Interventions designed to individualize salt and fluid restriction were associated with improved NYHA, weight, lowered diuretic dose, QoL, thirst, reduced fluid retention, and hospitalizations for patients with chronic HF.

Rozentryt,[17] 2010, Poland	n = 29; control: n = 6; intervention: n = 23. Female 24%. Race not specified. Mean age 51 y. NYHA II 28%, III 59%, IV 0.03%.	RCT: double-blind, placebo-controlled Control: 12 kcal/d drink of similar taste and consistency as Nutridrink + usual diet Intervention: 600 kcal/d as a commercially available formulation Nutridrink + usual diet	Measures: weight, inflammatory markers, lipoproteins. Follow-up not specified. Time points: baseline and 6 and 18 wk.	1. Increased edema-free body weight and lean tissue mass after 6 wk in intervention group 2. Significant reduction of TNF-α, soluble TNF-R1, and TNF-R2 from baseline to 18 wk 3. Significant increase in serum lipoprotein concentration
Philipson,[26] 2010, Sweden	n = 30; control: n = 13; intervention: n = 17. Female 27%. Race not specified. Mean age 74 y. NYHA II 17%, III 83%.	RCT Control: general diet info on heart failure Intervention: 1. Na restriction (2−3 g/d) and 1.5 L/d fluid restriction 2. Individualized dietary recommendations to maintain constant energy level	Measures: urine volume and Na level, thirst, weight, appetite. Follow-up: telephone calls with nurse or dietitian every 2−3 wk. Time points: baseline and 12 wk.	1. No significant changes in weight, thirst ,or appetite in intervention group over 12 wk 2. Better adherence to fluid restriction in intervention group 3. Reduced Na excretion in Intervention group (P = .049) 4. Reduced urine volume and urine Na in Intervention group (P = .042 and P = .039)
Parrinello,[25] 2009, Italy	n = 173; control: n = 87; intervention: n = 86. Female 39%. Race not specified. Mean age 73 y. Recent admission for ADHF (NYHA IV), NYHA II after discharge, LVEF <35%.	RCT Control: 1. Low-Na diet (80 mmol, 1.8 g/d) 2. 1-L fluid restriction 3. Lasix (125−250 mg bid) Intervention: 1. Moderate-Na diet (120 mmol, 2.8 g/d) 2. 1-L fluid restriction 3. Lasix (125−250 mg bid)	Measures: adherence to fluid and diet, neurohormone and cytokine activation, weight, readmissions, mortality. Follow-up: telephone call from physician or dietitian. Time points: weekly for 1 mo, every 2 wk for next 2 mo, every other month through 6 mo.	1. Neurohormonal (brain natriuretic peptide, aldosterone, plasma rennin activity) and cytokines values (TNF-α, interleukin-6) were significantly reduced with a significant increase of the antiinflammatory cytokine interleukin-10 at 12 mo in intervention group ($P \leq .0001$) 2. Intervention group showed no significant variation in body weight, whereas low-Na group showed significant increase ($P < .001$) 3. The low-Na diet showed significant activation of neurohormones and cytokines and worsening of body hydration, whereas moderate Na restriction maintained dry weight and improved outcomes 4. Significant reductions in readmissions ($P < .0001$) and mortality ($P < .005$) in intervention group
Paterna,[18] 2009, Italy	n = 410; 8 groups with 50−52 participants each. Female 63%. Race not specified. Mean age 75 y. Recent admission for ADHF (NYHA IV), currently compensated HF NYHA II−IV, LVEF <35%.	RCT Randomized 8 groups with all possible combinations of: 1-L or 2-L fluid restriction 125 or 250 mg/d furosemide 800 or 120 mmol/d Na	Measures: food diaries, lab values, readmissions, mortality. Follow-up: assigned medical visits. Time points: weekly for 1 mo, every 2 wk for next 2 mo, every other month through 6 mo.	1. Group A (normal-Na diet, fluid intake restriction, and high diuretic dose) showed significantly lower incidence in readmissions ($P < .001$) and lower rate of mortality than all other groups 2. Food diaries showed good compliance with assigned diets and fluid restriction in all groups 3. Data suggest that the combination of a normal-Na diet with high diuretic doses and fluid intake restriction leads to reductions in readmissions, neurohormonal activation, and renal dysfunction

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Table 2. (*Continued*)

Study	Sample, Demographics, and HF Characteristics	Design	Measures, Follow-Up, and Time Points	Key Findings
Paterna,[24] 2008, Italy	n = 232; group 1: n = 118; group 2: n = 114. Female 38%, Race not specified. Mean age 73 y. NYHA II–IV, LVEF <35%.	RCT Group 1: 120 mmol Na, oral furosemide (250–500 mg, bid), 1 L/d fluid Group 2: 80 mmol Na, oral furosemide (250–500 mg, bid), 1 L/d fluid Both groups' diets had same amount of fat, fruit, vegetables, etc.	Measures: readmission, serum labs, mortality. Follow-up not specified. Time points: every wk for 1 mo, every 2 wk for next 2 mo, every other month through 6 mo.	1. Decreased readmissions and deaths in normal-Na group ($P < .05$) 2. Lower BNP values in normal-Na compared with low-Na group ($P < .0001$) 3. Significant ($P < .0001$) increases in aldosterone and PRA in low-Na group during follow-up whereas normal-Na group had small significant reduction ($P = .039$) in aldosterone levels and no significant difference in plasma renin activity 4. Normal-Na diet improves outcomes, but low-Na depletion has detrimental renal and neurohormonal effects with worse clinical outcomes in compensated CHF patients

LVEF, left ventricular ejection fraction; CRP, C-reactive protein; BNP, B-type natriuretic peptide; QoL, quality of life; TNF, tumor necrosis factor; TNF-R, tumor necrosis factor receptor; PRA, panel reactive antibodies; other abbreviations as in Table 1.

Prescriptive interventions demonstrated improvement in adherence by self report[26,29] and decreased B-type natriuretic peptide,[24,28] aldosterone, tumor necrosis factor α, and interleukin-6.[24] Patients reported more difficulty in adhering to lower fluid allotments, with as few as 60% reporting adherence to 1-liter fluid restriction.[29] There was no difference in perceived thirst with moderate fluid restriction,[26,29] but thirst worsened in a very low sodium and fluid intervention (0.8 g/d and 0.8 L/d, respectively).[19]

Readmissions were decreased in interventions with a normal-sodium diet (120 mmol)[18,24,25] and in an educational intervention delivered via telephone.[15] Additionally, 1 study reported a trend toward decreased readmissions,[29] whereas a protein shake intervention resulted in no change in readmissions.[17] Mortality was also decreased in 1 educational intervention.[15] Low incidence rates may have biased the data in the studies that were shorter in length.

Trials had mixed results regarding changes in weight. Two trials found no difference in change in weight between the intervention and control groups,[19,26] and intervention-group LVAD patients who had dietary counseling along with physical training were able to maintain their body mass index, whereas the control group gained weight.[14]

Discussion

Defining an appropriate dietary regimen that provides the best overall nutrition for the HF population is still a moving target. Evidence supports reducing sodium to a "normal" level, 2–3 g/d. In the context of American sodium consumption, this goal is one-half of normal sodium consumption.[30] In addition, fluid restrictions were rarely included in education interventions, but prescriptive interventions suggest that a 1–1.5 L/d limit may be beneficial.[18,24,25,29] Studies testing prescribed nutrition interventions found low-sodium restrictions did not improve clinical outcomes. Our findings show reduced readmissions for normal- versus low-sodium diets. The utility of a low-sodium diet needs to be addressed through further research and by organizations that set HF nutrition guidelines to achieve consensus moving forward.

Heart failure nutrition interventions did not adequately address the composition of overall diet regarding other nutrient or quality of food choices that may affect outcomes. It is important for studies to report more details about the dietary intake of participants. Adding supplemental nutritional drinks such as V8 or protein shakes to the HF dietary regimen shows initial improvements in some outcomes, but should be further studied, particularly with respect to fluid restriction.[17,21] Dunbar et al demonstrated the benefit of including additional food quality and nutrient balance education, particularly for comorbid HF and diabetes.[10] Paterna et al demonstrated the benefit of a 120-mmol sodium diet and stated that this included a "variety of fruits and vegetables." It is possible that participants in the study benefited from their intake of fruits and vegetables more than adhering to a low-sodium diet.

Table 3. Educational Strategies

Strategy	Dunbar 2014[10]	Dunbar 2013[11]	Welsh 2013[12]	Donner Alves 2012[13]	Kugler 2012[14]	Ferrante 2010[15]	Arcand 2005[16]
Nurse/dietitian-led sessions	✓	✓	✓	✓	✓	✓	✓
Sodium goal	2–3 g	2 g	2 g	2–3 g	Not stated	Not stated	2 g
Study-developed materials	✓	✓	✓	✓	✓	✓	✓
Standardized materials	HFSA	HFSA	HFSA	AHA	✓		
Face-to-face visits	✓	✓	✓	✓	✓		✓
Individualized education/planning	✓	✓	✓	✓	✓	✓	✓
Food diary review with participant		✓					
Family involvement		✓	✓		✓		
Follow-up telephone calls	✓				✓	✓	
Published materials/online resources available			✓			✓	

Abbreviations as in Table 1.

Furthermore, understanding the overall nutritional intake for the participants would allow readers to determine if the findings are generalizable to their clinical population. Overall nutritional intake in a normal-sodium diet may differ radically between populations by race, ethnicity, and geographic location because food choices are heavily influenced by cost, availability, and culture.

There were several confounders of outcomes, including small sample sizes, multidimensional interventions, inconsistent adherence to the intervention, brief follow-up periods, and low incidence rates. Additionally the samples were homogeneous, predominately white and male, making it difficult to generalize the results to many settings.

Because of the various strategies used in each of the educational studies, it is difficult to determine which approaches are most effective. Most interventions involved individualized planning, which is not well explained and may affect overall outcomes. To allow comparisons across nutrition studies, interventions need to be described in more detail through the publication of protocols and making developed educational materials available for use in research as well as to support translation into practice (Fig. 2).

Hospital administrators looking for ways to minimize HF readmissions with the use of an educational intervention would likely want to know the most cost-effective means to achieve improved outcomes. The long follow-ups in several of the studies bring into question the feasibility and transferability of such interventions to usual practice. Likewise, the cost and resources required to complete interventions are of concern within a currently overburdened health care environment. Nevertheless transitions of care models have proven to be beneficial and may be able to incorporate many aspects of these interventions.[31]

Many studies reported improvement in adherence to restriction according to participant self-report but divergent findings for urine sodium. Others did not collect an objective measurement to assess adherence. Future research and clinical practice should implement the use of criterion-standard measurement of sodium restriction adherence, urine sodium. Additional instruments should be developed, such as the Fluid Restriction Behaviors Scale, to assess adherence to fluid restriction. Improvement in daily weight monitoring and the use of weight logs may further assist in assessing fluid restriction adherence. Also, family caregivers are heavily involved in the care of persons with HF and often help to make decisions on the type of foods to buy and meals to prepare.[32] More studies are needed to compare the effect of individual versus group education interventions on nutrition outcomes on an individual and family level.

Table 4. Sodium and Fluid Restrictions Used in Prescriptive Interventions

	Sodium			Fluid	
Study	High	Normal/ Moderate	Low	High	Low
Biddle,[34] 2015	—	—	—		
Colin-Ramirez,[35] 2015		2.3 g	1.5 g		
Albert,[29] 2013				2 L/d	1 L/d
Badin Aliti,[19] 2013	3–5 g		0.8 g	2.5 L/d	0.8 L/d
Philipson,[20] 2013	5 g				1.5 L/d
Rozentryt,[17] 2010	—	—	—	—	—
Philipson,[26] 2010			2–3 g/d		1.5 L/d
Parrinello,[25] 2009		2.8 g/d	1.8 g/d		1 L/d
Paterna,[18] 2009		120 mmol	800 mmol	2 L/d	1 L/d
Paterna,[24] 2008		120 mmol	800 mmol		

Review Limitations

This review has some important limitations. It is possible that relevant studies were not included in the review. However, efforts to minimize this were taken by consulting with an experienced health care librarian to finalize search terms. The types of interventions and outcomes measured were heterogeneous, limiting our ability to make comparisons across studies and draw conclusions. In addition, many of the studies included in this review were pilot studies and may not have been adequately powered to see significance in the outcomes of interest. However, the findings of this review agree with many suggestions from the National Heart, Lung, and Blood Institutes' executive summary for next steps in HF nutrition trials.[33] Strengths of this review include the evaluation of RCTs and the evaluation of these studies by a multidisciplinary team.

Suggestions for Future Educational Studies and Clinical Programs

- Prioritize understanding food access, cultural, and family considerations
- Involve family in education
- Frequent individualized follow-up, either in person or by telephone
- Measure adherence subjectively (e.g. food diaries) and objectively (e.g. urine sodium, weight)
- Use food diaries as a teaching tool, not just as a study measurement
- Consider use of emerging technologies, apps, texting, and websites.
- Use of standardized, expert-developed materials such as those offered by HFSA and AHA.
- Ensure the language of all materials is culturally appropriate
- Health literature should be produced at a 4th grade reading level

Fig. 2. Suggestions for future educational studies and clinical programs. HFSA, Heart Failure Society of America; AHA, American Heart Association.

Conclusion

Educational nutritional interventions to limit sodium are effective in improving HF patient outcomes, although it is unclear which components of educational programs are most effective. Additional trials are needed to test nutrition education regarding other nutrients, food quality, and energy balance. The majority of studies did not randomize an adequate number of women, elderly adults, or minorities. Further research will need to include greater diversity in patient populations. Health care professionals must take into account cost, availability, and culturally appropriate food when recommending nutrition interventions to their patients with HF. This review supports findings in other cardiac populations that very-low-sodium diets (<2 g/d) may increase risks of readmission and mortality. Support of programs with ongoing follow-up is needed to improve the nutritional status of patients with HF to reduce hospital admissions and to improve quality of life.

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Disclosures

None.

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