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Effectiveness of brief nutrition interventions on dietary behaviours in adults: a systematic review

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Abstract.

Brief interventions are effective in improving health behaviours including alcohol intake, however the effectiveness of brief interventions targeting nutrition outcomes has not been determined. The aim of this systematic review was to determine the effectiveness of brief nutrition interventions in adults. Seven databases were searched for RCT/ pseudo RCT studies published in English to April 2016, and evaluating brief interventions (i.e. single point of contact) designed to promote change in eating behaviours in healthy adults (≥ 18 years). Of 4849 articles identified, 45 studies met inclusion criteria. Most studies targeted fruit and/or vegetable intake

(n=21) or fat intake (n=10), and few targeted diet quality (n=2). Median follow-up was 3.5 months, with few studies (n=4) measuring longer-term outcomes (≥ 12 months). Studies aimed to determine whether a brief intervention was more effective than another brief intervention (n=30), and/or more effective than no intervention (n=20), with 17 and 11 studies, respectively, reporting findings to that effect. Interventions providing education plus tailored or instructional components (e.g. feedback) were more effective than education alone or non-tailored advice. This review suggests that brief interventions, which are tailored and instructional, can improve short-term dietary behaviours, however evidence for longer-term behaviour change maintenance is limited.

Key words: Nutrition, brief intervention, behaviour change techniques

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Introduction

Chronic diseases such as cardiovascular disease and diabetes are a major global health problem, accounting for 70% of annual deaths ¹, while 40% of adults worldwide are overweight or obese ². Poor nutrition, characterised by diets low in nutrient rich foods, such as fruits and vegetables, and high in energy-dense, nutrient poor foods, such as foods high in saturated and trans fats, sugar and salt, are associated with increased chronic disease risk and weight gain ³. Improving dietary behaviours could help to prevent morbidity and mortality from these chronic diseases, however the majority of adults fail to meet dietary guidelines ⁴⁻⁶. Therefore,

there is a need for effective intervention approaches to improve dietary behaviours, and consequently health outcomes, of adults.

The majority of nutrition interventions provided to adults involve multiple contacts delivered over periods of weeks to months ⁷⁻¹⁰, essentially taking an intensive approach ¹¹. However, a brief or minimal approach may be an effective alternative ¹¹. A brief intervention is one *“purposely limited in the number and length of contacts,”* or more specifically an intervention designed to involve the minimum input and contact required to achieve significant and sustainable impact ¹¹. In the absence of a standard or specific definition for the number or length of contacts constituting a ‘brief’ intervention, brief is defined in this review as a single contact. Brief interventions have been employed for a range of health behaviours including alcohol use, tobacco smoking, and drug use, with studies demonstrating largely positive outcomes across behaviours ¹¹⁻¹⁶. Most extensively evaluated is the application of brief interventions to reduce alcohol use, with several systematic reviews demonstrating significant outcomes to that effect ¹⁵⁻¹⁸. For example, Oosterveen et al. recently conducted a meta-analysis of brief web or computer based alcohol interventions in young adults, showing a significant reduction in weekly alcohol consumption in intervention compared with control participants up to 12 months post the single session interventions (Mean Difference -2.43 drinks/week [-3.54, -1.32], $P < 0.0001$) ¹⁸.

Brief interventions pose several advantages which may contribute to their effectiveness, as well as increased reach and engagement. Firstly, they may be more cost-effective due to reduced time and expertise required for implementation

compared with longer, multi-session interventions ^{11,16}. Furthermore, many adults may not be interested in an intensive intervention ^{11,19}, thereby a brief intervention may be more appealing due to the reduced participant burden in terms of time and commitment ^{11,16}. A brief intervention is also well suited to a range of delivery modes, including eHealth (e.g. website or smartphone application), print resources, face-to-face (including individual or group sessions), or a combination ^{11,20-23}. Conversely, the shorter timeframe of a brief intervention presents some limitations. As brief interventions involve less exposure, they may be unable to include a multitude of behaviour change techniques (BCTs), which may limit their long-term efficacy. With less exposure, it may also be more difficult to change entrenched behaviours, or to change multiple behaviours. Therefore, the effectiveness of brief nutrition interventions warrants further investigation.

As such, the primary aim of this systematic review was to assess the effectiveness of brief interventions aiming to improve nutrition outcomes in adults. The secondary aim was to identify the behaviour change techniques commonly used in brief nutrition interventions, and which techniques are associated with effective interventions.

Methods

This systematic review was conducted as per the PRISMA guidelines ²⁴, and using a pre-defined protocol registered with PROSPERO (CRD42016038483)

http://www.crd.york.ac.uk/PROSPERO/display_record.asp?ID=CRD42016038483.

Criteria for study inclusion

Participants/population

Participants were adults aged ≥ 18 years, who were healthy. As this review aimed to determine whether a brief nutrition intervention could be effective in healthy individuals as a preventative strategy against chronic disease/risk factors, participants from specific populations (e.g. eating disorders, severe mental illness) or with diagnosed health conditions (e.g. diabetes mellitus, coeliac disease) were excluded.

Types of interventions

Brief interventions with the primary aim of improving nutrition outcomes were included, including interventions focused on dietary intake or eating behaviours and designed to promote behaviour change. A 'brief' intervention was defined as one where the intervention was delivered during a single point of contact ^{11,25}.

Types of comparators

Studies had to have a comparison group to be included, a no intervention or brief alternative intervention control group, or another brief nutrition intervention.

Types of outcomes

Studies where the primary outcome was a nutrition outcome (e.g. reporting energy, nutrient or food group intake, dietary patterns or diet quality) were included.

Types of studies

Randomised controlled trials (RCT) and pseudo RCT (i.e. alternate allocation to group based on a specified factor, such as date of study enrolment) were included.

Literature search

Seven databases (MEDLINE, MEDLINE in process, EMBASE, PsycINFO, Scopus, CINAHL, and The Cochrane Library) were searched using pre-determined keywords and index terms with searches limited to studies published in the English language up to 28 April 2016 (Supplementary Table 1). The reference lists of all included papers were searched, and a citation search of included papers using Scopus was conducted, to identify any additional papers meeting the criteria. The Scopus citation search involved screening the articles in the 'cited by' list for each of the included articles.

Study selection

The title, abstract and keywords of all identified papers were assessed by two independent reviewers (MW and MH or AP). For all records meeting inclusion criteria, or if this was unclear, the full-text was retrieved. Papers selected for retrieval were assessed by two independent reviewers to determine inclusion or exclusion (MW and MH or AP), with a third reviewer making the final decision in cases of disagreement (MH or AP). Where papers did not provide sufficient detail to determine eligibility (e.g. intervention description, study design) the author was contacted to clarify whether inclusion criteria were met (n=4). Reasons for exclusion were recorded for all retrieved papers deemed ineligible for inclusion in this review.

Risk of bias

All included studies were appraised for study quality by two independent reviewers (MW and AP), with a third reviewer used in cases of disagreement (MH). The Academy of Nutrition and Dietetics (ADA) Quality Criteria Checklist for Primary Research ²⁶ was used for quality appraisal. This checklist assesses 10 criteria,

including whether 1) the research question was clearly stated; 2) selection of study participants was free from bias; 3) study groups were comparable; 4) methods for handling withdrawals were detailed; 5) blinding of study participants/personnel was used; 6) intervention/exposure were described in detail; 7) outcomes were clearly defined and measurements valid and reliable; 8) statistical analyses were appropriate for study design and outcomes 9) conclusions were commensurate with results and with consideration to biases and limitations, and 10) funding and conflicts of interest were reported and likely to have introduced bias. Study quality was then determined based on the number, and relating criterion, of 'yes,' 'unclear,' and 'no' responses, and rated as positive (if criteria 2, 3, 6, 7, and one other were yes), neutral (if criteria 2, 3, 6 and/or 7 were no or unclear) or negative (if six or more criteria were no). Inter-rater reliability was calculated as percentage agreement, using a dichotomous scale (agree or disagree).

Data extraction

Data were extracted by one reviewer (MW) and checked by a second reviewer (LA), including study characteristics (e.g. authors, date of publication, country, duration), study participants (e.g. sample size, age, gender), experimental conditions (e.g. number of study arms, description of intervention and comparator, BCTs used) and study outcomes (e.g. nutrition outcomes reported and significance of results). Intervention content was assessed for the inclusion of BCTs according to the techniques and definitions listed in the 93-item Behaviour Change Taxonomy v1²⁷, specifically from the information provided in the intervention description. The Behaviour Change Taxonomy v1 provides a standardised method for reporting

techniques used in behaviour change interventions, allowing for between study comparisons and effective intervention features to be identified.

Data synthesis

Results are described in narrative form. An effective intervention was defined as one where the change in one or more nutrition outcomes was positive and statistically significantly different from baseline, compared with control, or if no control comparator, compared with another brief intervention. To identify the BCTs associated with effective interventions a percentage effectiveness ratio was calculated, similar to Martin et al. ²⁸, with the number of times the technique was a component of an effective intervention divided by the total number of times the technique was a component of an intervention.

Results

Description of included studies

Of the 4849 articles identified, 45 studies met the inclusion criteria (Figure 1). Study characteristics are summarised in Table 1, with detailed study characteristics provided in Supplementary Table 2. Most studies were RCTs (n=41), published between 2006 and 2015 (n=30), and were conducted in Europe (n=18). The included studies had a total of 23,327 participants (Median 319, range: 49 to 2977). The mean age of participants was 34.3 years, while the mean percentage of female participants was 70%. Most studies provided limited participant sociodemographic information, however, of those that reported ethnicity (n=17), participants were predominantly white (n=14), of those reporting income/socioeconomic status (n=7), participants were predominantly low or middle range (n=5), and of those reporting education

(n=21), participants mainly had some tertiary education (n=13). Most study participants were members of the general public (n=19) or university students (n=14).

Twelve studies had a single intervention group, 20 had two, nine had three, two had four, and one study each had five and six intervention groups. Sixteen studies included a 'no intervention' control as a comparator, four included an alternative intervention group comparator, and thirty studies compared two or more brief intervention groups. There were five studies that compared both a no intervention control group and two or more brief intervention groups. The total number of study arms was 119, of which 98 were active brief intervention groups. Most interventions were delivered using print materials (n=58), followed by internet (n=15). Most studies were aiming to increase fruit and vegetable intake (n=15), or decrease fat intake (n=10). Seven studies targeted multiple health behaviours in addition to nutrition, including physical activity, alcohol intake, smoking, sleep and/or stress management 23,29-34.

Figure 1. Flow diagram of included studies

Table 1 Summary of study characteristics

		N	%
Publication year	1996 - 2000	7	15.6
	2001 - 2005	8	17.8
	2006 - 2010	18	40.0
	2011-2015	12	26.7
Country	United Kingdom	13	28.9
	United States	11	24.4
	Europe	18	40.0
	Australia	2	4.4
	Thailand	1	2.2
Number of participants	Total number	23327	
	Median	319.0	
	Range	49-2977	
Gender	Mean female %	70.0	
	All female	4	8.9
Age	Mean (years)	34.3	

Ethnicity	Not reported	4	8.9
	Predominantly white	14	31.1
	Predominantly non-white	3	6.7
Education	Not reported	28	62.2
	Predominantly high school or less	8	17.8
	Predominantly tertiary education	13	28.9
	Current university/college students	15	33.3
Income/socio-economic status	Not reported or unclear	9	20.0
	≥50% defined as low range	5	11.1
	≥50% defined as high range	2	4.4
Nutrition outcome/s	Not reported or unclear	38	84.4
	Fruit	5	11.1
	Vegetable	1	2.2
	Fruit and vegetable	15	33.3
	Fat	10	22.2
	Fat, fruit and vegetable	7	15.6
	Fibre	1	2.2
	Breakfast	1	2.2
	Soda	1	2.2
	Multiple diet components and/or diet score	4	8.9
Study arms	Total	119	
	Active	98	74.8
Type of intervention	Education	22	22.4
	Feedback	5	5.1
	Action or goal planning	16	16.3
	Motivational message	14	14.3
	Education + feedback	26	26.5
	Education + action or goal planning	5	5.1
	Education + feedback + action or goal planning	3	3.1
	Motivational message + action or goal planning	7	7.1
Mode of intervention delivery	Print materials	58	59.2
	In person with or without print materials	12	12.2
	Computer program	8	8.2
	Internet	15	15.3
	Internet + email	3	3.1
	Video	2	2.0
Setting	University	14	31.1
	Workplace	8	17.8
	Online (e.g. internet research panel)	4	8.9
	Primary care (e.g. general practitioner wards, health screening clinics)	7	15.6
	Community setting (e.g. community centre, community assistance program)	7	15.6
	Combination of above settings	5	11.1
Length of follow up	Minimum	Immediate	
	Maximum	2 years	
	Average	3.5 months	

Risk of bias

Risk of bias assessment is summarised in Supplementary Table 3. Inter-rater reliability was high (82%). Twelve studies were rated as positive quality, with the remaining (n=33) rated as neutral. All studies had a low risk of bias with respect to study funding/sponsorship, while the majority (n=44) reported conclusions in line with results and with consideration of limitations. The majority of studies also provided adequate detail to describe interventions/ comparators (n=44), provided clear definitions for, and used valid and reliable tools to measure study outcomes (n=39) and used appropriate statistical analyses for the outcomes and study design (n=44). The main risk of bias (n=13), or where this was unclear (n=22), was in terms of participants/personnel being blinded. For a large number of studies the selection of study participants was not free from bias (n=23) or this was unclear (n=5). In ten studies, study groups were either not comparable (n=3) or this was unclear (n=7), while eleven studies did not describe the method of handling withdrawals.

Effectiveness of brief interventions targeting fruit and vegetable intake (n=15)

Brief intervention versus control

Three studies targeting fruit and vegetable intake compared eight brief interventions against 'no intervention' control groups ^{32,35,36}. Four of the eight brief interventions were effective ^{32,35,36}. Wiedemann et al. found that participants who wrote action plans to increase their fruit and vegetable intake reported greater increases at one week follow up ³⁶, however, only the intervention groups where participants wrote four and five action plans (+0.3 and +0.64 servings/day respectively, p=0.03 and p=0.04), and not one, two or three ³⁶. Participants provided with tailored education and feedback on their current intake also reported greater increases at six weeks (+0.45 servings/day for fruit, +0.35 servings/day for vegetables, p values<0.001) ³⁵,

and greater odds of meeting fruit and vegetable recommendations at 3.5 months (OR=2.28, p=0.029) ³². However, non-tailored education leaflets did not increase fruit and vegetable intake compared with controls at 3.5 months ³².

Two studies compared three brief interventions against an alternative intervention control group (e.g. stress management intervention) ^{37,38}. The studies involved nutrition education and tailored feedback on current intake ³⁷, and participants listening to a motivational health message focused on fear and persuasion, or action planning ³⁸. However, none were effective compared with controls at two month ³⁷ and one-week follow-ups ³⁸ respectively.

Comparing multiple brief interventions

Eleven studies compared multiple brief interventions ^{21,29,38-46}, with 26 different brief interventions within these studies. Seven studies compared brief interventions which included education and action/goal planning, with education only ^{29,39,40,42-44,46}, and five were found to be effective, including greater improvements in the planning intervention groups ^{39,42-44,46}. Participants reported greater increases in servings/day (+0.3 to +0.7 servings/day, p values<0.02), frequency of intake (from once to twice daily, p values <0.01), or number of days meeting recommended serves (+0.5 days/week, p<0.01) of fruit and/or vegetables at follow-ups one week to two years later ^{39,42-44,46}. However, studies by Djuric et al. and Lippke et al. reported no between group differences in similar comparisons at one and three month follow ups ^{29,40}.

Effectiveness of brief interventions targeting fat intake (n=10)

Brief intervention versus control

Six studies aiming to reduce participants' fat intake included a no intervention control group ^{23,30,47-50}, of which four were effective, showing greater reductions in fat intake compared with control ^{23,30,47,49}. Four studies compared interventions where participants were provided with nutrition education, feedback on current fat intake and tailored advice to reduce intake via an interactive computer program or website ^{23,30,48,49}. In three of these studies, intervention participants reported greater reductions in total fat intake compared with controls, one to six months post intervention (1.2% to 8% greater reduction in % energy from fat, and 0.7 greater reduction in fat score, p values <0.01) ^{23,30,49}. Conversely, Campbell et al, found no between group differences up to three months post intervention ⁴⁸. Participants asked to plan eating a low fat diet significantly reduced their total and saturated fat intake compared with controls at the one-month follow up (1.25% greater reduction in % energy from total fat, $p < 0.05$, 1.65g/day greater reduction in saturated fat, $p < 0.01$) ⁴⁷. In another study, simply providing participants with feedback on their current intakes compared with recommendations (i.e. with no advice on changing behaviour) failed to significantly lower fat intake compared with controls at four or 18 weeks follow-up ⁵⁰.

Comparing multiple brief interventions

Five studies compared multiple brief interventions ^{49,51-54}, with 17 different brief interventions within these studies. Three studies compared a tailored intervention, where participants were provided with education, feedback and advice on lowering fat intake, and motivational messages/encouragement to change behaviour, with a non-tailored education and standard advice intervention ^{49,52,53}. Two studies were

found to be effective, reporting effects in favour of the tailored intervention ^{49,52}. De Bourdeaudhuij et al. reported a significantly greater reduction in percentage energy from fat at six-months follow up in the tailored versus non-tailored group (-9.1% and -2.3% respectively, $p < 0.001$) ⁴⁹. Kroeze et al. compared the same tailored intervention delivered via interactive computer program or print materials, and found both groups had significantly lower total fat intake (grams/day) compared with the non-tailored group at one-month follow up ⁵². However, change from baseline was not reported and differences were not significant after six months ⁵². The third study found no significant between group differences in total or saturated fat intakes at one or six months follow up ⁵³.

Effectiveness of brief interventions targeting fat, fruit and vegetable intake

(n=7)

Brief intervention versus control

Two studies compared a brief intervention with a no intervention control group ^{55,56}, of which one was effective, however only for fat intake. Participants who received education, feedback on current intake and dietary advice tailored to their stage of change reported significantly reduced grams/day of total and saturated fat at four months follow-up compared with controls (-9g/day and -4.3g/day respectively, $p = 0.03$ and $p = 0.04$) ⁵⁶. In the same study, participants provided with standard educational materials showed no significant between group differences with controls ⁵⁶, while Campbell et al. also found no difference between participants completing an interactive computer module involving education and tailored feedback, and controls, after one to two months follow up ⁵⁵.

Comparing multiple brief interventions

Five studies, including 10 brief interventions, targeted fruit and vegetables ^{33,57-60}.

Two studies by Brug et al. compared interventions where participants were provided with tailored feedback on current intakes, dietary advice and education or non-tailored advice and education ^{57,58}. In both studies, the tailored interventions were found to be effective, with participants significantly lowering their fat score compared with non-tailored participants, at follow-ups three weeks and eight weeks post intervention (0.9 to 1.1 greater reductions in fat score, p values <0.01) ^{57,58}. Fruit and vegetable intakes, however, were not significantly different between groups in either study. The remaining three studies compared tailored interventions, including feedback on current intakes and psychosocial factors (e.g. self-efficacy, social support), dietary advice and education, with non-tailored intervention, including education and standard advice ^{33,59,60}. One study reported no significant between group differences in any outcome at 3-4 weeks follow up ⁵⁹. One study reported significantly reduced saturated fat scores, and increased fruit serves/day in the tailored intervention group at three months (-1.5 and +0.24 respectively, $p < 0.05$ and $p < 0.01$) ³³. The remaining study reported a significantly greater increase in fruit and vegetable servings/day in the tailored intervention group at four months (+0.5 servings/day, $p = 0.01$), which was not sustained at seven months ⁶⁰.

Effectiveness of brief interventions targeting fruit intake (n= 5)

Brief intervention versus control

In two studies comparing a brief intervention with a no intervention control ^{20,61}, participants were instructed to write action plans to increase their fruit intake. Of these, one study was effective, reporting a greater increase in fruit servings than

controls at two weeks follow up (+2.69 and -1.45 pieces/2 weeks respectively, $p<0.01$)²⁰. In the second study a greater proportion of intervention participants reported consuming an extra fruit serve (9% vs 4% consuming an extra serve/day, $p<0.05$) at one-week follow up, however total fruit intake (grams/day) was not greater compared with control⁶¹.

Comparing multiple brief interventions

Three studies compared multiple brief interventions⁶²⁻⁶⁴, with 10 brief interventions included within these studies. In one study, a comparison of three action planning interventions found that providing participants with specific instructions and example actions plans was most effective, compared with instructions and no instructions, including a greater increase in fruit servings/day at one month follow up (+0.1, +0.07 and -0.05 servings/day respectively, p values <0.05)⁶². In another study, greater fruit intake (cups/day) was demonstrated in participants exposed to positively vs negatively framed health messages designed to encourage fruit consumption at one week follow up (1.2 vs 0.7 cups/day respectively, $p=0.03$)⁶³. The remaining study, comparing three intervention groups where participants received feedback on current intakes in a match-mismatch design based on stage of change, found no between group differences at the one-week follow up⁶⁴.

Effectiveness of interventions targeting multiple dietary behaviours/diet quality (n=4)

Brief intervention versus control

One study compared two brief interventions, an education intervention and an education plus goal planning intervention, with a no intervention control group⁶⁵.

However, neither intervention was effective, with no significant improvements in healthy food servings, or individual food group intakes, compared with controls at one month follow up ⁶⁵.

Two studies compared a brief intervention against an alternative intervention control group ^{31,34}, with one found to be effective ³¹. In the study by Parekh et al, intervention participants who received education and feedback on current behaviour were found to have greater odds of meeting recommended serves of a range of foods, for example fruit and vegetables (OR=1.22, $p<0.001$) and milk (OR=1.15, $p<0.001$), at 12 months follow up than controls, who received a similar intervention for alternative behaviours (e.g. sun protection) ³¹. Werch et al. provided participants with education and feedback on current behaviours as well as encouragement to change using a social comparison approach ³⁴. However, no between group differences were found for any nutrition outcome (fruit and vegetables, carbohydrates and fats) at three months follow up compared with control intervention (targeting physical fitness) ³⁴.

Comparing multiple brief interventions

Two studies compared two brief interventions ^{22,65}. Brouwer et al. found that an education plus goal planning intervention was more effective than education only in terms of increasing consumption of low fat dairy at one month follow up (+1.0 and +0.53 cups/day, $p=0.03$) ⁶⁵, however not for any other nutrition outcome studied.

Sacerdote et al. found that a consultation providing personalised feedback and advice on current intake, compared with generic nutrition information, resulted in a greater increase in healthy diet score at six-months follow up, which was sustained at 12 months (+0.29 and -0.04 respectively, $p<0.00001$) ²².

Description of behaviour change techniques applied

The behaviour change techniques applied in the 98 active intervention arms, coded according to the Behaviour Change Taxonomy v1 ²⁷, are summarised in Table 2. Examples of how interventions utilised BCTs are provided in Supplementary Table 4. Of the 93 BCTs, 41 were coded one or more times, with a total of 356 BCTs coded across the active intervention arms. The brief interventions considered a median of 3 BCTs, ranging from zero to 14 across intervention arms. The most frequently coded techniques included '*Information about health consequences*' (n=58), '*Instruction on how to perform a behaviour*' (n=46), '*Action planning*' (n=30), '*Feedback on behaviour*' (n=29) and '*Social comparison*' (n=22). The least coded techniques (n=1) included '*Commitment*', '*Social support*', '*Information about others' approval*', '*Pros and cons*', '*Adding objects to the environment*' and '*Valued self-identity*'.

Table 2 Behaviour change techniques used^a

Behaviour change technique	N	%
1.1 Goal setting (behaviour)	7	7.1
1.2 Problem solving	11	11.2
1.3 Goal setting (outcome)	3	3.1
1.4 Action planning	30	30.6
1.9 Commitment	1	1.0
2.2 Feedback on behaviour	29	29.6
2.3 Self-monitoring of behaviour	6	6.1
3.1 Social support (unspecified)	1	1.0
3.3 Social support (emotional)	1	1.0
4.1 Instruction on how to perform the behaviour	46	46.9
4.2 Information about antecedents	12	12.2
5.1 Information about health consequences	58	59.2
5.2 Salience of consequences	6	6.1
5.3 Information about social and environmental consequences	3	3.1
5.5 Anticipated regret	3	3.1
5.6 Information about emotional consequences	16	16.3
6.1 Demonstration of the behaviour	2	2.0
6.2 Social comparison	22	22.4
6.3 Information about others' approval	1	1.0
7.1 Prompts/cues	4	4.1

8.1 Behavioural practice/rehearsal	9	9.2
8.2 Behaviour substitution	18	18.4
8.3 Habit formation	3	3.1
8.6 Generalisation of target behaviour	2	2.0
9.1 Credible source	12	12.2
9.2 Pros and cons	1	1.0
9.3 Comparative imagining of future outcomes	6	6.1
10.9 Self-reward	2	2.0
11.2 Reduce negative emotions	2	2.0
12.2 Restructuring the social environment	2	2.0
12.3 Avoidance/reducing exposure to cues for the behaviour	5	5.1
12.5 Adding objects to the environment	1	1.0
13.1 Identification of self as role model	3	3.1
13.3 Incompatible beliefs	7	7.1
13.4 Valued self-identify	1	1.0
13.5 Identity associated with changed behaviour	2	2.0
15.1 Verbal persuasion about capability	4	4.1
15.2 Mental rehearsal of successful performance	3	3.1
15.3 Focus on past success	6	6.1
15.4 Self-talk	3	3.1
16.3 Vicarious consequences	2	2.0

^a Median number of BCTs used in interventions = 3, Range = 0-14

^b Supplementary Table 4 provides examples of how interventions utilised BCTs

Effectiveness of behaviour change techniques

Figure 2 shows the percentage effectiveness ratio for the coded BCTs. Effectiveness was determined for 38 studies (n=78 brief intervention arms). For the remaining seven studies, effectiveness could not be determined due to the reporting of results (i.e. change from baseline was not reported) ^{38,41,45,52,53,63}. BCTs coded only once (n=7) have also been excluded, as this does not provide a meaningful representation of effectiveness ²⁸. Sixteen BCTs had an effectiveness ratio >50%. The BCTs with the highest effectiveness ratio were '*Generalisation of target behaviour*,' '*Reduce negative emotions*' and '*Verbal persuasion about capability*,' effective in 2/2 or 100% of interventions. '*Information about antecedents*' was effective in 9/11 interventions (82%), followed by '*Social comparison*' (n=8/10, 80%), '*Prompts/cues*' (n=3/4, 75%) and '*Focus on past success*' (n=3/4, 75%).

Figure 2 Percentage effectiveness of behaviour change techniques

^a Supplementary Table 4 provides examples of how interventions utilised BCTs

^b (n=) refers to the number of interventions the BCT was used in

The ratio of effective versus non-effective interventions by the number of BCTs was also explored (Figure 3). The proportion of effective interventions was <30% for interventions with zero, one and two BCTs, 100% of interventions with seven BCTs,

and 50% for interventions with nine BCTs. There were only two interventions with more than nine BCTs, and neither were found to be effective.

Figure 3 Percentage effectiveness of interventions by number of behaviour change techniques

^a (n=) refers to the number of interventions with the corresponding number of BCTs

Discussion

This is the first systematic review to assess the effects of brief interventions aiming to improve nutrition outcomes in adults, and included 41 RCTs and four pseudo RCTs. Predominantly, studies targeted fruit and/or vegetable intake (n=21), while few studies targeted overall diet quality (n=2). Additionally, few studies (n=4) measured longer-term outcomes (≥ 12 months). Studies compared effectiveness of interventions against another brief nutrition intervention (n=30), no intervention control (n=16) or alternative intervention control (n=4). Across studies and comparators, the types of intervention found to be most effective were those

providing education and more tailored and instructional components such as feedback. The most effective behaviour change techniques were generalisation of target behaviour, reduce negative emotions and verbal persuasion about capability. Overall, this review suggests that brief interventions can effect short-term change in dietary behaviour, particularly for fruit, vegetable and fat intakes, with limited evidence for longer-term maintenance of behaviour change.

Effectiveness of brief nutrition interventions

Almost half of the studies (n=20) aimed to determine whether a brief intervention was more effective than no intervention or an alternative intervention control, with 11 studies showing positive outcomes in favour of the brief intervention. In studies targeting fruit and vegetable intake, the size of intervention effect was 0.3 to 0.64 servings/day greater than controls, whereas for studies targeting fat intake, decrease in percentage energy from total fat ranged from 1.2% to 8% greater than controls. These findings are similar to other reviews of nutrition interventions. A systematic review by Rees et al., investigating interventions of varying length and intensity, also found greater effects of dietary advice interventions compared with no or minimal intervention (generic nutrition education) on a range of nutrition outcomes in adults⁶⁹. Over the median follow up of 12 months, meta-analysis found that dietary advice interventions (ranging from single session to multi-session over four years) were effective in facilitating changes of +1.18 servings/day in fruit and vegetables and - 4.48% in percentage energy from fat compared with no or minimal advice interventions⁶⁹. Similarly, in a systematic review and meta-analysis of nutrition interventions in primary care settings, Bhattarai et al. found fruit and vegetable intake increased by 0.50 servings/day, and percentage energy from fat decreased by 5.2%

in intervention compared with no or minimal intervention (generic nutrition education), and with follow up conducted one year or more post intervention ⁷⁰. Interventions ranged from one to 20 sessions, while intervention types were varied e.g. tailored dietary intervention materials ⁷⁰. Therefore, short-term effects of the brief nutrition interventions in this review are comparable with non-brief interventions for fruit and vegetable and fat intakes, however further studies are needed to make a conclusion on longer-term effectiveness. Promisingly, three of four studies included in this review, measuring outcomes at 12-24 months post intervention, found sustained changes in fruit and vegetable intake, multiple dietary behaviours and healthy diet scores, which suggests at long-term effectiveness.

Two thirds (n=30) of the studies in this review aimed to determine whether one brief intervention was more effective than another, with 17 studies reporting findings to that effect. In most studies, providing education alone, particularly standard educational materials with no tailoring of the content to the individual (e.g. by age, gender, stage of change), was less effective than interventions with tailored and additional content such as feedback, recommendations, instructing participants to plan their behaviour change, and motivational health messages. For example, the three studies by Brug et al. found greater reductions in fat intake in participants in the tailored intervention (education, feedback and recommendations for behaviour change) compared with non-tailored participants (standard education and advice) up to two months post intervention ⁵⁷⁻⁵⁹, including a 4% greater reduction in fat score when pooled in meta-analysis in a subsequent study by the same author ⁷¹. Several reviews also support the efficacy of providing personalised nutrition education with feedback and instructions for making behaviour change as opposed to generic

education interventions ^{69,70,72-75}. For example, in the context of computer-tailored nutrition education in adults ^{74,75} and nutrition interventions in university students ⁷² and workplace settings ⁷³.

Overall, this review suggests that the types of brief interventions which may be more effective are those providing education as well as including more instructional intervention components, such as feedback on current behaviours, tailored advice or recommendations for making behaviour change, and writing plans to achieve the desired behaviour. Simply providing education on its own or with non-tailored advice appears to be less often associated with positive outcomes, and these findings were consistent across the nutrition outcomes studied. These findings are supported by other reviews of nutrition interventions. For example, in the review by Rees et al. dietary advice interventions, where advice was typically tailored and/or combined with other components such as planning and feedback, were found to be superior to minimal intervention (generic nutrition education) ⁶⁹. In the review by Bhattarai et al, interventions were more varied, including for example group or individual nutrition education sessions, and tailored dietary intervention materials encompassing education, feedback and motivational encouragement. These interventions were also found to be more effective than a minimal intervention providing generic nutrition education ⁷⁰. Therefore, researchers or health professionals developing brief nutrition interventions should include components such as specific instructions or advice, that are tailored to the individual, as well as nutrition education, in order to positively and effectively impact nutrition outcomes.

Effectiveness of behaviour change techniques

These findings highlight the importance of identifying the behaviour change techniques used, as a means to further explain the differences in effectiveness between types of interventions ^{28,76-78}. This review compared the inclusion of individual BCTs in effective versus non-effective interventions in an attempt to identify specific BCTs which may be agents of change. Sixteen BCTs had a high effectiveness ratio, including several techniques related to psychosocial factors. For example, generalisation of the target behaviour and reducing negative emotions about the behaviour. Examples of these techniques in the interventions studies include, instructing participants to plan to increase fruit and vegetable consumption by generalising previous success in making healthy food choices, and reducing negative emotions by instructing participants to anticipate and plan strategies to cope with barriers to achieving a target behaviour. Also found to be effective were several BCTs related to self-belief, for example self-talk, as well as the use of social comparison. Examples of these techniques in the interventions studied include, instructing participants to describe themselves as 'doers' of a particular desired behaviour, and providing participants with epidemiological data on population intakes of the target food group/nutrient as a comparative for their current behaviour. Consideration of psychosocial factors has also been found to be effective in other health behaviour change interventions, for example, brief alcohol interventions using a personalised normative feedback approach effectively reduced weekly alcohol consumption in university students ¹⁵. Additionally, very brief interventions targeting physical activity in primary care settings found prompting self-talk to be an effective technique ⁷⁹, while reviews of nutrition interventions in university students suggest that interventions encouraging social support networks (e.g. peer support) and focusing on peer social norms may have greater impact ^{8,72,80}.

Planning actions in terms of performing a target behaviour, as well as identifying and problem solving to overcome barriers to performing behaviour were also found to be effective behaviour change techniques. Examples of these techniques in the interventions studied include, providing instructions and examples to facilitate planning of the behaviour in terms of what, when and how, and presenting participants with situational examples where performing the desired behaviour may be challenging and asking them to plan strategies to overcome this (e.g. consuming healthy foods at a social occasion). Providing feedback on behaviour was also an effective technique, for example interventions utilised this by providing a comparison of the individuals' current eating behaviours against dietary guidelines as a measure of performance. Action planning and providing feedback on behaviour have also demonstrated effectiveness in very brief physical activity interventions in primary care settings ⁷⁹. Additionally, Lara et al, in a systematic review of BCTs associated with effective fruit and vegetable interventions in older adults, found barrier identification/problem solving to be the most effective technique, associated with a 93g/day greater intake in interventions where this technique was used compared with not ⁸¹. Lara et al. also identified providing feedback on behaviour as a key BCT, associated with a 39g/day difference in fruit and vegetable intake ⁸¹, while this technique has also demonstrated efficacy in nutrition interventions in university students ^{8,72,80}, weight loss interventions in overweight adults ⁷⁶, and alcohol use interventions in young adults ^{15,18}.

A proposed limitation of a brief intervention was the reduced exposure and therefore limit to the number of included BCTs and subsequent effectiveness. However, most

interventions in the current review included between 1-9 BCTs (range 0-14), which is comparable with reviews of non-brief interventions by Bhattarai et al.⁷⁰ and Lara et al.⁸¹ where interventions ranged up to more than 35 sessions and included between 2-8 and 2-16 BCTs respectively. While Lara et al. found that intervention effect (increase in fruit and vegetable intake) significantly increased concordant with an increased number of BCTs⁸¹, the majority of reviews have found no clear relationship between the number of BCTs used in an intervention and the effectiveness or effect size^{25,70,82}. The current review found a higher ratio of effective versus non-effective interventions in those including 3-9 BCTs as opposed to 0-2 BCTs, however only two interventions included more than nine BCTs and these were not effective. Overall, findings suggest that a greater number of BCTs is not necessarily more efficacious, and the utility of the individual BCTs may be more significant.

Overall, there appears to be a trend that the individual BCTs with greater effectiveness were those requiring some level of active involvement from participants, e.g. performing a task such as problem solving barriers to behaviour change, or where participants were provided tailored and specific advice for changing behaviour, e.g. instructions on how to incorporate healthy foods into the diet. In addition, BCTs which targeted participants' self-belief for performing a behaviour, e.g. prompting focus on past success in making healthy food choices, also had greater effectiveness. This suggests that providing participants with skills or instructions which they can translate into behaviour change, as well as boosting their belief in themselves to action change, may be more enabling, as opposed to simply providing information without a means for application or cognisance of their sense of

self. Therefore, researchers or health professionals designing brief nutrition interventions should aim to incorporate skill building, instructive and self-belief targeted BCTs, perhaps in combination with information provision, to effectively facilitate behaviour change.

Some BCTs are not applicable to, or may be more difficult to employ, within a brief intervention due to the nature of a single exposure. For example, rewarding completion, which involves providing rewards for completion of a sequence of behaviours contributing to an overall target behaviour. However, the frequency of use of these or similar BCTs in the brief interventions in this review is fairly consistent with the nutrition literature for other interventions of varying length and intensity^{70,81,83}. Therefore, this is not necessarily a limitation of brief interventions specifically. Examples of the use of some of these less common BCTs within the brief interventions in this review include, teaching the use of prompts/cues by providing participants with examples of cues to facilitate a behaviour e.g. increasing availability of fruit in the home, and prompting self-talk by instructing participants to describe themselves as 'doers' of a particular desired behaviour.

Strengths and limitations of the included studies

The risk of bias assessment identified several strengths and limitations of the included studies. Overall, studies had a low risk of bias from funding/sponsorship, and the majority provided adequate detail to describe, and/or used valid and reliable tools or methods to determine, research questions, intervention/ comparators, study outcomes, statistical analyses, and study conclusions. In terms of limitations, there were a number of studies where participants/personnel were not blinded to group

allocation, the selection of study participants was not free from bias, study groups were not comparable, or studies were lacking in the necessary detail to judge these factors. Additionally, some studies were lacking in the reporting of the results, specifically not reporting change, or significance of, in the nutrition outcome from baseline. As the effectiveness of these studies was unclear, they were not included in the effectiveness ratio of the BCTs, however this only applied to a small number of studies (n=7). The quality of future intervention studies could be improved by ensuring study samples are non-biased, randomly selected and comparable, and study information is adequately reported. Additionally, most studies were conducted in primarily female populations, which limits generalisability, however other study characteristics were more diverse, such as country and setting. Studies primarily focused on a limited selection of food groups and macronutrients, and only a small number considered overall diet quality, therefore, further studies are needed to determine the efficacy of brief interventions targeting a whole diet approach. Since a limited number of studies measured long-term outcomes, there is not enough evidence to determine the long-term effectiveness of brief nutrition interventions.

Strengths and limitations of the review

The novelty of a 'brief' nutrition intervention, and being the first review to evaluate the efficacy, is a particular strength. Exploring the BCTs associated with effective interventions is also a major strength, and the use of an existing taxonomy²⁷ to code BCTs is a robust method. This goes beyond a description of the types of interventions associated with positive outcomes, to identify the techniques used, and allows for replicability of effective techniques in developing future interventions. A comprehensive search strategy was used, including reference list searching and an

additional Scopus citation search, two independent reviewers at each stage of the review and the use of the ADA Quality Criteria Checklist ²⁶. The limitations of the review should also be acknowledged. As a 'brief' intervention is not a clearly defined concept across nutrition research, some relevant studies may have been missed in the search. In addition, all studies evaluating brief nutrition interventions may not have been included due to the need for studies to include nutrition behaviour as the primary outcome. However, the included studies best answer the specified research question. Limiting to studies published in the English language may also have excluded relevant studies, and could limit the generalisability of findings to other countries.

Conclusion

This review suggests that a brief nutrition intervention can improve nutrition outcomes in the short-term, however, more studies are needed to determine longer-term effectiveness, and with consideration of overall diet quality. Researchers and health professionals designing brief nutrition interventions should aim to incorporate skill building and instructive BCTs, such as problem solving and action planning, and self-belief targeted BCTs, such as self-talk, as well as providing education, to enable participants to effectively translate nutrition information into behaviour change. This review highlights the importance of linking intervention efficacy to the underpinning intervention components, and future studies should describe interventions in detail to allow for identification and replication of information, for example publishing intervention protocol papers. Brief nutrition interventions present a simple, adaptable and cost effective strategy to improve dietary behaviours at a population level, and warrant further investigation. Specifically, those interventions with short-term efficacy

should be investigated over the longer-term, to determine whether brief nutrition interventions can facilitate sustained changes in eating behaviours.

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