Original Paper

Development and preliminary evaluation of an internet-based healthy eating programme: A randomised controlled trial.

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Abstract

Background: The HealthValues Healthy Eating Programme is a stand-alone, internet-based intervention that employs a novel strategy for promoting behaviour change (analysing one's reasons for endorsing health values) alongside other psychological principles that have been shown to influence behaviour. The programme consists of phases targeting motivation (dietary feedback and advice, analysing reasons for health values, thinking about health-related desires and concerns), volition (implementation intentions with mental contrasting) and maintenance (reviewing tasks, weekly 'tips').

Objective: To examine the effects of the programme on consumption of fruit and vegetables, saturated fat and added sugar over a 6-month period.

Methods: A total of 82 females and 18 males were recruited using both online and print advertisements in the local community. They were allocated to an intervention or control group using a stratified block randomisation protocol. The programme was designed such that participants logged onto a website every week for 24 weeks and completed health-related measures. Those allocated to the intervention group also completed the intervention tasks at these sessions. Additionally, all participants attended laboratory sessions at baseline, 3 months and 6 months. During these sessions, participants completed a food frequency questionnaire (FFQ, the Block Fat/Sugar/Fruit/Vegetable Screener, adapted for

the UK), and researchers (blind to group allocation) measured their body mass index (BMI), waist-to-hip ratio (WHR) and heart rate variability (HRV).

Results: Data were analysed using a series of ANOVA models. Per protocol analysis (n = 92) showed a significant interaction for fruit and vegetable consumption ($P = .048$); the intervention group increased their intake between baseline and 6 months (3.7 cups to 4.1 cups) relative to the control group (3.6 cups to 3.4 cups). Results also showed overall reductions in saturated fat intake, ($P < .001$), and added sugar intake, ($P < .001$), during this period (saturated fat = 20.2g to 15.6g; sugar = 44.6g to 33.9g), but there were no interactions with group. Similarly, there were overall reductions in BMI ($P = .001$; BMI = 27.7 to 27.3), and WHR ($P = .009$; WHR = 0.82 to 0.81), but no interactions with group. The intervention did not affect alcohol consumption, physical activity, smoking or HRV. Data collected during the online sessions suggested that the changes in fruit and vegetable consumption were driven by the motivational and maintenance phases of the programme.

Conclusions: Results suggest that the programme helped individuals to increase their consumption of fruit and vegetables and to sustain this over a 6-month period. The observed reduction in fat and sugar intake suggests that monitoring behaviours over time is effective, though further research would be needed to confirm this conclusion. The web-based nature of the programme makes it a potentially cost-effective way of promoting healthy eating.

Introduction

A diet that is high in saturated fat and added sugars and low in fruit and vegetables is associated with a range of chronic diseases, including cardiovascular disease, cancer and diabetes.[1-5] However, such a diet is typical for a large proportion of European and North American adults,[3,6-8] and lifestyle-related diseases are now the leading cause of death globally.[9] Therefore dietary improvement has become a priority for many Western governments.[10]

One way of promoting a more healthy diet is via internet-based intervention. This has a range of potential advantages,[11] including the ability to incorporate interactive and tailored features into a programme that is fully automated. This makes it a potentially very cost-effective approach. Indeed, a number of fully automated internet-interventions have shown positive effects on diet. For example, compared to control groups, four studies have found significant reductions in fat intake at up to 8 months from baseline,[12-15] three studies have found significant increases in fruit and vegetable consumption at up to 15 months[15-17] and one study has found a significant reduction in added sugar intake at 4 months, though not 8 months.[15]

While these results offer a useful first step in understanding the efficacy of internet-based health promotion interventions, most of them draw on the same set of behaviour change theories to guide content development. In particular,

Social Cognitive Theory, the Theory of Reasoned Action / Planned Behaviour, and the Transtheoretical Model are frequently utilised.[18] Whilst theory is a powerful tool for effective interventions,[18] these models sometimes lack empirical support as well as specific details about *how* to actually change behaviour.[19-21] Additionally, they do not always encompass latest research findings.

This paper describes the initial evaluation of a new, fully automated internet-based healthy eating intervention: the 'HealthValues Healthy Eating Programme'. This programme differs from previous web interventions in its use of novel behaviour change techniques. In developing the HealthValues Programme we used a more 'bottom up' approach, employing a selection of distinct, brief interventions that have been shown to influence behaviour. There are a wide range of such techniques in the research literature, but these often fail to get translated into practice. As such, the strategies we selected can be viewed as a starting point rather than a comprehensive selection.

The first strategy involved asking individuals to spend five minutes thinking about why the value of health is important or unimportant to them. There is evidence that social values (e.g., equality, helpfulness) often lack cognitive support. In other words, although individuals believe them to be important, they have not necessarily thought about *why* they are important.[22] This means that they tend to behave in accordance with the value only when it is relatively easy to do so. However, asking individuals to think about the reasons underpinning social values can help them build cognitive support for these values, and in turn

promote more value consistent behaviour.[23] Recent research has suggested that health values also lack cognitive support, to the extent that thinking about reasons for health can have a positive influence on eating behaviours.[24] Given that this lack of cognitive support was evident across a range of social groupings, and regardless of whether individuals lead healthy or unhealthy lifestyles, it suggests that this very simple strategy may be beneficial for a large number of individuals.

The second and third strategies asked individuals to spend five minutes considering (a) their desires and aspirations in relation to their health together with how achieving these would make them feel and (b) their concerns in relation to their health alongside how failing to avoid these would make them feel. These strategies map onto techniques commonly employed in Motivational Interviewing (MI).[25] MI aligns with the principles of Self-Determination Theory (SDT)[26] and has been shown to be effective in promoting dietary change.[27] These two strategies also draw on suggestions that affective messages may result in greater behavioural change than cognitive-based messages[28, 29] but, consistent with MI and SDT, these strategies take a non-directive approach.

The fourth strategy consists of implementation intentions with mental contrasting. Implementation intentions are specific plans of when, where and how someone will change their behaviour. They are believed to work by (a) increasing the accessibility of the situational cue that is relevant to the target behaviour and (b) increasing the efficiency with which one performs the target

behaviour in the presence of the situational cue.[30] There is considerable evidence that implementation intentions can help promote behaviour change.[31,32] In the present study implementation intentions were employed in combination with mental contrasting. Mental contrasting involves thinking about both positive outcomes following successful behaviour change as well as obstacles that might stand in the way of behaviour change.[33] Mental contrasting with implementation intentions has been shown to reduce unhealthy snacking to a greater degree than either strategy in isolation[33] and has also been shown to increase fruit and vegetable consumption over a two year period.[34]

In order to enhance the efficacy of the implementation intentions we also utilised evidence about moderators by including a number of other features. These were the use of an 'If…then…' format,[35] use of self-formulated, rather than assigned, implementation intentions,[36] visualisation of the implementation intention,[33] the formation of just one implementation intention at a time,[37, 38] emailed reminders of the implementation intention,[18] the opportunity to review and modify the implementation intention in subsequent weeks,[39,34] and a limited amount of tailored feedback aimed at promoting self-efficacy and autonomy.[40]

The fifth strategy was the use of tailored dietary feedback in conjunction with standard health promotion advice.[41,42] Participants were provided with estimates of their intake of saturated fat, added sugar and fruit and vegetables, along with government intake recommendations, information on the health

consequences of high or low intake, and some simple strategies for adjusting one's diet. Whilst this component of the intervention was similar to what might be contained in an intervention with a more educational approach, an awareness of one's own diet and how it might be improved was deemed to be a prerequisite for subsequent change.[43]

Finally, the programme also incorporated weekly 'tips' during the last phase. These were primarily aimed at maintaining user engagement[44] rather than promoting behaviour change per se. They were designed to be light-hearted and engaging but were also evidence-based.

Drawing on the Model of Action Phases,[45] these strategies were divided into a motivational phase (dietary feedback, reasons for health values, health-related desires and aspirations, health-related concerns) and a volitional phase (implementation intentions). This was followed by a maintenance phase during which participants could repeat or review previous tasks and information and could also access the 'Tip of the Week'. We evaluated the programme over a 6-month period through the use of lab-based measures taken at baseline, 3 months and 6 months, and via weekly online measures. The intervention group was compared with a control group who completed the lab and online measures, but not the intervention strategies. The main aim of the study was to examine the effects of the programme on different types of health-related eating behaviours; those that require engagement (eating more fruit and vegetables) and those that require disengagement (eating less saturated fat and added sugar). However, we

were also interested in examining 'spill-over' effects to other health-related behaviours (physical activity, alcohol consumption, smoking).[46]

Method

Sample size

Given that this study serves as an initial test of the programme, there were no comparable studies on which to base sample size calculations. That said, our sample size was informed by our previous research that examined the effects of one of the intervention components (thinking about reasons for values) on eating behaviour over a 7-day period.[24] The eating behaviour measure showed a mean difference between groups of 0.92 and a standard deviation of 1.51, meaning that at 80% power, 44 participants per group would be needed to detect a significant difference (two-tailed, $P < .05$). Assuming an attrition rate of no more than 15%,[47] we concluded that a sample size of 100 would be appropriate for this trial.

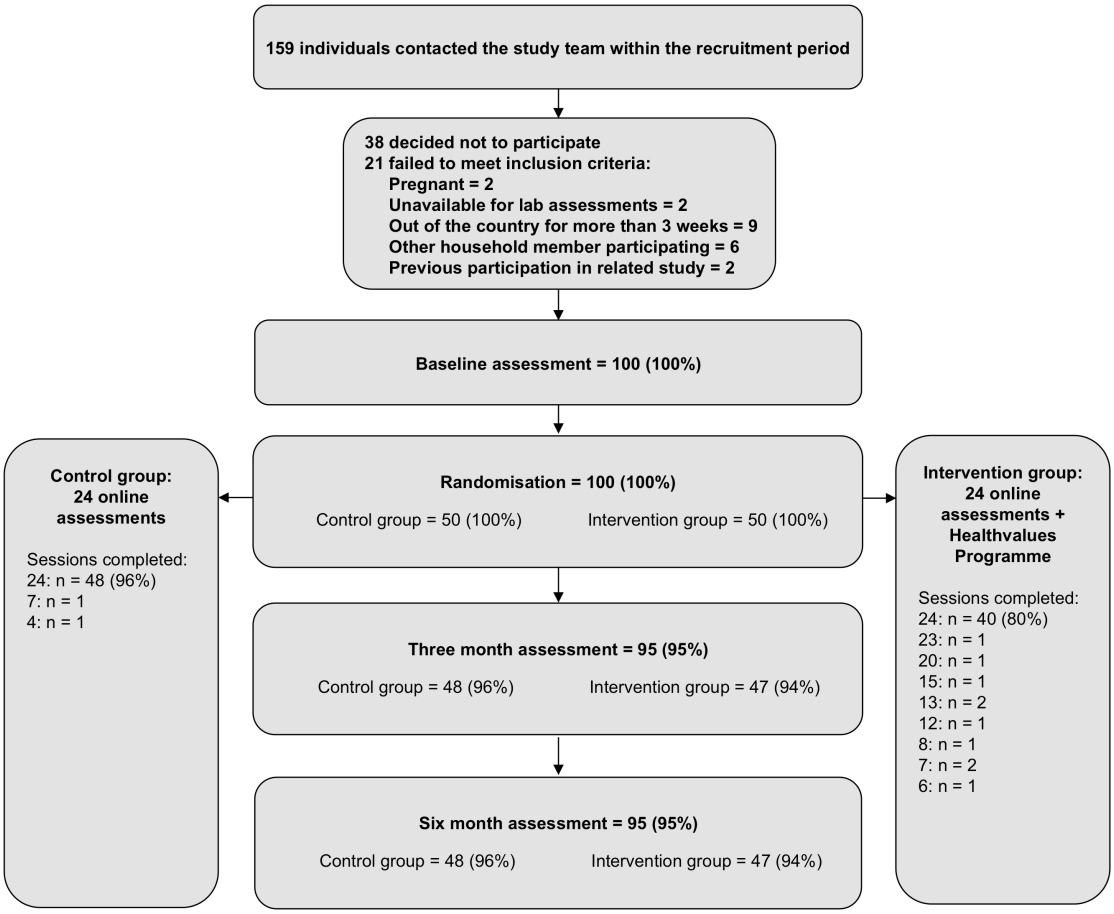
Participants

Participants were recruited using both online and print advertisements in the local community. These included posters and flyers in local shops and community facilities, and advertisements on social media sites, email networks and in local newspapers. The advertisements stated that the study team were looking for individuals to test a new online healthy eating programme and noted that individuals would be reimbursed for participation. The study's website

address (which included a full participant information sheet) was included in the advertisement. (See Appendices 1 and 2 for study homepage and information sheet.)

As inclusion criteria, we stipulated that participants were aged 18 or over and able to comply with the study procedures (i.e., attend the laboratory appointments and complete the weekly online sessions). Other exclusion criteria were pregnancy, being out of the country for more than 3 weeks during the study period, another household member already participating, and participation in a previous related study. A total of 159 individuals contacted the study team during the recruitment period. Of these, 38 decided not to take part or failed to respond to subsequent communications and 21 did not meet inclusion criteria. Figure 1 shows the flow of participants through the study. Of the 100 participants recruited, 82 were females and 18 were males. Mean age was 39 years and mean BMI was 27.68 $kg \cdot m^{-2}$. Twenty-three participants were dieting to lose weight. Ethnic origin was predominantly White (93%) and the majority of participants had English or Welsh as a first language (94%) and were well-educated (63% to degree level).

Figure 1. Flow of participants through the study.



Study design and procedure

The study received ethics approval from Swansea University Psychology Department Ethics Committee. Informed consent was collected by researchers at the first laboratory assessment (see below). Although the study was a randomised controlled trial design, given its exploratory nature the trial was not registered.

Laboratory measures were taken at baseline (February to April), 3 months (May to July) and 6 months (August to October) by GJB and a second research assistant, both of whom were blind to group allocation. Following baseline assessment GJB emailed KT details of each participant's dieting status and fruit and vegetable consumption. KT then allocated participants to an intervention or control ('monitoring') group using a stratified block randomisation protocol on the basis of dieting status (dieting versus non-dieting) and fruit and vegetable consumption (5 or more portions a day versus less than 5 a day). Block size was 2 and random numbers were generated in Excel. KT then emailed the participant details of their user ID and password and they were informed of their group allocation the first time they logged on. Although participants were not blind to group allocation they were informed that both the 'experimental' group and the 'monitoring' group would monitor eating behaviours and that this had been shown to be useful for reaching health goals. Participants in the control group were offered the opportunity to complete the programme tasks at the end of the study.

All participants were asked, by automated email, to log onto the study website every week on 24 separate occasions to complete measures (intervention and control group) and programme tasks (intervention group only). Each session could be accessed 6 days after completion of the previous session. Once the session became available the participant was sent an email asking them to log in to complete it. Up to three automated reminders were emailed two, four and six days later to participants who had failed to complete the session. After completion of each session the participant was sent an automated email

thanking them and reminding them to log in again the following week. Where participants failed to login for 3 weeks GJB attempted to contact them by phone and then email to establish whether they still wanted to participate in the online sessions and, if not, to assure them that we would still be keen for them to attend the laboratory assessments.

Each participant received £10 (approximately $17 USD) for attending the first laboratory session, £25 ($42 USD) for the second and £50 ($84 USD) for the third. Additionally they received £2 ($3 USD) per session for completing the first ten online sessions, £2.50 ($4 USD) per session for completing the next ten online sessions and £5 ($8 USD) per session for completing the last four online sessions. Thus, participants could receive up to £150 ($253 USD) for completing all laboratory and online sessions. Money for completing the online sessions was given at the final laboratory assessment and amounts allocated were indicated in emails sent to prompt, remind and thank participants. In a further effort to limit attrition participants received small gifts (a fabric bag and a mousemat pad) at the first and second laboratory assessments. These were branded with the 'HealthValues' logo.

Measures

Outcome measures

Primary outcome measures were intake of (a) saturated fat, (b) added sugar and (c) fruit and vegetables. These were assessed in a laboratory using the Block Fat/Sugar/Fruit/Vegetable screener, a 55-item food frequency questionnaire

(FFQ) adapted from a longer version that has been shown to have good reliability and validity.[48,49] The FFQ included questions about both frequency and quantity of intake. It was developed in North America and for our purposes adapted for use in the UK. Since the questionnaire often referred to quantities in terms of 'cups', participants were also given four UK measuring cups (1 cup, ½ cup, ¼ cup, 1/8 cup) to assist them with their portion estimates when completing the questionnaire.

Secondary outcome measures were body mass index (BMI), waist-to-hip ratio (WHR), heart rate variability (HRV), smoking status, smoking frequency, quantity of alcohol consumed, binge drinking, physical activity, dietary behaviours and additional online assessments of saturated fat, added sugar and fruit and vegetable intake. BMI, WHR and HRV were assessed in the laboratory by trained researchers. These physiological measures provide an objective assessment of health status.[50] For example, HRV is a surrogate measure of cardiac control via the autonomic nervous system and can be considered to be a measure of cardiac 'fitness'. Less favourable HRV profiles are associated with hypertension, cardiovascular disease and ageing[51] whilst physical activity has a positive effect on HRV profile.[52,53] In this study we quantified HRV using the common statistical indices SDRR (standard deviation of the beat-to-beat cardiac interval) and RMSSD (square root of the mean squared differences of successive cardiac intervals), which reflect overall HRV and short-term (respiratory-mediated) HRV, respectively.[54] Higher scores represent better cardiac control.

Alcohol consumption was measured in the laboratory using a questionnaire designed to capture episodes of binge drinking as well as typical drinking behaviours.[55] It contained four items asking about frequency of consumption and number of units consumed for both usual consumption and for days when the respondent consumed larger-than-usual quantities. The questionnaire was scored by converting frequencies to drinks per week and then multiplying frequency by number of units to obtain the number of units consumed per week from usual drinking. To compute additional units consumed from larger-than-usual episodes, the usual number of units consumed was first subtracted from the larger-than-usual number of units. This gave the number of additional units consumed on these occasions. This number was then multiplied by the larger-than-usual frequency to obtain a figure for the additional number of units consumed per week from 'more-than-usual' drinking. The two figures were then added together to obtain the overall number of units consumed per week. In line with British government recommendations, binge drinking was defined as eight or more units per day for men, and six or more units per day for women.[56] Where quantities consumed for either usual consumption or larger-than-usual consumption met these criteria they were coded as an episode of binge drinking.

Smoking was assessed in the laboratory by asking participants whether they smoked cigarettes and, if yes, the number they usually smoked, either per day, per week, or per month. Scores were recorded into number smoked per week.

Physical activity was assessed online at sessions 1, 8, 12 and 24 using the short version of the International Physical Activity Questionnaire.[57] Participants

indicated on how many days, and for how long, they had engaged in vigorous activity, moderate activity, and walking during the previous week. These scores were converted into total number of Metabolic Equivalent of Task (MET) units expended per day.[58]

In addition to the laboratory assessments, saturated fat, added sugar and fruit and vegetable consumption were also assessed online at sessions 1, 8, 12 and 24 using a validated UK FFQ.[59] Respondents recorded the frequency with which they consumed 63 common food items over the previous month. The FFQ has been shown to have good test-retest reliability,[60] as well as good convergent validity with 10-day weighed records[61] and with 24-hour dietary records.[59] The FFQ has also been shown to possess good construct validity.[62]

To compute daily intake of saturated fat and added sugar, the proportions of these macronutrients in each of the 63 foods were calculated, based on data provided by the British Food Standards Agency.[63,64] Each participant's daily intake of each food was then computed by multiplying frequency of consumption by average portion size. Average portion sizes were based on Bingham and Day[65] and the British Food Standards Agency.[64] Finally, the quantities of saturated fat and added sugar consumed were calculated by multiplying daily intake values of the various food types by the proportion of saturated fat/added sugar in each food. These were then summed across the 63 foods to provide daily total consumption of saturated fat and added sugar for each participant.

Two additional questions were used in the calculation of fruit and vegetable consumption. These were the number of portions of fruit (excluding fruit juice), and the number of portions of vegetables (excluding potatoes, beans and lentils) eaten on a typical day during the previous week. Examples of portions were provided. These scores were combined with scores from items relating to fruit juice and beans/lentils from the FFQ to compute daily servings of fruit and vegetables. In line with UK guidelines, juice and beans/lentils were counted as a maximum of one serving a day each.

Dietary behaviours were assessed at the start of each of the 24 online sessions using a questionnaire that was developed for the project. This consisted of 17 items associated with standard dietary advice related to consumption of saturated fat, added sugar and fruit and vegetables (e.g., reducing the number of teaspoons of sugar added to hot drinks, cereals and desserts; replacing red meat with white meat or fish). The items were a mix of quantitative (e.g., number of high fat snacks during the previous week) and categorical (e.g., type of milk mainly drunk). To reduce respondent burden, after the first session participants were presented with their responses from the previous session and asked to simply adjust their answers where they had made a dietary change. The questionnaire was scored by calculating the number of positive versus negative changes made since the previous session (-17 to +17).

All online questionnaires were tested for usability prior to the study. Questionnaires and items were presented in the same order for each participant

and participants needed to complete all items before progressing to the next screen. Adaptive questioning was used for the IPAQ.

Demographic measures

Details of participants' gender, age, level of education and first language were collected at the first online session.

Additional measures

Data relating to potential mediators (habits, intentions, self-efficacy, anticipated emotions), moderators (need for affect, need for cognition, behavioural approach system sensitivity, behavioural inhibition system sensitivity, environmental change), and process measures (post-study feedback questionnaires and telephone interviews) were also collected but these are not discussed in the present paper.

Intervention

The intervention was tested for usability prior to the study. At all sessions, intervention components were delivered after assessment measures. The intervention components are detailed in Appendix 3. For information purposes, Appendix 1 also shows how the components relate to Michie and colleagues' recommended taxonomy of behaviour change techniques.[66] Further details of the intervention components can be obtained from the first author.

Statistical analysis

Baseline characteristics of the two groups were compared using t-tests and chi-square tests. Given the exploratory nature of the trial, intention-to-treat analyses were conducted on primary outcomes only. Missing data were replaced by calculating the mean change from previous observations in the control group and adding or subtracting this figure from the previous observation relating to the missing data point. In order to examine changes in time over the 6 month period, ANOVA models, with time as an independent variable, were employed for the main analyses. Thus a series of 3 x 2 mixed ANOVA models were used to examine the effects of the intervention on lab measured intake of (a) saturated fat, (b) added sugar and (c) fruit and vegetables. Independent variables were time (baseline, 3 months, 6 months) and group (control, intervention). There were seven outliers (defined as greater than 3.5 SDs from the mean) and the analysis was conducted both with these unchanged and by adjusting them to 3.5 SDs from the mean.

Per protocol analysis was conducted on all primary and secondary outcomes by including only those participants who completed all three laboratory assessments as well as 12 or more of the 24 online sessions (for laboratory measures) or all 24 online sessions (for online measures). Although the samples for such analyses are subject to bias, they are an important means of examining intervention efficacy in exploratory trials. A series of 3 (time) x 2 (group) mixed ANOVA models were used to examine effects on lab-based measures whilst 4 (time) x 2 (group) ANOVA models were used for online measures. Analyses were conducted with outliers (defined as 3.5 SDs from the mean) both included and

excluded. Fishers exact test was used to examine smoking status and Chi-square was used for binge drinking status.

To examine the effects of the individual intervention strategies employed in the motivational phase, change scores were calculated using the dietary behaviours questionnaire. These were computed using figures from the session in which the strategy was employed and two sessions later (e.g., change between Sessions 1 and 3, see Appendix 1 for details of strategies). Change score was then employed as the dependent variable in a 2(condition) x 4(strategy) mixed ANOVA.

Results

Baseline characteristics

Analysis of baseline characteristics showed that the intervention and control groups were well-matched across a range of variables (see Table 1).

Table 1. Baseline characteristics of the intervention and control groups.

Variable	Control group (n = 50)	Intervention group (n = 50)	*P* value
Gender, % women	84	82	.79[b]
Age (years), mean (SD)	37.7 (13.2)	41.1 (14.1)	.21[c]
BMI, mean $kg \cdot m^{-2}$ (SD)	28.1 (5.8)	27.1 (5.7)	.40[c]
Dieting status, % dieting	22	24	.81[b]
Education level, % degree level or higher[a]	58	68	.86[b]
First language, % English/Welsh	98	90	.09[b]
Ethnic background, % White-British	84	68	.32[b]

[a]Highest level of educational attainment coded as GCSEs, A-levels, Degree (or equivalent), still studying or other.

[b]t-Test

[c]Chi-square

Intention to treat analyses

Descriptive and inferential statistics for intention to treat analyses (without outlier adjustment) are shown in Table 2. The results suggest that whilst both groups showed significant reductions in saturated fat and added sugar over the

6-month period, participants allocated to the intervention group did not show greater improvements than those allocated to the control group. There was no overall change in fruit and vegetable consumption over time, but a trend toward an increase in the intervention group relative to the control group (small to medium effect size). Repeating the analyses but with outlier adjustment showed near identical results.

Table 2. Means (SDs) and results from ANOVA models for intake of (a) saturated fat, (b) added sugar and (c) fruit and vegetables at baseline, 3 months and 6 months in the intervention and control groups, for the intention to treat analysis.

Variable	**Time**	**Control group (n = 50)**	**Intervention group (n = 50)**	**Effects for time**	**Effects for time x group**
Saturated fat (grams)	Baseline	21.4 (8.9)	19.7 (9.6)	F = 38.6	F = 0.0
	3 months	17.3 (8.3)	16.1 (7.7)	$P < .001$	$P = .83$
	6 months	15.9 (6.6)	15.7 (9.9)	$n_p^2 = 0.27$	$n_p^2 = 0.01$
Added sugar (grams)	Baseline	47.6 (34.0)	43.2 (42.0)	F = 8.6	F = 0.2
	3 months	36.7 (30.4)	30.3 (25.5)	$P = .004$	$P = .62$
	6 months	38.5 (37.6)	30.5 (37.0)	$n_p^2 = 0.08$	$n_p^2 = 0.00$
Fruit and vegetables (cups)	Baseline	3.6 (1.5)	3.7 (1.7)	F = 0.0	F = 3.1
	3 months	3.5 (1.9)	3.8 (1.7)	$P = .98$	$P = .08$
	6 months	3.3 (1.5)	3.9 (1.6)	$n_p^2 = 0.00$	$n_p^2 = 0.03$

Per protocol analyses

Descriptive and inferential statistics for continuous primary and secondary outcome measures collected at laboratory sessions are shown in Table 3. Over

the 6-month period participants in both groups showed comparable declines in saturated fat intake, added sugar intake, BMI and WHR. For fruit and vegetable intake the intervention group showed significant increases relative to the control group. Follow-up independent t-tests indicated no difference in fruit and vegetable consumption between the intervention and control groups at baseline and 3 months, $t(90) = 0.31$, $P = .78$ and $t(90) = 1.01$, $P = .28$ respectively, but significantly greater intake in the intervention group at 6 months, $t(90) = 2.30$, $P = .02$. For the RMSSD HRV measure there was a trend toward a significant group by time interaction but no main effect of time. SDRR HRV and total alcohol intake did not change over time and were not influenced by group status. The same pattern of results occurred when these analyses were repeated but with outliers excluded.

Table 3. Means (SDs) and results from ANOVA models for laboratory assessed primary and secondary outcomes at baseline, 3 months and 6 months in the intervention and control groups, for the per protocol analyses.

Variable	**Time**	**Control group (n = 47)[a]**	**Intervention group (n = 45)[b]**	**Effects for time**	**Effects for time x group**
Saturated fat (grams)	Baseline	21.0 (8.9)	19.3 (8.9)	F = 28.7	F = 1.2
	3 months	16.7 (8.0)	16.2 (7.3)	$P < .001$	$P = .23$
	6 months	15.5 (6.4)	15.7 (9.6)	$n_p^2 = 0.24$	$n_p^2 = 0.01$
Added sugar (grams)	Baseline	46.7 (34.3)	42.3 (43.0)	F = 7.2	F = 0.1
	3 months	35.8 (30.5)	30.4 (26.1)	$P = .009$	$P = .76$
	6 months	37.2 (38.1)	30.4 (38.5)	$n_p^2 = 0.07$	$n_p^2 = 0.00$
Fruit and vegetables (cups)	Baseline	3.6 (1.4)	3.7 (1.7)	F = 0.3	F = 4.0
	3 months	3.4 (1.7)	3.8 (1.7)	$P = .57$	$P = .048$
	6 months	3.4 (1.5)	4.1 (1.6)	$n_p^2 = 0.00$	$n_p^2 = 0.04$
Alcohol (units per week)	Baseline	6.4 (5.6)	6.3 (6.2)	F = 1.6	F = 0.2
	3 months	6.8 (7.2)	6.7 (6.9)	$P = .20$	$P = .69$
	6 months	7.2 (7.5)	6.7 (7.3)	$n_p^2 = 0.02$	$n_p^2 = 0.00$

BMI (kg·m^{-2})	Baseline	28.4 (5.8)	27.0 (5.9)	F = 11.2	F = 0.1
	3 months	28.3 (5.9)	26.8 (5.7)	P = .001	P = .93
	6 months	28.0 (5.9)	26.6 (5.9)	n_p^2 = 0.11	n_p^2 = 0.00
WHR	Baseline	0.82 (0.09)	0.82 (0.09)	F = 7.2	F = 0.0
	3 months	0.81 (0.09)	0.82 (0.09)	P = .009	P = .71
	6 months	0.81 (0.08)	0.81 (0.08)	n_p^2 = 0.07	n_p^2 = 0.00
HRV: SDRR (ms)	Baseline	45.0 (20.1)	49.6 (19.7)	F = 1.4	F = 2.0
	3 months	46.4 (20.1)	47.8 (18.7)	P = 0.254	P = 0.134
	6 months	46.1 (17.9)	43.1 (15.2)	n_p^2 = 0.02	n_p^2 = 0.02
HRV: RMSSD (ms)	Baseline	28.9 (14.6)	33.1 (19.6)	F = 1.4	F = 2.9
	3 months	19.3 (15.3)	30.5 (16.3)	P = .243	P = .060
	6 months	30.2 (15.4)	25.8 (12.9)	n_p^2 = 0.02	n_p^2 = 0.03

[a]For alcohol consumption n = 46 due to questionnaire completion error

[b]For alcohol consumption n = 44 due to questionnaire completion error

For smoking status there were 91 participants who provided data on smoking at all three laboratory assessments and completed at least 12 of the online sessions. At each of the three time-points there was no difference in the proportion of smokers in the experimental group compared to the control group. (Baseline: control n = 6, experimental n = 2, P = .27; 3 months: control n = 4, experimental n

= 1, P = .36; 6 months: control n = 4, experimental n = 3, P = 1.00.) Smoking frequency was not analysed due to the small number of smokers in the sample.

Analysis of binge drinking included 90 participants who provided data on alcohol consumption at all three laboratory assessments and completed at least 12 of the online sessions. Again, at each of the three time-points, there was no difference in the proportion of individuals who engaged in binge drinking in the experimental group compared to the control group. (Baseline: control n = 25, experimental n = 23, χ^2 = 0.04, P = .84; 3 months: control n = 23, experimental n = 17, χ^2 = 1.18, P = .28; 6 months: control n = 20, experimental n = 17, χ^2 = 0.22, P = .64.)

Descriptive and inferential statistics for secondary outcome measures collected during the online sessions are shown in Table 4. Consistent with laboratory assessments these show there were significant reductions in intake of saturated fat and added sugar over time, but that the extent of these reductions did not differ between intervention and control groups. Also consistent with laboratory assessments, the results show an increase in fruit and vegetable consumption amongst the intervention group relative to the control group. This was coupled with an overall increase in fruit and vegetable consumption over time. Follow-up independent t-tests indicated no difference in fruit and vegetable consumption between the intervention and control groups at Sessions 1, 8 and 12; t(86) = 0.19, P = .85; t(86) = 1.64, P = .11; t(86) = 1.48, P = .14 respectively, but significantly greater intake in the intervention group at Session 24, t(86) = 2.45, P = .02. Additionally the results showed no significant change in physical activity

over time and no effect of the intervention on physical activity. The same pattern of results occurred when these analyses were repeated with outliers excluded.

Table 4. Means (SDs) and results from ANOVA models for secondary outcomes assessed online at sessions 1, 8, 12 and 24 in the intervention and control groups, for the per protocol analyses.

Variable	**Session**	**Control group (n = 48)[a]**	**Intervention group (n = 40)[b]**	**Effects for time**	**Effects for time x group**
Saturated fat (grams)	1	24.4 (9.9)	26.0 (15.4)	F = 7.8	F = 0.6
	8	22.3 (10.6)	21.4 (13.0)	$P < .006$	$P = .43$
	12	21.2 (10.4)	21.7 (11.4)	$n_p^2 = 0.08$	$n_p^2 = 0.01$
	24	22.4 (10.0)	21.5 (9.1)		
Added sugar (grams)	1	47.8 (43.6)	57.32 (74.47)	F = 8.41	F = 2.0
	8	34.4 (22.7)	34.4 (32.3)	$P = .005$	$P = .16$
	12	31.7 (21.4)	32.1 (25.3)	$n_p^2 = 0.10$	$n_p^2 = 0.02$
	24	39.8 (27.0)	31.8 (19.4)		
Fruit and vegetables (portions)	1	4.9 (2.1)	5.0 (2.0)	F = 5.6	F = 5.5
	8	5.2 (2.4)	6.0 (2.3)	$P = .02$	$P = .02$
	12	5.3 (2.8)	6.1 (2.2)	$n_p^2 = 0.06$	$n_p^2 = 0.06$
	24	4.9 (2.3)	6.2 (2.7)		

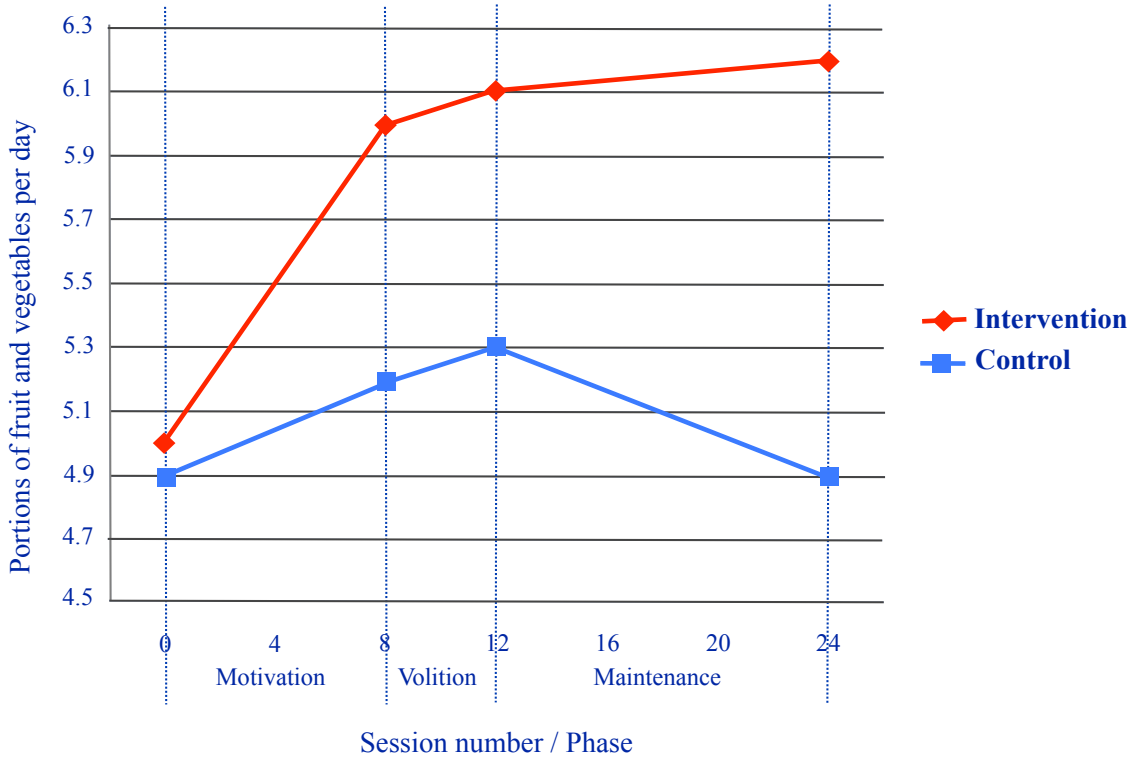
Physical activity (METS per week)	1	2857 (2320)	2432 (1626)	F = 0.2	F = 0.2
	8	2534 (2290)	2138 (1522)	*P* = .67	*P* = .69
	12	2932 (4270)	2420 (1966)	n_p^2 = 0.00	n_p^2 = 0.00
	24	2985 (3525)	2350 (2344)		

[a]For physical activity n = 39 due to participants coding *Don't know*

[b]For physical activity n = 37 due to participants coding *Don't know*

Figure 2 shows levels of fruit and vegetable consumption in the intervention and control groups at the start and end of each of the three programme phases. As noted above, follow-up analyses indicated that significant differences between intervention and control groups occurred at the fourth measurement point only (i.e. Session 24, the end of the third phase, t(86) = 2.45, *P* = .02). These results, together with Figure 2, suggest that the most likely explanation for this effect is that it was primarily driven by the combination of motivation and maintenance phases. However, it is also possible that the maintenance phase played no part in the changes but that the differences at Session 24 were a result of the motivational phase continuing to exert effects over the 6 month period. Additionally, the data suggest that (in its position within the intervention) the volitional phase had no immediate impact, (though a delayed impact cannot be ruled out). The pattern of results from the per protocol analysis were unchanged after repeating the analysis with only the intervention participants who had formed at least one volitional phase implementation intention related to the relevant outcome measure (fruit and vegetables, n = 24; saturated fat, n = 30; added sugar, n = 32).

Figure 2. Portions of fruit and vegetables consumed in the intervention and control groups at the start and end of each programme phase.

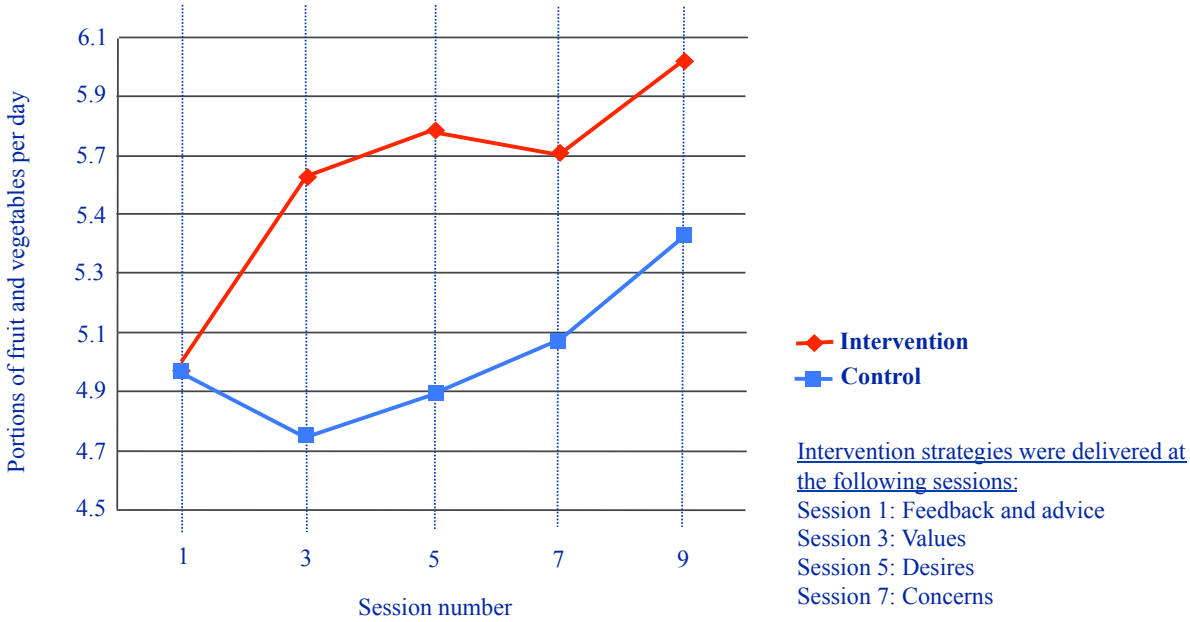


Effects of individual strategies employed in the motivational phase

For analysis of motivational phase strategies, all participants who completed the first nine online sessions were included (control, n = 47; intervention, n = 46). Because fruit and vegetable consumption was improved by the intervention, we conducted exploratory analyses examining changes in fruit and vegetable consumption in the intervention and control groups in the two-week period following the delivery of each of the four different programme components (see Figure 3). There was no main effect of strategy, $F(1, 91) = 0.53$, $P = .47$, $n_p^2 = 0.01$

or condition, $F(1, 91) = 0.87$, $P = .47$, $n_p^2 = 0.01$ and no significant interaction between strategy and condition, $F(1, 91) = 2.88$, $P = .09$, $n_p^2 = 0.03$ (though the latter results are marginal). These results suggest that the increases in fruit and vegetable consumption seen in the intervention group were brought about by a combination of intervention components in both the motivational and maintenance phases. Figure 3 suggests that the strategy employed in Session 1 (tailored feedback and advice) may have been particularly useful in eliciting change, though further research would be needed to confirm this.

Figure 3. Portions of fruit and vegetables consumed in the intervention and control groups during the motivational phase.



Discussion

Results of the per protocol analysis indicated that the HealthValues Healthy Eating Programme brought about significant increases in fruit and vegetable consumption relative to a control group. These equated to approximately 0.75 cups, or 1.3 portions of the recommended 5 or more portions per day. The results also suggested that these increases were primarily brought about by strategies employed in the motivational and maintenance phases of the programme, rather than the implementation intentions employed in the volitional phase. Thus it may be that low fruit and vegetable consumption amongst this particular group was primarily limited by motivation rather than any difficulties in implementing the behaviour; when we increased motivation, it had a direct effect on consumption.

In contrast, while the programme was associated with a decrease in saturated fat and added sugar consumption, these effects were comparable to those found in the control condition. Unlike increasing fruit and vegetable intake, which involves introducing additional foods into the diet, reducing fat and sugar entails cutting back. As such, intake may be influenced by additional factors that may not be as amenable to motivational strategies. In particular, consumption of high fat and sugar foods may be habitual and carried out with a degree of automaticity.[67,68] Since habits tend to be resistant to changes in attitude,[69] motivational strategies alone may be ineffective in eliciting a reduction in these forms of consumptive behaviour. Additionally, foods that are high in fat and sugar may be the target of cravings.[70] Again, motivational strategies may not

be sufficient to overcome such cravings. Thus, techniques specifically designed to target habits and cravings might usefully be incorporated into future versions of the programme.

The results did, however, show overall reductions in intake of saturated fat and added sugar amongst both groups by approximately 4.7 and 11.4 grams per day respectively. These findings are consistent with the physiological data that showed significant reductions in BMI and WHR. Given that our recruitment method targeted individuals who wanted to improve their diet, it is possible that these changes would have occurred even in the absence of study participation. However, this seems unlikely given the general trend for weight to increase over time[71] and the fact that these data were collected over an extended (6-month) period. Instead, we would suggest that these changes might have been brought about by the monitoring component of the study, particularly the weekly brief diet questionnaire that mapped directly onto dietary advice. This questionnaire may have increased participants' knowledge of how to cut back on fat and sugar. It may also have increased attitude accessibility, the ease with which attitudes are retrieved from memory.[72] If intake of fat and sugar are determined by relatively weak habits, increased accessibility of negative attitudes toward fat and sugar may have been sufficient to disrupt automatic behaviours. Further research would be needed to confirm this. It would also be important to control for the effects of researcher contact. In the current study it is possible that the laboratory assessments, together with the incentives, may have inadvertently led to participants trying to please the researchers. These may have in some small part contributed to the overall reductions in fat and sugar intake.

The absence of effects for implementation intentions are at odds with previous non-internet interventions[34,73] but in line with several other internet-based studies.[74-77] One explanation is that participants had already formed action plans in response to the monitoring component of the study, making it difficult for the implementation intentions to bring about further change. This interpretation is consistent with other research showing implementation intentions to be less effective amongst individuals who are already good at action planning.[78] It also has implications for the development of interventions; since longer interventions may increase rates of drop out, it is important that all strategies employed make a unique contribution to behaviour change. However, an alternative explanation is that the fruit and vegetable related implementation intentions helped sustain behaviour change.[34] A weakness of the current study is that it is unable to distinguish between these possibilities or to identify with precision the components that are responsible for the effects. In future work it would be helpful to compare different versions of the programme to help determine which components are important and which may be redundant.

The benefits of participation did not generalise to behaviours that were not directly targeted by the programme; there were no significant spillover effects on levels of physical activity, alcohol consumption, smoking or HRV, either between groups or over time. Whilst some research has suggested that health improvements may show spill-over effects to other health-related

behaviours,[46] the results of this study suggest that effects are restricted to behaviours that are targeted.

In future research it would be important to trial the programme in the absence of incentives for session completion. Given the high rates of attrition in online interventions[79] we incorporated these incentives to enable a proper initial evaluation of the programme. However, a trial without these incentives would help indicate natural attrition and allow for calculations of cost-effectiveness.

It would also be important to examine the effects of the programme with different populations. In the current study, we recruited participants who were interested in improving their diet. Thus, they were a group who were already reasonably motivated (as indicated by a baseline mean of 4.16 on a scale of 1 to 5 on intention to eat a healthy diet). It is possible that the motivational strategies would have been more effective amongst a less motivated group of individuals who might, for example, be accessed via workplace settings.

In conclusion, the HealthValues Healthy Eating Programme significantly increased fruit and vegetable consumption amongst users. Future research, comparing different versions of the programme, should help to more accurately identify the elements that were responsible for this effect. It seems likely that the monitoring component of the study also brought about reductions in intake of saturated fat and added sugar, though further research would be needed to confirm this. Given that the programme is fully automated, it represents a potentially cost-effective way of promoting healthy eating.

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Conflicts of interest

None declared.

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