Group-Based Nutrition Interventions to Promote Health and Mobility in Community-Dwelling Older Adults: A Systematic Review

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Abstract

**Objective:** To identify the efficacy of group-based nutrition interventions to increase healthy eating, reduce nutrition risk, improve nutritional status, and improve physical mobility among community-dwelling older adults.

**Design:** Systematic review. Electronic databases MEDLINE, CINAHL, EMBASE, PsycINFO, and Sociological Abstracts were searched on July 15, 2020, for studies published in English since January 2010. Study selection, critical appraisal (using the Joanna Briggs Institute’s critical appraisal tools), and data extraction were performed in duplicate by two independent reviewers.

**Setting:** Nutrition interventions delivered to groups in community-based settings were eligible. Studies delivered in acute or long-term care settings were excluded.

**Participants:** Community-dwelling older adults aged 55+ years. Studies targeting specific disease populations or promoting weight loss were excluded.

**Results:** Thirty-one experimental and quasi-experimental studies with generally unclear-high risk of bias were included. A broad range of interventions were identified, including nutrition education with behaviour change techniques (e.g., goal setting, interactive cooking demonstrations) (n=21), didactic nutrition education (n=4), interactive nutrition education (n=2), food access (n=2), and nutrition education with behaviour change techniques and food access (n=2). Group-based nutrition education with behaviour change techniques demonstrated the most promise in improving food and fluid intake, nutritional status, and healthy eating knowledge compared to baseline or control. The impact on mobility outcomes was unclear.

**Conclusions:** Our findings should be interpreted with caution related to generally low certainty, unclear-high risk of bias, and high heterogeneity across interventions and outcomes in this body of literature. Quality research in group-based nutrition education for older adults is needed.

Introduction

Older adults are the fastest-growing age group, and the number of adults aged 65 years and older worldwide is expected to more than double from 727 million in 2020 to over 1.5 billion in 2050\(^1\). As the population ages, the prevalence of chronic diseases, multimorbidity, and frailty will also increase\(^{1–3}\). Several modifiable risk factors are associated with increased risk of disability and disease with aging, one of which is poor diet quality\(^{4,5}\). Unfortunately, many older adults do not meet current age-specific nutrition guidelines\(^{6,7}\) concerning both diet quality and quantity\(^{8,9}\). As individuals age, many decrease their total food intake\(^{10}\), in part due to reduced appetite, sensory impairment, hormonal imbalance, and changes in the gastrointestinal tract and dentition\(^{11}\). Age-related changes in living situations, retirement, social isolation, and loss of relationships can also negatively impact food intake and diet quality\(^{12,13}\). The intersection of financial, psychosocial, environmental, physical, cognitive, gender, and cultural factors are known to influence eating behaviour\(^{13}\), food access\(^{14}\), and mobility\(^{15}\) among older adults.

The relationship between mobility (the ability to move oneself within the immediate environment and broader community)\(^{15}\) and nutrition has been shown to be bidirectional in older adults. One's mobility can impact food access (e.g., ability to transport oneself to locations with high quality food sources)\(^{16}\) and may also be influenced by dietary quality. Reduced intake of both micronutrients and macronutrients may lead to sarcopenia\(^{17–19}\), and the loss of muscle mass in aging may result in mobility limitations and impaired quality of life\(^{20}\). Proper nutrition also plays an important role in maintaining skeletal strength and preventing falls and chronic diseases among older adults\(^{20–22}\). Given this, promoting healthier eating and reducing nutrition risk is necessary to maintain and improve health and mobility among community-dwelling older adults. However, many older adults perceive functional decline as an inevitable part of aging and may experience difficulties accessing available programs and services\(^{23}\).

Group-based nutrition interventions, including education, interactive discussion, and hands-on activities, have demonstrated benefit in supporting older adults to learn from each other's knowledge and experiences, overcome psychosocial and environmental barriers to healthy eating, enhance motivation, and promote dietary behaviour change\(^{24–26}\). Group-based interventions among older adults also foster a sense of group cohesion\(^{27}\), allowing individuals to feel acknowledged and form bonds with others who understand their experiences firsthand. Although many group-based nutrition interventions exist, some of which have been formally evaluated for effectiveness\(^{28,29}\), these interventions vary widely, and optimal design features remain unclear.

The Enhancing physical and community Mobility in OLDER adults with health inequities using commuNity co-design (EMBOLDEN) trial is a multi-year research program in Hamilton, Ontario, Canada that aims to promote mobility among older adults residing in areas of high health inequity\(^{30}\). EMBOLDEN uses a community co-design approach, partnering with older adults and service providers to combine the best available research evidence with local knowledge to develop an integrated service delivery model. To inform the co-design of a novel, group-based intervention targeting physical activity, nutrition, and system navigation, the EMBOLDEN team conducted an umbrella review\(^{31}\) to identify existing synthesized evidence regarding group-based physical activity and/or nutrition interventions for community-dwelling older adults. The team identified 54 systematic reviews; 46 were reviews of physical activity interventions alone, and eight combined physical activity with nutrition (namely protein supplementation). No systematic reviews of group-based nutrition interventions alone were identified, highlighting a lack of synthesized evidence to identify intervention effectiveness. This understanding is key to informing the development and implementation of evidence-informed community programs to promote health and mobility among older adults.

To address this gap, our team initiated a systematic review of single studies focused on group-based nutrition interventions targeting healthy eating in community-dwelling older adults. We specifically aimed to address whether group-based interventions targeting healthy eating in community-dwelling older adults (≥ 55 years) improved access to nutrition, affected nutritional intake, or changed markers of physical mobility.
Methods

This systematic review was registered with PROSPERO (CRD42020205045). The reporting of this review is based on PRISMA guidelines.32

Search Strategy

The electronic databases MEDLINE, CINAHL, EMBASE, PsycINFO, and Sociological Abstracts were searched to July 15, 2020, by a research librarian trained in building search strategies for systematic reviews (Supplementary Tables 1–5). To focus on interventions germane to the current context and nutrition guidelines, database searches were limited to studies published from January 2010. Only English language studies were eligible due to the research team’s capacity. Reference lists of all identified systematic reviews were screened for potentially relevant and eligible studies; experts in the field were contacted to locate any additional studies not identified in our search.

Study Selection

Citations were uploaded into Covidence (Vertitas Health Innovation Ltd., Melbourne, Australia), and duplicates were removed. Following a pilot test, titles and abstracts were screened by two independent reviewers against predetermined eligibility criteria. Full texts of potentially relevant studies were retrieved and screened for eligibility by two independent reviewers. Disagreements were resolved through discussion or with the input of a third reviewer.

Eligibility Criteria

Types of Studies

This review included experimental and quasi-experimental study designs, including randomized controlled trials (RCTs), non-randomized controlled trials, before and after studies, and interrupted time-series studies. Mixed methods studies with quantitative designs cited above were also included, although only quantitative data were extracted and analyzed. Theses and dissertations were eligible; publication status was not a criteria for inclusion. Conference abstracts, reviews, observational designs, and qualitative studies were excluded.

Participants

Eligible studies must have included community-dwelling older adults ≥ 55 years old or reported a mean age of participants as ≥ 55. Studies focused on disease-specific populations were excluded, although included participants could report risk factors for or the presence of chronic diseases.

Interventions

Studies that evaluated group-based interventions targeting healthy eating were eligible. Examples of modes of delivery included interventions based on nutrition, education, gardening, and congregate dining. If studies reported on interventions with multiple delivery modes, only group-based interventions were extracted and analyzed. Programs focused on weight management or weight loss were excluded. Interventions delivered in any community-based setting were eligible, including seniors’ and community centers. Studies that took place in acute or long-term care settings were excluded.

Comparators

Studies that compared an intervention to any comparison group (including single group pre-test/post-test) were eligible. Examples of comparator groups included pre-intervention, other intervention, or non-exposed control groups.

Outcomes

Studies that reported on a change in nutrition outcomes from pre- to post-intervention were eligible for inclusion. Nutrition outcomes were grouped retrospectively into three categories based on study findings: 1) food and fluid intake (e.g., vegetables and fruit, whole grain foods and protein), 2) nutrition risk, defined as factors that impact food intake (e.g., dietary habits, food access), and 3) healthy eating knowledge (e.g., nutrient functions, recommended servings). Physical mobility outcomes were considered secondary outcomes and were retrospectively grouped into two categories: 1) physical activity, and 2) functional outcomes (e.g., Timed Up and Go (TUG) test, gait speed).

Assessment of Methodological Quality

Two independent reviewers critically appraised the eligible studies for methodological quality using the Joanna Briggs Institute critical appraisal instruments for experimental or quasi-experimental studies. Overall scores for each study were calculated by responses to the questions. Any disagreements between reviewers were resolved through discussion or input from a third reviewer.

Data Extraction

Two independent reviewers performed data extraction using a pre-developed and tested data extraction form. This form included general study information (i.e., study aim, design, country, start/end dates), population (i.e., age, sex, number of participants, ethnicity, socioeconomic status), intervention details (including duration, frequency, who delivered, how it was delivered, where it was delivered, and theoretical framework, with questions framed according to the Template for Intervention Description and Replication (TIDieR) checklist and guide), comparison groups, limitations, and conclusions reported by study authors. Relevant nutrition and mobility outcomes were also extracted for all time points reported in the individual studies. When measures of overall food and fluid intake were reported (e.g., Food Frequency Score, Dietary Variety Score), these were extracted over specific food group intake results. Any disagreements between reviewers were resolved through discussion or by a third reviewer. Data collection forms and extracted data used for analyses are available upon request.

Data Synthesis
A meta-analysis was not possible given the variation in intervention types and outcomes across included studies. A narrative approach was used to synthesize included studies\(^{[36]}\), with data summarized and presented in supporting tables. Results tables with effect size measures, including mean differences, odds ratios, effect sizes, and proportional changes, were structured by intervention category and outcome measures to explore variation and possible sources of heterogeneity. When only pre-test/post-test means or percentages were reported, mean or percent differences between groups were calculated. When missing, mean differences, confidence intervals, and/or standard deviations of the changes were calculated using accepted equations\(^{[37]}\) and RevMan software\(^{[38]}\). A correlation coefficient of 0.5 was estimated for both food and fluid intake outcomes\(^{[39–43]}\) and physical activity outcomes\(^{[44–46]}\), based on available literature. Reporting bias was not explored as most studies did not cite a protocol or trial registration. Sensitivity analyses were not performed. A comprehensive approach to assess the overall certainty of the evidence for each outcome was not used due to high heterogeneity across interventions and outcomes.

### Results

#### Description of Included Studies

The search resulted in 4,482 unique records, of which 309 were identified as potentially relevant and underwent full text review (Fig. 1). A total of 31 studies met all eligibility criteria and were included in the analysis (Table 1), including 11 single group, pre-test/post-test studies\(^{[47–57]}\), 10 RCTs\(^{[58–67]}\), and 10 non-randomized, two group study designs\(^{[68–77]}\). A list of excluded studies with reasons for exclusion is provided in Supplementary Appendix 1. Studies were most often conducted in North America (n = 20, 65%), with the remainder in Asia (n = 7, 23%), Europe (n = 3, 9%), and Australia (n = 1, 3%). The total number of participants enrolled was 6,723 (Range: 10–761), with high loss to follow up noted (Range: 0%-65% where reported; 48% (n = 15) reported > 20% attrition). Mean age ranged from 64–82 years (range 50–98 years when mean age was not reported). Most participants were female, with 74% (n = 23) of studies reporting > 70% female participants. Nine studies (29%) explicitly targeted low-income or economically disadvantaged populations\(^{[47, 52, 54–56, 63, 65, 69, 71]}\).
| Study         | Design                  | Country | Year | Description of Intervention/ Comparator | Intervention Details | Population | Race/ Ethnicity (%) | SES | Income |
|--------------|-------------------------|---------|------|-----------------------------------------|----------------------|------------|---------------------|-----|---------|
| AbuSabha     | Single group pre/post   | USA     | 2008 | I: Veggie Mobile van delivers discounted fresh produce to low-income neighbourhoods C: None | Duration: 6mos Frequency: 1hr/wk Who? NR Where? 2 senior housing sites TF: NR | Community-dwelling seniors, ≥ 55 | White: 58; Black: 39 | Income <$10,000/yr: 51% |
| Beasley      | Single group pre/post   | USA     | 2018 | I: Diabetes Prevention Program, including reducing calories and fat, overall healthy eating, PA, and managing eating triggers. C: None | Duration: 6wks Frequency: 1hr/wk Who? Certified group facilitator How? Interactive webinars Where? Participants at senior center, facilitator remote TF: NR | Older adults ≥ 60 with diabetes risk score ≥ 5 | White: 56; Black/ African American: 38; Hispanic: 8; Asian: 6 | High school: 6%, some college or technical school: 31%, college: 63% |
| Brewer       | Non-randomized, two groups | USA     | 2015 | I: FV nutrition education (e.g., phytochemicals, serving sizes, shopping) and educational tools (e.g., recipe cards, phytochemical guide, health information) C: Educational tools | Duration: NR Frequency: 5x15min Who? Research personnel How? In-person lessons + handouts Where? Congregate dining programs at senior centres TF: NR | Community-dwelling, older adults, ≥ 60 | White, I: 84, C: 81 | At least high school, I: 74%, C: 88% |
| Chung        | Non-randomized, two groups | Hong Kong | NR   | I1: Nutrition seminars covering nutrient classification, healthy foods and labelling, recipes, cooking demo. Provided ingredient samples for low-cost, nutrient rich meals with 1-day food samples/wk I2: As above with three, 1-day food samples/wk | Duration: 3wks Frequency: 1x/wk Who? Nutritionists How? In-person; cooking steps via video Where? Mobile integrative health centre TF: NR | Elderly adults ≥ 55 living independently, without cognitive or mobility disabilities | NR | All lived in subsidized housing |

**Table 1**
Characteristics of Included Studies
| Study          | Design                | Country       | Year          | Description of Intervention/ Comparator                                                                 | Intervention Details                                                                 | Population                        | Race/ Ethnicity (%) | SES                  |
|---------------|-----------------------|---------------|---------------|--------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|-----------------------------------|---------------------|---------------------|
| Francis 2014  | RCT                   | USA           | NR            | I: Nutrition and health education including FV and calcium-rich food; PA; safe food handling; food security. Group discussion of smarter goal planning and taste-testing activity. C: Didactic education (newsletters) only | Duration: 6mos  
Frequency: Monthly  
Who? Program educator  
How? Newsletter + 30min in-person discussion and facilitated education  
Where? 4 urban congregate meal sites  
TF: Social Marketing Theory, Health Belief Model | Older adults ≥ 60  
White: 80; Black/ African American: 15 | High school or less: 26.7%  
Some college: 36.7%  
Bachelors: 33.4% |
| Gallois 2013  | Non-randomized, two groups | Germany       | 2008–2009     | I: Tools to track FV, dairy, fish, and PA; performance feedback and advice. Standard health info on PA, nutrition, recipes. C: Standard health info and recipes by mail | Duration: 3mos  
Frequency: 7x 45-60min  
Who? Trained moderators  
How? In-person discussion (6–10 participants), handouts  
Where? Community partners' institutions, churches, mosques  
TF: Kanfer's Self-regulation Model | Elderly people ≥ 57 with ability to care for oneself  
German, I: 90, C: 85; USSR, I: 2, C: 10; Turkish, I: 8, C: 5 | Low SES neighbourhood, I: 41%, C: 28%; High SES neighbourhood, I 59%, C: 73% |
| Geller 2012   | RCT                   | USA           | NR            | I1: Decisional balance sheet for FV intake. Provides basic health knowledge and empowers individuals to consider pros and cons of behaviour adoption.  
I2: Identical program targeting PA instead of FV | Duration: 1 day  
Frequency: Once  
Who? NR  
How? In-person, group discussion, guided completion of decisional balance sheet  
Where? 2 community housing sites  
TF: NR | Older adults residing in community living homes  
Japanese: 24; Filipino: 19; Caucasian: 19; Native American: 5; Native Hawaiian: 5; Hispanic: 5; Other: 24 | 80% graduated high school |
| Study     | Design                  | Country | Year          | Description of Intervention/ Comparator                                                                 | Intervention Details                                                                 | Population                  | Race/ Ethnicity (%) | SES |
|-----------|-------------------------|---------|---------------|--------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|------------------------------|---------------------|-----|
| Hersey    | Non-randomized, two groups | USA     | 2012          | I: "Eat Smart, Live Strong" nutrition education, including FV intake and PA goal setting; recipe modification; food assistance resources and community programs; recipe cards; fact sheets. C: Waitlist control | Duration: 4wks  
Frequency: 65min/wk  
Who? Nutrition educators  
How? In-person interactive education + handouts  
Where? Low-income senior centres in urban and rural communities  
TF: BEHAVE Decision-Making Theory | Older adults ≥ 60  
White: 69; Black: 19; Native American: 10; Hispanic or Latino: 8; Asian or > 1 race: 2 | Low-income older adults | 6 |
| Hsu       | Non-randomized, two groups | Taiwan  | 2004–2006     | I: Nutrition education and practice via dietary choice games (food categories, healthy diet, cooking principles, food recognition), guided by CCAA and NIA materials. PA component (endurance, strength, balance, flexibility)  
C: No intervention | Duration: 12wks  
Frequency: 1, 3hr session and 2 phone call follow-up reminders  
Who? Physical therapist, assistant trainers  
How? In-person; PA demo via video; brochure; follow-up via phone  
Where? 3 community public health centres  
TF: NR | Community-based elderly ≥ 65  
Mingnan, I: 24, C: 34; Hakka, I: 69, C: 58; Mainlander, I: 7, C:8 | NR | 5 |
| Jancey    | RCT                     | Australia | 2012         | I: PA and nutrition education (e.g., goal setting, monitoring and feedback; skill building; social support; exercise demo); educational resources (booklet, calendar, exercise chart, resistance bands, newsletters); motivational interviewing (goal setting, adherence, sustainability)  
C: No intervention | Duration: 6mos  
Frequency: Tailored to participant needs (weekly to monthly)  
Who? Peer trained program ambassadors  
How? Educational resources, 2 face-to-face meetings, motivational interviewing via telephone  
Where? Retirement village  
TF: Social Cognitive Theory | Older adults residing in retirement villages; not currently active or on special diet | NR | 3 |

51% completed Secondary school or less, 20% certificate or diploma, 29% University degree
| Study      | Design     | Country | Year         | Description of Intervention/ Comparator                                                                 | Intervention Details                                                                 | Population                        | Race/ Ethnicity (%) | SES |
|-----------|------------|---------|--------------|--------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|-----------------------------------|---------------------|-----|
| Kimura 2013<sup>(61)</sup> | RCT        | Japan   | 2005–2006    | I: “Sumida TAKE10” program. Lecture on good dietary habits; participants self-monitored dietary check sheets during lecture and received instructor feedback; stretching and strengthening exercise. C: Crossover | Duration: 3mos<br>Frequency: 1.5hrs/biweekly<br>Who? Researchers and staff<br>How? In-person 30min lecture/1hr exercise; home exercise and diet tracking<br>Where? 6 community centres<br>TF: NR | Community-dwelling older adults ≥ 65 | NR                 | 9   |
| Lara 2015<sup>(62)</sup>     | RCT        | England | 2011–2012    | I: Group education including benefits of Mediterranean diet, shopping tips, meal planning. Material package including guidelines, menus, recipes; asked to adopt for 3 wks. C: Educational group session and package (without menus, recipes or follow up) | Duration: 3wks<br>Frequency: 1, 2hr session<br>Who? Nutritionist, with research team support<br>How? In-person, interactive educational group session (PowerPoint + discussion) + 10-15min follow up phone calls on days 3, 11, 16<br>Where? Newcastle University<br>TF: NR | Healthy older adults ≥ 50 | NR                 | 83% retired | 2   |
| Lillehoj 2018<sup>(73)</sup> | Non-randomized, two groups | USA | NR          | I: Supplemental Nutrition Assistance Program-Education (SNAP-Ed) including goal setting, recipe tasting, PA break. C: No intervention | Duration: 9mos<br>Frequency: 30min/mos<br>Who? Trained facilitators<br>How? In-person, facilitative, non-didactic, discussion + newsletter<br>Where? Congregate meal sites<br>TF: Health Belief Model | Adults ≥ 60 from congregate meal sites | White: 92; Black: 2; Hispanic: 1; Asian: 1; Other: 1; Missing: 4 | 74.4% High or Marginal Food Security | 7   |
| Study       | Design                  | Country      | Year         | Description of Intervention/Comparator                                                                 | Intervention Details                                                                 | Population                              | Race/ Ethnicity (%) | SES          |
|------------|-------------------------|--------------|--------------|-------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-----------------------------------------|---------------------|--------------|
| Luten 2016 | Non-randomized, two groups | Netherlands  | 2011–2012   | I: Community-based media campaign to promote healthy eating and PA                                      | Duration: 3mos high-intensity, 6mos low-intensity                                    | Healthy, community-based older adults ≥ 55 | NR                  | Socio-economically disadvantaged areas |
|            |                         |              |              | C: Region where no intervention took place                                                            | Frequency: 244 posters, 600 radio broadcasts, 20 radio interviews, 4 newspaper ads  |                                        | I: 38.7%            | 6            |
|            |                         |              |              |                                                                                                      | Who? Local peers and healthcare professionals                                         |                                        | C: 58.6%            |              |
|            |                         |              |              |                                                                                                      | How? Posters, radio, newspaper                                                       |                                        |                     |              |
|            |                         |              |              |                                                                                                      | Where? Community                                                                      |                                        |                     |              |
|            |                         |              |              |                                                                                                      | TF: Integrated Model for Change, ANGELO, Ecological Model                             |                                        |                     |              |
| MacNab 2017 | Non-randomized, two groups | USA         | NR          | I1: Interactive whole grain nutrition education program, hands-on activities to identify whole grains, case scenarios to apply knowledge, taste-testing, worksheets, handouts, recipes | Duration: 3wks Frequency: 1hr/wk Who? Instructor How? I1 via PowerPoint with small group discussion, I2: discussion only (no PowerPoint) Where? Senior apartments, retirement communities, senior centers TF: Social Marketing Theory | Community residing adults ≥ 60 | White: 96; Other: 4 | High school, GED or less: 31.8% |
|            |                         |              |              |                                                                                                      |                                                                                     |                                        |                     | Some college or degree: 32.5% |
|            |                         |              |              |                                                                                                      |                                                                                     |                                        |                     | Bachelor's degree or higher: 35.0% |
| Manafo 2013 | Single group pre/post   | Canada       | NR          | I: Nutrition Information Series following Canada's Food Guide to Healthy Eating; interactive activities including making a food record and reading food labels; healthy snack C: None | Duration: 12wk Frequency: 1x/wk Who? NR How? In-person slideshow, discussion, Q&A, handouts; interpreters at each session Where? 3 neighbourhoods (only 1 included in analysis due to attendance) TF: NR | Seniors ≥ 55 | Chinese, Persian, Filipino, Tamil (%NR) | NR                  | 5            |
| Study       | Design         | Country | Year        | Description of Intervention/ Comparator | Intervention Details | Population                                      | Race/ Ethnicity (%) | SES |
|-------------|----------------|---------|-------------|------------------------------------------|----------------------|------------------------------------------------|---------------------|-----|
| Meethien 2011(63) | RCT            | Thailand | 2008–2009   | I: Nutrition education for elders and family members, Individual counseling, motivational plan for healthy eating, food preparation activities, training and guidance on meal planning, personal goal setting, behavioural monitoring, and maintenance C: Usual care | Duration: 3 mos Frequency: 1x/wk Who? Nurses How? In-person group discussion, phone, handouts Where? 2 community study sites + counselling in elder's home TF: Pender's Health Promotion Model | Elders ≥ 60 residing with at least 1 family member who is responsible for selecting and preparing their meals | Thai Buddhists | Low SES; participants perceived income as inadequate |
| Mendoza-Ruvalcaba 2015(64) | RCT            | Mexico   | NR          | I: 'I am Active' alternating sessions on nutrition or cognitive function; meal planning, goal setting, strength, balance, and mobility physical exercises C: Waitlist control, weekly social activities | Duration: 2mos Frequency: 2hrs, 2x/wk Who? Trainer How? In-person presentation, take home activities; 30-mins PA Where? Senior centre TF: WHO Model for Active Aging | Healthy adults ≥ 60 from senior centers | NR | Yrs of education I: 5.55 (3.12) C: 3.97 (3.28) |
| Moreau 2015(50) | Single group pre/post | Canada   | 2008–2012   | I: Nutrition education and cooking workshops including healthy eating, cancer, cardiovascular disease prevention, nutrition for aging, labels, fiber, bone health, eating for pleasure, social support, barriers and strategies, recipes, take-home meals. C: None | Duration: 8wks Frequency: 2hrs/wk Who? RD How? In-person interactive education, discussion, handouts. Out-of-pocket user fees ($20) for ingredients used, taken home for later consumption. Where? Community kitchen TF: NR | Community-dwelling adults ≥ 50 | NR | NR | 1 |
| Study          | Design          | Country   | Year         | Description of Intervention/ Comparator                                                                 | Intervention Details                                                                 | Population                                    | Race/ Ethnicity (%) | SES                         |
|---------------|-----------------|-----------|--------------|---------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|----------------------------------------------|--------------------|-----------------------------|
| Murayama 2020 | Non-randomized, two groups | Japan     | 2014–2015    | I: Drama-style lectures on nutrition (protein, fat, carbohydrates) and dietary variety; food tasting; discussion to share knowledge, success and failures; home activities.  C: Crossover | Duration: 8wks  
Frequency: 2h, Biweekly  
Who? Trained community health workers  
How? In-person, 30-40min lecture, 60min discussion, 20-30min meal tasting  
Where? Community centre  
TF: NR | Community-dwelling older people aged 65–74 | NR                  | “Normal” financial stability, I: 73%, C: 70%;  
“poor” financial stability, I: 10%, C: 0% | 8 |
| Pogge 2013    | Single group pre/post | USA       | NR           | I: “Mindful Choices” topics included calories, goal setting, building a support system, portion control, PA, nutrition, food labels, stress management. Snacks, tip sheets, and calorie counting books provided.  C: None | Duration: 12 wks  
Frequency: NR (1hr sessions, $50 incentive after 10 sessions)  
Who? RD, exercise director, pharmacist  
How? In-person classroom style with PowerPoint presentation, discussion  
Where? Seniors independent living campus  
TF: NR | Independent living seniors | 100% Caucasian | Income  
< 20,000: 26.1%  
20,000–30,000: 8.7%  
30,000–40,000: 13%  
>40,000: 21.7%  
NR: 30.4% | 3 |
| Salehi 2011   | RCT             | Iran      | 2008–2009    | I: Group-based tailored nutrition intervention based on stages of change aiming for 5 FV servings/day. Included goal setting, action planning, reinforcement.  C: 4 weekly general health education | Duration: 4wks  
Frequency: 90min/wk  
Who? NR  
How? In-person, 40min PowerPoint, 30min discussion, 10min Q&A, 10min reception with FV  
Where? 10 elderly centres  
TF: Transtheoretical Model | Community-based elderly ≥ 60 from existing elderly centres | NR                  | Low income: 76.5%  
Moderate income: 16.2%  
High income: 7.3% | 4 |
| Study | Design | Country | Year | Description of Intervention/ Comparator | Intervention Details | Population | Race/ Ethnicity (%) | SES |
|-------|--------|---------|------|------------------------------------------|----------------------|------------|-------------------|------|
| Schwingel 2017 \(^{22}\) | Single group pre/post + qualitative | USA | NR | I: Nutrition education and culturally tailored lifestyle change curriculum, including healthy living, healthy eating, nutrition labels, buying healthy food, stress management, barriers, goal setting, action plans, home activities (e.g., healthy meal prep, grocery shopping with grandchildren, PA, pedometer step-tracking), motivational telephone calls | Duration: 6mos active, 3mos maintenance Frequency: 6 workshops (frequency NR); weekly (active phase) and bi-weekly (maintenance phase) phone calls Who? Trained Promotoras How? In-person educational workshops (lectures plus group discussion and hands-on activities) + individual meetings, at home activities Where? Church facilities TF: Transtheoretical Model, Social Cognitive Theory | Healthy, Latina women aged ≥ 50 | Latina | 41% employed 88% encounter financial difficulty covered daily expenses |
| Silva-Smith 2013 \(^{64}\) | RCT | USA | 2009–2011 | I: "Promoting Older Adult Wellness", education, social network, motivational support and short/long term goal setting (for PA and DASH diet); supervised, progressive walking program | Duration: 8wks Frequency: 1hr/wk Who? Trained interventionist delivered sessions, lay health advisor (older adult) for social and motivational support How? Group session, workbook, newsletters Where? Community health centre TF: Wellness Motivation Theory | Community-dwelling overweight/obese adults ≥ 60, sedentary or recently physically active and able to participate in walking | White, I: 75, C: 65; African American, I: 13, C: 19 | Median monthly income $1000–1999 |
| Study | Design | Country | Year          | Description of Intervention/ Comparator | Intervention Details | Population | Race/ Ethnicity (%) | SES |
|-------|--------|---------|---------------|-----------------------------------------|----------------------|------------|---------------------|-----|
| Smith 2015\(^{53, 94}\) | Single group pre/post | USA | 2012–2013 | I: Texercise Select. Education on healthy dietary habits and cooking; PA and nutrition logs; goal setting, action plans and group brainstorming; PA component incorporating flexibility, strength, balance, endurance. | Duration: 10wks Frequency: 1.5h; 2x/wk Who? Trained lay facilitators How? In-person workshops + interactive group discussion + 30-45min guided exercise Where? Senior centres, community facilities, faith-based organizations, senior housing | Primarily marketed to adults ≥ 55 (although ≥ 45 allowed to participate) | White: 83; Black/ African American: 11; American Indian/ Alaska Native: 2; Asian: 1; Native Hawaiian or Pacific Islander: 1; Other: 3 | Less than high school: 4.7% Some high school: 9.5% High school graduate or equivalent: 27.4% Some college or vocational school: 37.9% College graduate or higher: 20.5% |
| Smith 2020\(^{77, 95}\) | Non-randomized, two groups | USA | 2015–2017 | I: Texercise Select. Education on healthy dietary habits and cooking; PA and nutrition logs; goal setting, action plans and group brainstorming; PA component incorporating flexibility, strength, balance, endurance. | Duration: 10wks Frequency: 1.5h, 2x/wk Who? 2 trained lay leaders How? In-person workshops + interactive group discussion + 30-45min guided exercise Where? Senior centers, faith-based and senior housing facilities, community centers | Middle-aged or older adults ≥ 45 (adults ≥ 60 focal target age group) | Non-Hispanic white: 47 | High school or lower: 39%, Some college: 31%, College graduate: 30% |
| Strout 2017\(^{54}\) | Single group pre/post + qualitative | USA | NR | I: 'GROW' (Green Organic Vegetable Gardens). Participants given a raised garden bed, ergonomic tools and supplies, and chose seeds and recipes. | Duration: 17wks Frequency: 1hr/wk Who? Gardening expert from partnering university How? In-person Where? Congregate housing site | Independent community-dwelling older adults ≥ 65 | NR | Low-income senior housing site | 1 |
| Study          | Design   | Country | Year | Description of Intervention/Comparator | Intervention Details | Population | Race/ Ethnicity (%) | SES          |
|---------------|----------|---------|------|----------------------------------------|----------------------|------------|---------------------|--------------|
| Thomas 2010(55) | Single group pre/post | USA | NR | I: Educational booklet including nutrition knowledge, recommended food items and PA to improve or prevent chronic diseases | Duration: 1mo Frequency: 5 days/wk | Rural older adults ≥ 65 | Caucasian: 81; Black/ African American: 13 | Low income, economically disadvantaged |
| Turk 2016(56)  | Single group pre/post | USA | 2014 | I: "Wise Choices" sessions focused on nutrition and PA, including FV, calcium, and fibre intake; portion sizes; USDA MyPlate food choices; step goals using pedometers given. | Duration: 12wks Frequency: 45min/wk | Older adults ≥ 50, regular diet, ambulating independently or with assistive device | White: 53; Black: 44; Asian: 1; Biracial: 2 | Low-income neighbourhoods Household income <$20 000: 59%, $20 001-$50 000: 30, >$50 000: 4% |
| Uemura 2018(67) | RCT | Japan | NR | I: Educational health promotion on exercise, diet, nutrition, cognitive activity including malnutrition, food labelling, walking, resistance exercise. PA self-monitored via accelerometer. Self-planning for and implementing behavioural change | Duration: 24wks Frequency: 90min/wk | Rural, community-dwelling elders ≥ 65 | Japanese | Average 12.9 years of education I: 83.3% unemployed C: 69.0% unemployed |
Four main intervention categories were identified: 1) nutrition education with behaviour change techniques (BCT) \((n = 21, 68\%)^{[49, 51–53, 57–61, 63–67, 70–73, 75–77]}\), 2) didactic nutrition education (e.g., lectures, handouts) \((n = 4, 13\%)^{[55, 56, 68, 74]}\), 3) interactive nutrition education (e.g., workshops, discussion) \((n = 2, 6\%)^{[48, 62]}\), and 4) food access (e.g., mobile markets, gardening, food samples) \((n = 2, 6\%)^{[47, 54]}\). Two studies \((6\%)\) combined nutrition education with BCT and food access \((50, 69)\). The BCT Taxonomy\(^{[76]}\) was used to identify interventions that incorporated BCT when components such as goal setting, action planning, feedback and monitoring, social support (e.g., motivational interviewing), shaping knowledge through instruction on how to perform a behaviour (e.g., cooking demonstrations), and behavioural practice/rehearsal (e.g., healthy food selection or recognition activities) were explicitly described. Physical activity education was reported as a co-intervention in nine studies \((29\%)^{[48, 51, 55, 58–60, 70, 71, 74]}\), and physical activity participation within sessions (e.g., strengthening, walking, step tracking) was reported in 10 studies \((32\%)^{[52, 53, 56, 61, 64, 66, 67, 72, 73, 77]}\).

Median intervention duration was 12 weeks (range one day to two years). Session frequency was variable, with weekly delivery most common \((n = 13, 42\%)^{[47–50, 54, 56, 63, 65–67, 69, 71, 75]}\). Interventionists included trained facilitators \((n = 6, 19\%)^{[48, 52, 66, 70, 73, 75]}\), research personnel \((n = 4, 13\%)^{[55, 56, 61, 68]}\), educators \((n = 3, 10\%)^{[54, 58, 71]}\), nutritionists \((n = 3, 10\%)^{[57, 62, 69]}\), physiotherapists and/or trainers \((n = 3, 10\%)^{[64, 67, 72]}\), registered dietitians \((n = 2, 6\%)^{[50, 51]}\), healthcare providers \((n = 2, 6\%)^{[63, 76]}\), lay leaders \((n = 2, 6\%)^{[53, 77]}\), and peer leaders \((n = 2, 6\%)^{[60, 74]}\). Four studies \((13\%)\) did not report interventionist details. Programs were delivered within congregate meal sites \((n = 5, 16\%)^{[55, 57, 58, 68, 73]}\), seniors’ housing sites \((n = 5, 16\%)^{[47, 51, 54, 59, 60]}\), seniors’ centers \((n = 4, 13\%)^{[48, 64, 65, 71]}\), community health centers \((n = 3, 10\%)^{[66, 69, 72]}\), community centers/kitchen \((n = 3, 10\%)^{[50, 61, 76]}\), a church facility \((n = 1, 3\%)^{[52]}\), and a university \((n = 1, 3\%)^{[62]}\), with seven \((23\%)^{[53, 56, 63, 70, 74, 75, 77]}\) delivered across multiple community settings, and two \((6\%)\) not reporting setting. Theoretical models were applied in 45% of studies \((n = 14)\); the most common were Social Cognitive Theory \((n = 4, 13\%)^{[52, 53, 66, 77]}\), Social Marketing Theory \((n = 2, 6\%)^{[58, 75]}\), Health Belief Model \((n = 2, 6\%)^{[58, 73]}\), and the Transtheoretical Model \((n = 2, 6\%)^{[52, 65]}\). Multiple theories were often combined within studies, although none applied them in the same manner.

**Methodological Quality**

The 10 RCTs had generally unclear or high risk of bias (Fig. 2). Only one study reported blinding of participants and delivery personnel\(^{[62]}\). There was unclear or no blinding of outcome assessors in 70% of RCTs \((n = 7)\)^{[58, 59, 61–65]} and 70% \((n = 7)\) did not adequately describe or analyze differences between groups when incomplete follow-up was reported\(^{[58–61, 63–65]}\). Selection bias was a concern, given that 60% of the RCTs \((n = 6)\) did not adequately report procedures for randomization\(^{[58, 59, 61–65]}\) and allocation concealment\(^{[58, 59, 63–65, 67]}\). Similarly, the 21 quasi-experimental studies had an unclear or high risk of bias (Fig. 3) due to lack of a comparator group \((n = 13, 62\%)^{[47–57, 69, 75]}\), inadequate description and analysis of groups when incomplete follow-up was reported \((n = 14, 67\%)^{[47, 49–51, 53–57, 72, 74–77]}\) and unreliable outcome measurements \((n = 14, 67\%)^{[47, 49–51, 53–57, 72, 74–77]}\). Full critical appraisal findings for each study are available in Supplementary Tables 6–7.

**Nutrition Outcomes**
Food and Fluid Intake

The 22 interventions assessing food and fluid intake included nutrition education with BCT (n = 14, 64%) (52, 53, 57, 59–61, 65–67, 70, 71, 75–77), didactic nutrition education (n = 3, 14%) (56, 68, 74), interactive nutrition education (n = 2, 9%) (48, 62), food access (n = 2, 9%) (47, 54), and nutrition education with BCT and food access (n = 1, 4%) (50). Food and fluid intake (e.g., vegetables and fruit, water, whole grains) were captured using a variety of tools, such as food frequency questionnaires (n = 10, 45%) (50, 52, 53, 56, 61, 65, 67, 68, 70, 76), 24-hour diet recalls (n = 3, 14%) (52, 66, 70), and food records (n = 2, 9%) (48, 62) (Table 2).
| Study ID | Description of Intervention/Comparator | Data Collection Tool | Outcome | Effect size (95% confidence interval or standard deviation, p-value) | Risk of Bias |
|----------|----------------------------------------|----------------------|---------|------------------------------------------------------------------|-------------|
| **Nutrition education with behaviour change technique interventions** |
| Gallois 2013(70) | I: Tools to track FV, dairy, fish, and PA; performance feedback and advice. Standard health info on PA, nutrition, recipes. C: Standard health info and recipes by mail | 24-hr diet recall | 5 servings FV/day, I vs. C at end of study | Adjusted OR 1.29 (0.84, 1.96) | 7/9 |
| | | 3 servings dairy products/day, I vs. C at end of study | Adjusted OR 1.09 (0.71, 1.68) | | |
| | | FFQ | 1 serving fish/wk, I vs. C at end of study | Adjusted OR 0.94 (0.54, 1.64) | | |
| Geller 2012(59) | I1: Decisional balance sheet for FV intake. Provides basic health knowledge and empowers individuals to consider pros and cons of behaviour adoption. I2: Identical program targeting PA instead of FV | National Health and Nutrition Examination Survey single item instrument | FV intake (servings/day) | I1: MD -0.74 (SD 2.82), descriptive statistics only | 5/13 |
| | | | | I2: MD 0.27 (SD 2.97), descriptive statistics only | | |
| Hersey 2015(71) | I: "Eat Smart, Live Strong" nutrition education, including FV intake and PA goal setting; recipe modification; food assistance resources and community programs; recipe cards; fact sheets. C: Waitlist control | University of California Cooperative Extension Food Behavior Checklist | FV intake (cups/day) | MD 0.52 (0.23, 0.82) | 8/9 |
| | | | | Fruit intake (cups/day) | MD 0.2 (0.01, 0.38) | |
| | | | | Vegetable intake (cups/day) | MD 0.31 (0.16, 0.47) | |
| Jancey 2017(60) | I: PA and nutrition education (e.g., goal setting, monitoring and feedback; skill building; social support; exercise demo); educational resources (booklet, calendar, exercise chart, resistance bands, newsletters); motivational interviewing (goal setting, adherence, sustainability) C: No intervention | Fat and Fibre Barometer | % Participants consuming > 2 servings fruit 3–7 days/wk | MD +11.3%, p = 0.007 | 10/13 |
| | | | | MD 4.3%, p = 0.052 | | |
| | | | | Fibre intake score (Range 1–5 with 1 indicating low fibre and 5 indicating high fibre) | MD 0.07 (-0.07, 0.21) | |
| | | | | Fat intake score (Range 1–5 with 1 indicating high fat and 5 indicating low fat) | MD 0.04 (-0.07, 0.15) | |
| | | | | Fat avoidance score (Range 1 to 5, interpretation NR) | MD -0.06 (-0.27, 0.15) | |
| Kimura 2013(61) | I: "Sumida TAKE10" program. Lecture on good dietary habits; participants self-monitored dietary check sheets during lecture and received instructor feedback; stretching and strengthening exercise. C: Crossover | Food frequency intake questionnaire (tool NR) | Food Frequency Score (Range 0 to 30, sum of intake scores across food groups) | MD 2.7 (0.79, 4.61) | 7/13 |
| | | | | Dietary Variety Score Overall score (Range 0 to 10, higher score indicates greater variety) | MD 1.5 (0.42, 2.58) | |
| MacNab 2017(75) | I1: Interactive whole grain nutrition education program, hands-on activities to identify whole grains, case scenarios to apply knowledge; taste-testing, worksheets, handouts, recipes I2: Modified intervention based on delivery style (same activities) | Dietary Screening Tool, 3-item subscale | Total grain frequency score (max score 15, higher score indicates greater frequency) | I1 and I2 combined: MD 0.9 (SD 4.23), p < 0.001 | 5/9 |
| Study ID | Description of Intervention/Comparator | Data Collection Tool | Outcome | Effect size (95% confidence interval or standard deviation, p-value) | Risk of Bias |
|----------|----------------------------------------|----------------------|---------|------------------------------------------------------------------|-------------|
| Murayama 2020<sup>(74)</sup> | I: Drama-style lectures on nutrition (protein, fat, carbohydrates) and dietary variety; food tasting; discussion to share knowledge, success and failures; home activities. C: Crossover | Dietary Screening Tool, 2-item subscale | Whole grain frequency score (max score 10, higher score indicates greater frequency) | I1 and I2 combined: MD 0.7 (SD 3.01), p < 0.001 | 7/9 |
| Salehi 2011<sup>(65)</sup> | I: Group-based tailored nutrition intervention based on stages of change aiming for 5 FV servings/day. Included goal setting, action planning, reinforcement. C: 4 weekly general health education | Food frequency intake questionnaire (tool NR) | Dietary Variety Score Overall score (Range 0 to 10, higher score indicates greater variety) | MD 1.60 (0.75, 2.45) | 4/13 |
| Schwingel 2017<sup>(82)</sup> | I: Nutrition education and culturally tailored lifestyle change curriculum, including healthy living, healthy eating, nutrition labels, buying healthy food, stress management, barriers, goal setting, action plans, home activities (e.g., healthy meal prep, grocery shopping with grandchildren, PA, pedometer step-tracking), motivational telephone calls C: Baseline | 24-hr diet recall | # Fruits consumed/day NS difference | 7/9 |
| Silva-Smith 2013<sup>(66)</sup> | I: "Promoting Older Adult Wellness", education, social network, motivational support and short/long term goal setting (for PA and DASH diet); supervised, progressive walking program C: Attention control health newsletters | 24-hr diet recall | Fruit (servings/day) MD -0.03 (90% CI: -0.44, 0.38) | 8/13 |
| Study ID | Description of Intervention/Comparator | Data Collection Tool | Outcome | Effect size (95% confidence interval or standard deviation, p-value) | Risk of Bias |
|----------|----------------------------------------|----------------------|---------|---------------------------------------------------------------|-------------|
|          |                                        |                      |         |                                                                |             |
|          |                                        |                      |         |                                                                |             |
| Meat and bean (servings/day) | MD 0.21 (90% CI: -1.41, 1.82) |                      |         |                                                                |             |
| Fat (g/day) | MD 5.26 (90% CI: -11.02, 21.53) |                      |         |                                                                |             |
| Total (kcal/day) | MD 100.49 (90% CI: -187.91, 388.89) |                      |         |                                                                |             |
| Sodium (mg/day) | MD 139.62 (90% CI: -633.07, 912.31) |                      |         |                                                                |             |
| Cholesterol (g/day) | MD 21.82 (90% CI: -68, 111.64) |                      |         |                                                                |             |
| Smith 2015[53, 94] | I: Texercise Select. Education on healthy dietary habits and cooking; PA and nutrition logs; goal setting, action plans and group brainstorming; PA component incorporating flexibility, strength, balance, endurance. | FFQ | FV consumption (servings/week) | MD 0.42, p = 0.002 | 6/9 |
|          | C: Baseline |                      |         |                                                                |             |
|          | FV consumption (drinks/week) | MD -0.13, p = 0.255 |         |                                                                |             |
|          | Water consumption (cups/day) | MD 0.59, p < 0.001 |         |                                                                |             |
|          | Fast food consumption (times/week) | MD -0.21, p = 0.2 |         |                                                                |             |
| Smith 2020[77, 95] | I: Texercise Select. Education on healthy dietary habits and cooking; PA and nutrition logs; goal setting, action plans and group brainstorming; PA component incorporating flexibility, strength, balance, endurance. | Diet recall (modified Starting the Conversation instrument) | FV consumption (proportional odds of a larger number of servings/week vs. baseline) | End of study | 6/9 |
|          | C: Usual care, waitlist control |                      | I: OR = 1.68 (1.15, 2.47) | C: OR = 0.83 (0.60, 1.15), I vs. C, p = 0.006 | Follow-up |
|          | |                      | I: OR = 0.84 (0.53, 1.35) | C: OR = 0.74 (0.50, 1.09), I vs. C, p = 0.656 | Follow-up |
|          | |                      | I: OR = 0.73 (0.45, 1.19) | C: OR = 0.82 (0.58, 1.16), I vs. C, p = 0.71 | Follow-up |
|          | |                      | End of study | I: OR = 0.88 (0.60, 1.30) | Follow-up |
|          | |                      | End of study | C: OR = 1.09 (0.82, 1.44), I vs. C, p = 0.393 | Follow-up |
|          | |                      | End of study | I: OR = 0.73 (0.45, 1.19) | Follow-up |
|          | |                      | End of study | C: OR = 0.82 (0.58, 1.16), I vs. C, p = 0.71 | Follow-up |
| Study ID | Description of Intervention/Comparator | Data Collection Tool | Outcome | Effect size (95% confidence interval or standard deviation, p-value) | Risk of Bias |
|----------|----------------------------------------|----------------------|---------|------------------------------------------------------------------|-------------|
| **Uemura 2018**<sup>(67)</sup> | I: Educational health promotion intervention on exercise, diet, nutrition, cognitive activity including malnutrition, food labelling, walking, resistance exercise. PA self-monitored via accelerometer. Self-planning for and implementing behavioural change | Food frequency intake questionnaire (tool NR) | Water consumption (proportional odds of a larger number of cups/day) | End of study | I: OR = 1.46 (1.10, 1.94) C: OR = 1.14 (0.89, 1.47), I vs. C: p = 0.204 Follow up: NR |
| | C: No intervention | | | | |
| **Wunderlich 2011**<sup>(57)</sup> | I: Elderly Nutrition Program, including education sessions focused on common conditions among older adults (e.g., hypertension and salt intake) and cooking demos. | Self-reported checklist | Fast food consumption (proportional odds of a larger number of servings/week vs. baseline) | End of study | I: OR = 0.66 (0.48, 0.91) C: OR = 1.04 (0.77, 1.40), I vs. C: p = 0.046 Follow up | I: 0.65 (0.42, 1.02) C: 0.97 (0.66, 1.42), I vs. C, p = 0.184 |
| | C: Baseline | | | | |
| **Didactic nutrition education interventions** | | | | | |
| **Brewer 2016**<sup>(68)</sup> | I: FV nutrition education (e.g., phytochemicals, serving sizes, shopping) and educational tools (e.g., recipe cards, phytochemical guide, health information) | FFQ | FV intake (servings/week) | MD 2.72 (-3.77, 9.21) | 8/9 |
| | C: Educational tools | | | | |
| **Luten 2016**<sup>(74)</sup> | I: Community-based media campaign to promote healthy eating and PA | Number of days/wk and amount consumed (tool NR) | Fruit intake (g/day) | Partial eta squared (mid-point): -0.01 (NS) Partial eta squared (end of study): -0.10 (NS) | 7/9 |
| | C: Region where no intervention took place | | | | |
| **Turk 2016**<sup>(56)</sup> | I: "Wise Choices" sessions focused on nutrition and PA, including FV, calcium, and fibre intake; portion sizes; USDA MyPlate food choices; step goals using pedometers given. | 17-item nutrition questionnaire | % Who consumed 3 servings of fruits/day | +11%, p = 0.035 | 6/9 |
| | C: Baseline | | | | |
| Study ID       | Description of Intervention/Comparator                                                                 | Data Collection Tool          | Outcome                                                                                     | Effect size (95% confidence interval or standard deviation, p-value) | Risk of Bias |
|---------------|---------------------------------------------------------------------------------------------------------|-------------------------------|---------------------------------------------------------------------------------------------|---------------------------------------------------------------------|--------------|
| Beasley 2019  | I: Diabetes Prevention Program, including reducing calories and fat, overall healthy eating, PA, and managing eating triggers. C: Baseline | 4-Day Food Record             | % Who consumed 3 servings of vegetables/day                                                   | +10%, p = 0.032                                                     | 7/9          |
|               |                                                                                                          |                               | % Who consumed 3 servings of whole grains and high-fiber foods/day                            | +10.3%, p = 0.004                                                   |              |
|               |                                                                                                          |                               | % Who consumed 3 servings of milk, cheese, and yogurt/day                                     | +12.1%, p = 0.072                                                   |              |
|               |                                                                                                          |                               | % Who consumed 3 8-oz servings of water/day                                                   | +0.1%, p = 0.124                                                    |              |
| Lara 2015     | I: Group education including benefits of Mediterranean diet, shopping tips, meal planning. Material package including guidelines, menus, recipes; asked to adopt for 3 wks. C: Educational group session and package (without menus, recipes or follow up) | 3-Day Food Record             | Adherence to Mediterranean Diet (9-point score)                                             | MD 0.1 (SE 0.3), p = 0.721                                           | 11/13        |
|               |                                                                                                          |                               | Fish                                        | NS difference                                                      |              |
|               |                                                                                                          |                               | FV                                           | NS difference                                                      |              |
|               |                                                                                                          |                               | Legumes                                      | NS difference                                                      |              |
|               |                                                                                                          |                               | Cereals                                      | NS difference                                                      |              |
|               |                                                                                                          |                               | Meat                                         | NS difference                                                      |              |
|               |                                                                                                          |                               | Dairy                                         | NS difference                                                      |              |
| AbuSabha 2011 | I: Veggie Mobile van delivers discounted fresh produce to low-income neighbourhoods                    | Modified Behavioural Risk Factor | FV intake (servings/day)                      | MD 0.45 (-0.23, 1.14)                                              | 3/9          |
Nutrition education with behaviour change techniques and food access interventions

| Study ID | Description of Intervention/Comparator | Surveillance Data Collection Tool | Outcome | Effect size (95% confidence interval or standard deviation, p-value) | Risk of Bias |
|----------|----------------------------------------|----------------------------------|---------|------------------------------------------------------------------|-------------|
| Moreau 2015(60) | I: Nutrition education and cooking workshops including healthy eating, cancer, cardiovascular disease prevention, nutrition for aging, labels, fiber, bone health, eating for pleasure, social support, barriers and strategies, recipes, take-home meals. | Abbreviated FFQ | Consumption of recommended portions of food groups (FV, cereal or whole grain, meats and alternatives, water and milk) | Significant improvement pre-post intervention (p < 0.05, values NR) | 4/9 |
| C. Baseline | | | | | |
| Strout 2017(54) | I: “GROW” (Green Organic Vegetable Gardens). Participants given a raised garden bed, ergonomic tools and supplies, and chose seeds and recipes. | | Adequate protein intake | % Reporting positive change: 50 | 5/9 |
| C. Baseline | | | | | |

Note: Bold text indicates statistical significance. C = comparator group; CI = confidence interval; FFQ = Food Frequency Questionnaire; FV = fruits and vegetables; g = grams; hr = hour; I = intervention group; kcal = kilocalorie; mcg = microgram; MD = mean difference; mg = milligram; mo = month; NR = not reported; NS = not statistically significant; OR = odds ratio; oz = ounce; PA = physical activity; SD = standard deviation; SE = standard error; wk = week

Between and within intervention categories, inconsistent findings were reported. Although the greatest number of studies utilized nutrition education with BCT interventions, findings were mixed. Five interventions found consistently positive changes in food and/or fluid intake(61, 65, 67, 71, 75). The Sumida TAKE10 program (three months of bi-weekly lectures, take-home activities, monitoring, and feedback) (moderate risk of bias)(61), and a 24-week intervention incorporating nutrition education, skill-building activities, and planning/implementing behavioural change (low risk of bias)(67) improved both food intake frequency and dietary variety compared to a cross-over control, and no-intervention comparator group, respectively. The "Eat Smart, Live Strong" intervention (four weekly interactive nutrition education sessions with goal setting) improved vegetable and fruit intake when compared to a waitlist control (low risk of bias)(71). Tailored nutrition education based on the stages of change with goal setting, action planning, and reinforcement resulted in increased vegetable and fruit consumption after four weekly sessions compared to general health education (high risk of bias)(65). Two modes of delivery of a whole grain education program (both including skill-building activities and taste testing) increased total and whole-grain intake frequency after three weekly sessions compared to a cross-over control, and no-intervention comparator group, respectively. The "Eat Smart, Live Strong" intervention incorporating nutrition education, skill-building activities, and planning/implementing behavioural change (low risk of bias)(67) improved both food intake frequency and dietary variety compared to a cross-over control, and no-intervention comparator group, respectively.

Five studies showed improvements in some but not all aspects of food and fluid intake following nutrition education with BCT, as findings were inconsistent across outcomes(52, 53, 60, 76, 77). Physical activity and nutrition education with goal setting and skill-building components increased the percentage of participants meeting recommended fruit intake, but not other food groups and macronutrients, as compared to no intervention (low risk of bias)(60). Nutrition education and culturally tailored lifestyle program incorporating goal setting, action planning, and hands-on activities increased the number of participants consuming ≥ 3 meals/day and decreased fried food consumption, but also decreased vegetable intake and found no change in fruit intake as compared to baseline (low risk of bias)(52). Eight weeks of bi-weekly drama-style lectures, food tasting, and group discussion improved dietary variety compared to control, but inconsistent findings were noted for macronutrient consumption (low risk of bias)(76). Two studies evaluated the effects of the Texercise Select
intervention (10-weeks of twice-weekly education, physical activity, goal setting and action planning). In the first study, Texercise Select increased the likelihood of vegetable and fruit consumption and decreased the likelihood of fast-food intake but did not change soda or water consumption compared to a non-randomized waitlist control (moderate risk of bias)\(^{(77)}\); improvements were not sustained at six month follow up. Texercise Select improved vegetable, fruit, and water consumption but not soda and fast food consumption compared to baseline in the second study (moderate risk of bias)\(^{(53)}\).

Although heterogeneity across interventions was evident, similar nutrition education with BCT interventions were used in four studies (low to high risk of bias) that found no significant changes in food and fluid intake\(^{(57, 59, 66, 70)}\). Didactic nutrition education\(^{(56, 68, 74)}\), interactive nutrition education\(^{(48, 62)}\), and food access\(^{(47, 54)}\) interventions alone did not appear to change food and fluid intake for the better. Only one study evaluated a nutrition education with BCT and food access (take-home meal portions) intervention and found improved consumption of recommended portions of all food groups (moderate risk of bias)\(^{(50)}\).

**Nutrition Risk**

Nine studies evaluated the effectiveness of nutrition education with BCT (n = 7, 78%)\(^{(49, 57, 58, 63, 64, 72, 73)}\), food access (n = 1, 11%)\(^{(54)}\), and nutrition education with BCT and food access (n = 1, 11%)\(^{(69)}\) for decreasing nutrition risk. Measures such as the Mini Nutritional Assessment (n = 3, 33%)\(^{(54, 64, 69)}\), Dietary Screening Tool (n = 2, 22%)\(^{(58, 73)}\), problematic dietary habits (n = 2, 22%)\(^{(49, 72)}\), and food security (n = 1, 11%)\(^{(58)}\) were used (Table 3). Heterogeneous interventions and outcomes and inconsistent results were found.
| Study ID   | Description of Intervention/ Comparator | Data Collection Tool | Outcome | Effect size (95% confidence interval or standard deviation, p-value) | Risk of Bias |
|------------|----------------------------------------|----------------------|---------|---------------------------------------------------------------|-------------|
| **Nutrition education with behaviour change technique interventions** | | | | | |
| Francis 2014[58] | I: Nutrition and health education including FV and calcium-rich food; PA; safe food handling; food security. Group discussion of smarter goal planning and taste-testing activity. C: Didactic education (newsletters) only | Dietary Screening Tool | Nutrition risk (Maximum score 100 where < 60 is "at nutrition risk", 60–75 is "possible nutrition risk" and > 75 is "not at nutrition risk") | MD 5.35 (0.08, 10.61) | 6/13 |
| Hau 2010[72] | I: Nutrition education and practice via dietary choice games (food categories, healthy diet, cooking principles, food recognition), guided by CCAA and NIA materials. PA component (endurance, strength, balance, flexibility) C: No intervention | U.S. Household Food Security Survey | Food security (% in each category) | Very low: MD 3.3 (p = NR) Low: MD -13.3 (p = NR) Marginal/High: MD + 10 (p > 0.05) Overall change in distribution, p < 0.001 | 4/9 |
| Lillehoj 2018[73] | I: Supplemental Nutrition Assistance Program-Education (SNAP-Ed) including goal setting, recipe tasting, PA break. C: No intervention | Dietary Screening Tool | Problematic dietary habits | NS difference | |
| Manafo 2013[49] | I: Nutrition Information Series following Canada’s Food Guide to Healthy Eating; interactive activities including making a food record and reading food labels; healthy snack C: Baseline | Canadian Community Health Survey single item: “I consider my eating habits to be...” | Personal eating habits (‘very poor’ to ‘very good’ on 5-point Likert scale) | MD (frequent attenders [attended four or more sessions] vs. control) 1.69 (SD 15.6), p = 0.04 (controlling for gender and self-efficacy) | 6/9 |
| Meethien 2011[63] | I: Nutrition education for elders and family members. Individual counseling; motivational plan for healthy eating; food preparation activities; training and guidance on meal planning; personal goal setting, behavioural monitoring, and maintenance C: Usual care | Elder’s Healthy Eating Scale | Overall healthy eating score (114-item scale, total possible score range 114–570) | MD (end of study): 147.8 (SD NR), p < 0.001 MD (follow up): 172.4 (SD NR), p < 0.001 | 6/13 |
| Mendoza-Ruvalcaba 2015[64] | I: "I am Active" alternating sessions on nutrition or cognitive function; meal planning; goal setting; strength, balance, and mobility physical exercises C: Waitlist control, weekly social activities | Mini Nutritional Assessment | Normal nutritional status (%) | MD + 31.4%, p < 0.05 At risk for malnutrition (%) | 5/13 |
| Wunderlich 2011[57] | I: Elderly Nutrition Program, including education sessions focused on common conditions among older adults (e.g., hypertension and salt intake) and cooking demos. C: Baseline | Nutrition Survey Risk Screening | Nutrition risk score (0–2 good, 3–5 moderate risk, ≥6 high risk) | MD -0.44, p = 0.14 | 3/9 |

**Food access interventions**
| Study ID | Description of Intervention/ Comparator | Data Collection Tool | Outcome | Effect size (95% confidence interval or standard deviation, p-value) | Risk of Bias |
|---|---|---|---|---|---|
| Strout 2017(54) | I: “GROW” (Green Organic Vegetable Gardens). Participants given a raised garden bed, ergonomic tools and supplies, and chose seeds and recipes. C: Baseline | Mini Nutritional Assessment | Self-view of nutritional status | % Reporting positive change: 30 % Reporting negative change: 20 (descriptive statistics only) | 5/9 |
| Chung 2014(69) | I1: Nutrition seminars covering nutrient classification, healthy foods and labelling, recipes, cooking demo. Provided ingredient samples for low-cost, nutrient rich meals with 1-day food samples/wk I2: As above with three, 1-day food samples/wk | Mini Nutritional Assessment | Nutritional status (< 17 is malnourished, 17-23.5 is at risk of malnutrition, 24–30 is normal nutritional status) | I1: MD 0.9 p = 0.641 I2: MD 2.7, p = 0.019 | 7/9 |

Note: Bold text indicates statistical significance. C = comparator group; CCAA = Canadian Center for Activity and Aging; CI = confidence interval; FV = fruits and vegetables; I = intervention group; MD = mean difference; NIA = National Institute of Aging; NR = not reported; NS = not statistically significant; PA = physical activity; SD = standard deviation; wk = week

Among seven studies that combined nutrition education with BCT, five demonstrated consistently positive effects(49, 58, 63, 64, 73). The “I am Active” intervention (twice weekly nutrition sessions including meal planning and goal setting for two months) increased the percentage of participants with “normal” nutritional status (as defined by the Mini Nutritional Assessment) and decreased the number at risk for malnutrition compared to waitlist control (moderate risk of bias)(64). Compared to didactic education alone, six-monthly nutrition and health education sessions incorporating goal setting and taste testing decreased nutrition risk (moderate risk of bias)(58). People who frequently attended Supplemental Nutrition Assistant Program-Education (SNAP-Ed) nutrition education sessions with goal setting and recipe tasting decreased their nutrition risk status as compared to control (moderate risk of bias)(73); however, it is important to note that only those attending four or more sessions were included in the analysis. Compared to usual care, weekly nutrition education that incorporated counselling, food preparation, goal setting, and behavioural monitoring improved overall healthy eating scores after three months (moderate risk of bias)(63). Finally, interactive nutrition education and skill-building activities also improved personal eating habits as compared to baseline (moderate risk of bias)(49).

Conversely, two additional studies that combined nutrition education with BCT did not improve nutritional status (moderate to high risk of bias)(57, 72). Two studies (low to moderate risk of bias) evaluated food access or nutrition education with BCT and food access(54, 69); these did not consistently reduce nutrition risk.

**Healthy Eating Knowledge**

Five studies reported changes in healthy eating knowledge, generally using study-specific single-item questions (e.g., roles of nutrients, recommended servings) following nutrition education with BCT (n = 3, 60%)(51, 75, 76), nutrition education with BCT and food access (n = 1, 20%)(60), and didactic nutrition education (n = 1, 20%)(55). Nutrition education with BCT may improve healthy eating knowledge, as found in four studies (low to moderate risk of bias) that incorporated skill-building activities into nutrition education interventions(50, 51, 75, 76) (Table 4).
| Study ID | Description of Intervention/ Comparator | Data Collection Tool | Outcome | Effect size (95% confidence interval or standard deviation, p-value) | Risk of Bias |
|----------|----------------------------------------|----------------------|---------|------------------------------------------------------------------|-------------|
| **Nutrition education with behavioural change technique interventions** |
| MacNab 2017(75) | I: Interactive whole grain nutrition education program, hands-on activities to identify whole grains, case scenarios to apply knowledge, taste-testing, worksheets, handouts, recipes  
I2: Modified intervention based on delivery style (same activities) | Whole Grain Knowledge Questionnaire | Knowledge of whole grains score (maximum score 31) | I1 (PowerPoint-based): 22.2 (SD 0.4) at post  
I2 (Non-PowerPoint): 20.3 (SD 0.2) at post  
I1 and I2 combined: 15.1 (SD 4.9) pre to 21.6 (SD 4.0) post, p < 0.001 | 5/9 |
| Murayama 2020(76) | I: Drama-style lectures on nutrition (protein, fat, carbohydrates) and dietary variety; food tasting; discussion to share knowledge, success and failures; home activities.  
C: Crossover | Single item 'I understand the roles of nutrients"  
Single item 'I understand my appropriate amount of food intake" | Knowledge score (7-point Likert scale where 1 is "disagree" and 7 is "agree")  
Knowledge score (7-point Likert scale where 1 is "disagree" and 7 is "agree") | MD 0.69 (0.16, 1.21)  
MD 1.31 (0.63, 1.99) | 7/9 |
| Pogge 2013(51) | I: "Mindful Choices" topics included calories, goal setting, building a support system, portion control, PA, nutrition, food labels, stress management. Snacks, tip sheets, and calorie counting books provided.  
C: Baseline | 15-item nutrition knowledge test | Knowledge score (higher score = more knowledge) | MD 20.3, p < 0.001  
Pre: 61.4 (SD 19.7), Post: 81.7 (SD 19.5) | 5/9 |
| **Nutrition education with behaviour change techniques and food access interventions** |
| Moreau 2015(50) | I: Nutrition education and cooking workshops including healthy eating, cancer, cardiovascular disease prevention, nutrition for aging, labels, fiber, bone health, eating for pleasure, social support, barriers and strategies, recipes, take-home meals.  
C: Baseline | 48-item questionnaire related to knowledge on nutrition, health, and related diseases | Knowledge score (higher score = more knowledge) | Significant increase pre-post intervention (p < 0.05, values NR) | 4/9 |
| **Didactic nutrition education interventions** |
| Thomas 2010(55) | I: Educational booklet including nutrition knowledge, recommended food items and PA to improve or prevent chronic diseases  
C: Baseline | Single item: "Do you think vegetable experts recommended that the average American should be eating more or less of these foods?"  
Vegetable (% yes)  
Sugar (% yes)  
Meat (% yes)  
Fat (% yes)  
Fiber (% yes)  
Salt (% yes) | MD -0.017 (SD 0.247), p = 0.367  
MD -0.011 (SD 0.280), p = 0.594  
MD -0.028 (SD 0.573), p = 0.151  
MD -0.011 (SD 0.333), p = 0.656  
MD 0.006 (SD 0.343), p = 0.628  
MD -0.028 (SD 0.247), p = 0.132 | 2/9 |
| Study ID | Description of Intervention/ Comparator | Data Collection Tool | Outcome | Effect size (95% confidence interval or standard deviation, p-value) | Risk of Bias |
|----------|----------------------------------------|----------------------|----------|---------------------------------------------------------------|-------------|

Note: **Bold text indicates statistical significance.** C = comparator group; CI = confidence interval; I = intervention group; MD = mean difference; PA = physical activity; SD = standard deviation

Physical Mobility Outcomes

Physical Activity

Physical activity outcomes were assessed in 13 studies consisting of nutrition education with BCT (n = 10, 77%)\(^{52, 53, 59–61, 66, 67, 70, 72, 77}\), didactic nutrition education (n = 2, 15%)\(^{56, 74}\), and interactive nutrition education (n = 1, 8%)\(^{48}\) interventions (Table 5). These were captured through both self-reported (e.g., International Physical Activity Questionnaire, 24-hour/7-day recall) and objective measurements (e.g., pedometers, accelerometers). All interventions included a physical activity component either through education or participation during the group-based sessions.
| Study ID | Description of Intervention/Comparator | Physical Activity Co-Intervention | Data Collection Tool | Outcome | Effect size (95% confidence interval or standard deviation, p-value) | Risk of Bias |
|----------|----------------------------------------|-----------------------------------|----------------------|---------|-----------------------------------------------------------------|-------------|
| **Gallois 2013**<sup>(70)</sup> | I: Tools to track FV, dairy, fish, and PA; performance feedback and advice. Standard health info on PA, nutrition, recipes. C: Standard health info and recipes by mail | Education | 24-hr recall | Achieving 30 MVPA min/day, I vs. C at end of study | Adjusted OR 0.78 (0.51, 1.19) | 7/9 |
| **Geller 2012**<sup>(59)</sup> | I1: Decisional balance sheet for FV intake. Provides basic health knowledge and empowers individuals to consider pros and cons of behaviour adoption. I2: Identical program targeting PA instead of FV | Education | IPAQ | PA minutes/day | I1: MD 47.05 (SD 79.77), descriptive statistics only I2: MD 32.19 (SD 47.34), descriptive statistics only | 5/13 |
| **Hsu 2010**<sup>(72)</sup> | I: Nutrition education and practice via dietary choice games (food categories, healthy diet, cooking principles, food recognition), guided by CCAA and NIA materials. PA component (endurance, strength, balance, flexibility) C: No intervention | Participation | Regular exercise behaviour (tool NR) | % Doing exercise for at least 30 minutes, 3x/week (yes/no) | Increased (p < 0.001) | 4/9 |
| **Jancey 2017**<sup>(60)</sup> | I: PA and nutrition education (e.g., goal setting, monitoring and feedback; skill building; social support; exercise demo); educational resources (booklet, calendar, exercise chart, resistance bands, newsletters); motivational interviewing (goal setting, adherence, sustainability) C: No intervention | Education | IPAQ | Walking time (min/wk) | MD -16.57 (-83.48, 50.34) | 10/13 |
| | | | | Sitting time (min/wk) | MD -211.6 (-457.59, 34.39) | |
| | | | | Moderate activity (min/wk) | MD 71.09 (15.7, 126.48) | |
| | | | | Vigorous activity: % participating > 10 min | MD -2.7%, p = 0.716 | |
| | | | | Strength exercise: % participating > 10 min | MD 22.4%, p = 0.002 | |
| **Kimura 2013**<sup>(61)</sup> | I: “Sumida TAKE10” program. Lecture on good dietary habits; participants self-monitored dietary check sheets during lecture and received instructor feedback; stretching and strengthening exercise. C: Baseline | Participation | Physical activity questionnaire (tool NR) | Days of walking or exercise/wk | No difference within or between groups (p > 0.05) | 7/13 |
| **Schwingel 2017**<sup>(52)</sup> | I: Nutrition education and culturally tailored lifestyle change curriculum, including healthy living, healthy eating, nutrition labels, buying healthy food, stress management, barriers, goal setting, action plans, home activities (e.g., healthy meal prep, grocery shopping with grandchildren, PA, pedometer step-tracking), motivational telephone calls C: Baseline | Participation | Accelerometers | MVPA (min/wk) | % Meeting MVPA guidelines | 7/9 |
| | | | | | % (end of study): +20.4% | |
| | | | | | % (follow up): +28.1% | p = 0.08 (linear trend) | |
| Study ID         | Description of Intervention/Comparator                                                                                                                                                                                                 | Physical Activity Co-Intervention | Data Collection Tool | Outcome | Effect size (95% confidence interval or standard deviation, p-value) | Risk of Bias |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|----------------------|---------|---------------------------------------------------------------------|--------------|
| **Silva-Smith 2013**<sup>56)<sup>  | I: “Promoting Older Adult Wellness”, education, social network, motivational support and short/long term goal setting (for PA and DASH diet); supervised, progressive walking program  
C: Attention control health newsletters                                                                                                                                         | Participation                     | 7-day pedometer     | Steps/wk | Adjusted MD 4573.24 (90% CI: -259.37, 9405.86)                 | 8/13         |
|                 |                                                                                                         |                                    |                      |          | **7-day self-report**  PA (units NR)                               |              |
|                 |                                                                                                         |                                    |                      |          | Adjusted MD 48.17 (90% CI: 5.77, 90.58)                          |              |
| **Smith 2015**<sup>53, 64)<sup>  | I: Texercise Select.  
Education on healthy dietary habits and cooking; PA and nutrition logs; goal setting, action plans and group brainstorming; PA component incorporating flexibility, strength, balance, endurance.  
C: Baseline                                                                                                                | Participation                     | RAPA-1               | Aerobic PA score (Range 1–5, 5 = highest) | MD 0.65, p < 0.001                           | 6/9          |
|                 |                                                                                                         |                                    |                      |          | OR 4.04, p < 0.001                                               |              |
|                 |                                                                                                         |                                    |                      |          | OR 5.48, p < 0.001                                               |              |
| **Smith 2020**<sup>77, 93)<sup>  | I: Texercise Select. Education on healthy dietary habits and cooking; PA and nutrition logs; goal setting, action plans and group brainstorming; PA component incorporating flexibility, strength, balance, endurance.  
C: Usual care, waitlist control                                                                                           | Participation                     | IPAQ                 | Sedentary (hr/day)                                                | Adjusted MD (end of study): -0.77 (-1.63, 0.09) | 6/9          |
|                 |                                                                                                         |                                    |                      |          | Adjusted MD (end of study): 27.24 (-35.96, 90.44)                |              |
|                 |                                                                                                         |                                    |                      |          | Adjusted MD (follow up): -1.1 (2.13, -0.07)                      |              |
|                 |                                                                                                         |                                    |                      |          | Light PA (min/wk)                                                 | Adjusted MD (end of study): 44.95 (11.59, 78.31) |              |
|                 |                                                                                                         |                                    |                      |          | Adjusted MD (follow up): 59.94 (20.59, 99.29)                    |              |
|                 |                                                                                                         |                                    |                      |          | Moderate PA (min/wk)                                              | Adjusted MD (end of study): 90.36 (15.07, 165.65) |              |
| Study ID | Description of Intervention/Comparator | Physical Activity Co-Intervention | Data Collection Tool | Outcome | Effect size (95% confidence interval or standard deviation, p-value) | Risk of Bias |
|----------|----------------------------------------|---------------------------------|----------------------|---------|---------------------------------------------------------------|--------------|
|          |                                        | Vigorous PA (min/wk)             |                      |         | Adjusted MD (end of study): 14.36 (-3.58, 32.3)               |              |
|          |                                        |                                 |                      |         | Adjusted MD (follow up): 31.67 (10.41, 52.93)                  |              |
| Uemura 2018<sup>(67)</sup> | I: Educational health promotion on exercise, diet, nutrition, cognitive activity including malnutrition, food labelling, walking, resistance exercise. PA self-monitored via accelerometer. Self-planning for and implementing behavioural change | Participation | Accelerometer | Steps/day | MD 1,674 (SE 452), p < 0.001 | 10/13 |
|          | C: No intervention                      |                                 |                      | PA level | MD 0.05 (SE 0.02), p = 0.01                                  |              |
|          |                                        |                                 |                      | (units NR) |                                                  |              |
| Didactic nutrition education interventions | | | | | | |
| Luten 2016<sup>(74)</sup> | I: Community-based media campaign to promote healthy eating and PA | Education | Short Questionnaire to ASsess Health-enhancing physical activity (SQUASH) | Total PA | Partial eta squared (mid-point): -0.05 (NS) | 7/9 |
|          | C: Region where no intervention took place |                      |                      | Partial eta squared (end of study): -0.03 (NS) | | |
|          |                                        | Transport-related PA            |                      | Partial eta squared (mid-point): 0.32, p < 0.01 | | |
|          |                                        | Household-related PA            |                      | Partial eta squared (end of study): 0.38, p < 0.01 | | |
|          |                                        | Leisure-time PA                 |                      | Partial eta squared (mid-point): 0.15, p < 0.05 | | |
| Study ID | Description of Intervention/Comparator | Physical Activity Co-Intervention | Data Collection Tool | Outcome | Effect size (95% confidence interval or standard deviation, p-value) | Risk of Bias |
|----------|----------------------------------------|-----------------------------------|---------------------|---------|---------------------------------------------------------------|-----------|
| Turk 2016<sup>(56)</sup> | I: "Wise Choices" sessions focused on nutrition and PA, including FV, calcium, and fiber intake; portion sizes; USDA MyPlate food choices; step goals using pedometers given. | Participation | 9-item PA questionnaire | Moderate activity (hrs/wk) | Weekday: no difference (p = 0.99) | 6/9 |
| | | | | | Weekend: no difference (p = 0.83) | |
| | | | | Vigorous activity (hrs/wk) | Weekday: no difference (p = 0.90) | |
| | | | | | Weekend: no difference (p = 0.37) | |
| | | | | City blocks walked/day | Pre: Median 3 (Range: 0–36), Post: Median 6 (Range: 0–90), p < 0.001 | |
| | | | | Pedometers | Steps/day | Pre: Median 3,143 (Range: 274–10,593), Post: Median 3,480 (Range: 662–18,592), p < 0.001 | |

**Interactive nutrition education interventions**

| Beasley 2019<sup>(48)</sup> | I: Diabetes Prevention Program, including reducing calories and fat, overall healthy eating, PA, and managing eating triggers. | Education | CHAMP | Moderate PA (min/wk) | MD 66 (-178, 310) | 7/9 |
| | | | | All PA (min/wk) | MD 127 (-264, 518) | |
| | | | PA trackers (Fitbit) | Lightly active (min/wk) | MD -10 (-55, 35) | |
| | | | | Fairly active (min/wk) | MD -2 (-13, 9) | |
| | | | | Very active (min/wk) | MD -3 (-4, 2) | |
| | | | Total activity (min/wk) | MD -15 (-76, 46) | |

Note: Bold text indicates statistical significance. CHAMP = Cardiovascular Healthy Activities Model Program for Seniors; C = comparator group; CCAA = Canadian Center for Activity and Aging; CI = confidence interval; d = day; FV = fruits and vegetables; hr = hour; I = intervention group; IPAQ = International Physical Activity Questionnaire short form; MD = mean difference; min = minutes; mph = miles per hour; MVPA = moderate to vigorous intensity physical activity; NIA = National Institute of Aging; NR = not reported; NS = not statistically significant; OR = odds ratio; PA = physical activity; RAPA = Rapid Assessment of Physical Activity; s = seconds; SD = standard deviation; SE = standard error; wk = week

Across ten studies evaluating nutrition education with BCT, findings were mixed. Four studies found a consistent increase in exercise<sup>(53, 72)</sup> (moderate risk of bias) or physical activity<sup>(67, 77)</sup> (low to moderate risk of bias); each of these included physical activity participation within group-based sessions. Six other studies (low to moderate risk of bias) did not report consistent improvements, with three studies including physical activity education only<sup>(59, 60, 70)</sup> and three<sup>(52, 61, 66)</sup> including physical activity participation. Didactic nutrition education<sup>(56, 74)</sup> and interactive nutrition education<sup>(48)</sup> interventions alone did not appear to increase physical activity.

**Functional Outcomes**
Five studies reported the impact of nutrition education with BCT (n = 4, 80%)\(^{[53,64,67,72]}\) and didactic nutrition education (n = 1, 20%)\(^{[56]}\) on functional mobility (Table 6). Although heterogeneous intervention and outcome types were again noted, both nutrition education with BCT and didactic nutrition education generally improved functional outcomes (e.g., TUG, gait speed), as noted in four studies (low to moderate risk of bias)\(^{[53,56,64,67]}\). Each of these also included participation in physical activity as a co-intervention.
| Study ID | Description of Intervention/Comparator | Physical Activity Co-intervention | Data Collection Tool | Outcome | Effect size (95% confidence interval or standard deviation, p-value) | Risk of Bias |
|----------|----------------------------------------|----------------------------------|----------------------|---------|-----------------------------------------------------------------|-------------|
| Hsu 2010(72) | Nutrition education and practice via dietary choice games (food categories, healthy diet, cooking principles, food recognition), guided by CCAA and NIA materials. PA component (endurance, strength, balance, flexibility) C: No intervention | Participation | Elderly Functional Index | ADL difficulty | NS difference | 4/9 |
| Mendoza-Ruvalcaba 2015(64) | "I am Active" alternating sessions on nutrition or cognitive function; meal planning; goal setting; strength, balance, and mobility physical exercise C: Waitlist control, weekly social activities | Participation | Tinetti scale | Risk of falls | Cohen's d (end of study): 0.34 (p < 0.05); Cohen's d (follow up): 0.24 (NS) | 5/13 |
| | | | | | C: Cohen's d (end of study): 0.02 (NS); Cohen's d (follow up): 0.21 (NS) | |
| | | | | | | |
| | | | | | Balance | Cohen's d (end of study): 0.41 (p < 0.05); Cohen's d (follow up): 0.01 (NS) |
| | | | | | C: Cohen's d (end of study): 0.01 (p < 0.05); Cohen's d (follow up): 0.12 (NS) | |
| | | | | | Gait | Cohen's d (end of study): 0.16 (NS); Cohen's d (follow up): 0.48 (NS) |
| | | | | | C: Cohen's d (end of study): 0.33 (NS); Cohen's d (follow up): 0.29 (NS) | |
| | | | | | Goniometer | Flexibility | Cohen's d (end of study): 0.65 (p < 0.05); Cohen's d (follow up): 0.07 (NS) |
| | | | | | C: Cohen's d (end of study): 0.01 (NS); Cohen's d (follow up): 0.22 (NS) | |
| Study ID | Description of Intervention/Comparator | Physical Activity Co-intervention | Data Collection Tool | Outcome | Effect size (95% confidence interval or standard deviation, p-value) | Risk of Bias |
|----------|----------------------------------------|----------------------------------|---------------------|---------|---------------------------------------------------------------|-------------|
| Smith 2015(53, 54) | I: Texercise Select. Education on healthy dietary habits and cooking; PA and nutrition logs, goal setting, action plans and group brainstorming; PA component incorporating flexibility, strength, balance, endurance. C: Baseline | Participation | TUG (s) | MD -1.5, p < 0.01 | 6/9 |
| Uemura 2018(67) | I: Educational health promotion on exercise, diet, nutrition, cognitive activity including mainutrition, food labelling, walking, resistance exercise. PA self-monitored via accelerometer. Self-planning for and implementing behavioural change C: No intervention | Participation | TUG (s) | MD 0.84 (SE 0.18), p = 0.001 | 10/13 |
| Turk 2016(54) | I: "Wise Choices" sessions focused on nutrition and PA, including FV, calcium, and fibre intake; portion sizes; USDA MyPlate food choices; step goals using pedometers given. C: Baseline | Participation | TUG (s) | Median 0.9 (Range: -23.4 to 9.7), p < 0.001 | 6/9 |

Note: Bold text indicates statistical significance. ADL = activities of daily living; C = comparator group; CCAA = Canadian Center for Activity and Aging; CI = confidence interval; I = intervention group; kg = kilograms; m = metres; m/s = metres per second; MD = mean difference; mo = month; mph = miles per hour; NIA = National Institute of Aging; NS = not statistically significant; PA = physical activity; s = seconds; SD = standard deviation; SE = standard error; TUG = Timed Up and Go test; wk = week

### Discussion

Given the wide heterogeneity and inconsistent findings across this body of literature, our certainty in the effectiveness of group-based community nutrition interventions to improve food and fluid intake, nutritional status, healthy eating knowledge, and measures of physical activity or physical function in older"
adults is low. The available evidence suggests that nutrition education with BCT may be the most promising approach to improving food and fluid intake, nutritional status, and healthy eating knowledge. Given the variation across interventions and outcomes, it is unclear which intervention is optimal for implementation in community-based settings. Both intervention duration and frequency varied widely across studies, with no discernable patterns to suggest a minimally or optimally effective intervention “dose”. While one would suspect that longer programs or more frequent sessions would have a greater impact, this did not appear to be the case in the studies included in this review. Overall, these conclusions should be interpreted with caution related to high variability among intervention components and outcome measurements, in addition to unclear to high risk of bias within the studies themselves.

Most of the interventions combined nutrition education with BCT. Although we broadly grouped interventions as either including BCT or not, we did not explicitly code these based on the BCT Taxonomy\(^\text{(78)}\) to identify the discrete strategies used. The effectiveness of nutrition education with BCT, particularly concerning food and fluid intake and nutrition risk, remains unclear; there is lack of evidence on which specific BCT are required to elicit significant change. Given wide heterogeneity across intervention components, duration, frequency, interventionists, locations, and theoretical frameworks used, we could not distinguish any noticeable patterns among nutrition education with BCT interventions that were consistently effective versus those that were not. Interventions that described nutrition education with BCT appeared to be more intensive than interventions that focused on didactic or interactive nutrition education alone. However, it is conceivable that individuals who consent to participate in a more intensive program could perhaps be more committed to overall behavioural change. Appropriately selecting and evaluating the effectiveness of BCT remains an emerging area of inquiry\(^\text{(79)}\); thus, understanding the most relevant and effective BCT to improve nutrition and mobility outcomes among community-dwelling older adults is an important next step. More fulsome reporting of intervention components following definitions from the BCT Taxonomy\(^\text{(78)}\) or using a recognized framework such as the TIDieR checklist\(^\text{(35)}\) would allow future exploration of key intervention components.

We explored physical activity and functional outcomes given the established link between adequate nutritional intake and mobility in older adults; however, all studies that explored mobility outcomes also included a physical activity co-intervention. The existence of a co-intervention made it difficult to determine which component(s) of these multifaceted interventions were driving change when observed. Although we hypothesized that comprehensive healthy lifestyle programs might have a greater impact on behavioural change overall, we did not observe any clear trends to indicate whether the interventions that included both nutrition and physical activity components were more effective than those focused on nutrition alone. There is limited available evidence regarding the effectiveness of single versus multiple health behaviour change interventions in older adults\(^\text{(80)}\), highlighting a potential area for further investigation\(^\text{(81)}\).

Given the complex factors (e.g., financial, environmental, cultural) known to impact older adults’ ability to maintain a healthy diet\(^\text{(14)}\), it is important to recognize that while nutrition education and skill-building may be effective at increasing healthy eating knowledge and intentions, they may be insufficient to change outcomes such as food and fluid intake or nutrition risk. Using an equity lens, we assessed the nine studies included in this review that explicitly targeted populations with low socioeconomic status (e.g., recruitment from low-income housing). Overall, findings were inconsistent, with improvements following education with BCT noted in some but not others. This may not be surprising if the primary barriers to quality food intake (e.g., vegetable and fruit consumption) are cost or ease of access\(^\text{(9)}\). Environmental support and policy-level public health interventions are likely needed to ensure equitable access to healthy food before nutrition education and skill-building can be expected to make a meaningful difference\(^\text{(82–84)}\).

To our knowledge, this review is the first to systematically identify, appraise, and synthesize evidence regarding the effectiveness of nutrition-focused group-based interventions targeting food and fluid intake, nutrition risk, and mobility outcomes in community-dwelling older adults. However, our results are consistent with recommendations from a pair of evidence syntheses and an expert commentary published in 2003 that concluded nutrition education alone was insufficient to improve nutritional status among older adults\(^\text{(24, 85, 86)}\). In line with our findings, the authors recommended that education be paired with behaviour change strategies and community participation to enhance program effectiveness. Similarly, a 2007 review of Canadian research highlighted successful components of community nutrition programs for older adults, including cooking classes, recipe exchanges, counselling, social support and engagement, motivation, and interactivity\(^\text{(87)}\). Consistent with our findings, these strategies would also be considered techniques to support behaviour change.

Several important considerations should be made while interpreting the findings from this review. Although our search strategy was comprehensive, it was limited to studies published in English since 2010. Given the consistency with findings from older, related reviews, it is unlikely that literature published before 2010 would be of higher methodological quality or change our overall conclusions. Given that the aim of this review was to explore the effectiveness of group-based interventions, it was appropriate to focus on intervention studies only. Qualitative data may highlight important insights into reasons for variable intervention effectiveness (e.g., implementation insights). While we did include two mixed-methods studies, only quantitative data were extracted. Further, although we did endeavour to integrate considerations about study quality, consistency, and directness throughout, the wide variability in outcomes across included studies limited us from applying a formal approach, such as GRADE\(^\text{(88)}\) to assess certainty in this body of evidence.

Our conclusions are also limited by the nature of the primarily quasi-experimental single studies with incomplete follow-up included within the review. Lack of reliable outcome measurement tools may explain some of the inconsistency across studies. Challenges associated with measuring the impact of community nutrition programs have previously been documented\(^\text{(89)}\); given the nature of self-reported data, outcomes such as food intake, dietary behaviour, and knowledge are notoriously complex constructs to measure accurately. Despite previous calls for community nutrition interventions for older adults based on behaviour change theories\(^\text{(86)}\), less than half of the studies in this review used a theoretical framework to inform intervention delivery; this might further explain some of the variability noted in our results. We also observed variability in the content of the nutrition education provided across interventions. It is unclear if recommendations were consistently based on current, evidence-based healthy eating guidelines for older adults, further explaining the inconsistent effectiveness observed.

**Implications for Research**
More studies using RCT designs are needed to increase confidence in the impact of group-based community nutrition interventions. Although blinding of participants and interventionists is nearly impossible given the nature of the interventions, future studies should strive to blind outcome assessors and data analysts to enhance internal validity. Authors using quasi-experimental approaches should include control groups to facilitate stronger comparisons. Given that community-based nutrition programming tends to be delivered via public health initiatives and not always through funded programs of research, challenges noted with intervention design, outcome assessment, study quality, and inappropriate statistical analyses might be attributed to the probable lack of resources available to support community program development and evaluation. Prioritizing research funding to support the development and evaluation of community-based nutrition programs for older adults is necessary to improve the quality of the evidence base.

**Implications for Practice**

For organizations looking to design and implement community-based nutrition programming for older adults, nutrition education with embedded BCT (e.g., goal setting, hands-on skill-building activities, taste testing) demonstrated the most promise to improve healthy eating outcomes. However, there is wide heterogeneity in the available evidence, including program length and session frequency. The discrete techniques and intervention components that might be most important to include have yet to be determined. These will likely need to be tailored based on the needs and preferences of the community and local context. Future program design should be based on recognized theories of behaviour change. There is a potential to draw upon significant recent advancements in behaviour change theory\(^{(90,91)}\), which have been applied in developing complex interventions for healthy eating\(^{(92,93)}\).

**Conclusion**

Group-based nutrition education with BCT demonstrated the most promise in improving food and fluid intake, nutritional status, and healthy eating knowledge among community-dwelling older adults. The impact of these programs on mobility outcomes is less clear. These findings should be interpreted with caution, given the generally unclear to high risk of bias and low quality, heterogeneous evidence base. We have highlighted several key takeaways regarding how the quality of this body of literature could be improved. Future group and community-based programs should use recognized behavioural change theories to develop and implement evidence-based nutrition education with skill-building activities to improve healthy eating among older adults.

**Declarations**

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**Conflict of Interest:**

SMP declares that he is a named inventor on a patent held by Exerkine, but receives no fees/payment, and is an unpaid member of the Scientific Advisory Board for Enhanced Recovery. The other authors have no conflicts of interest to disclose.

**Authorship**

RG and SNS conceptualized the study; RG, DS, CM, and SNS designed the study and carried out the search and study selection. KT, DS, and CM completed data collection and critical appraisal. KT led data analysis and writing of the manuscript with substantial contributions from RG, DS, CM, HK, CS, SMP, and SNS. All authors were involved in critically revising the manuscript and have approved the final version.

**Ethical Standards Disclosure**

Not applicable.

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**Supplementary Material**

Supplementary Table 1: MEDLINE (Ovid) Search Strategy

Supplementary Table 2: CINAHL (EBSCO) Search Strategy

Supplementary Table 3: EMBASE (Ovid) Search Strategy
Supplementary Table 4: PsychINFO (Ovid) Search Strategy

Supplementary Table 5: Sociological Abstracts (ProQuest) Search Strategy

Supplementary Table 6: JBI Critical Appraisal Checklist for Randomized Controlled Trials

Supplementary Table 7: JBI Critical Appraisal Checklist for Quasi-Experimental Studies

Supplementary Appendix 1: Excluded Studies Following Full-Text Review

**Figures**

![PRISMA Flow Diagram](image)

**Figure 1**

PRISMA Flow Diagram
Figure 2
Summary of Risk of Bias in Randomized Controlled Trials Assessed using JBI Critical Appraisal Checklist for Randomized Controlled Trials.

Figure 3
Summary of Risk of Bias in Quasi-Experimental Studies

Page 41/42
Summary of Risk of Bias in Quasi-Experimental Studies Assessed using JBI Critical Appraisal Checklist for Quasi-Experimental Studies (includes single-group, pre-test/post-test and two-group, non-randomized study designs).

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- CommunityNutritionProgramsforOlderAdultsSupplementaryMaterial.docx