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Web-based tailored nutrition education: results of a randomized controlled trial

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Abstract

There is ample evidence that printed, computer-tailored nutrition education is a more effective tool for motivating people to change to healthier diets than general nutrition education. New technology is now providing more advanced ways of delivering tailored messages, e.g. via the World Wide Web (WWW). Before disseminating a tailored intervention via the web, it is important to investigate the potential of web-based tailored nutrition education. The present study investigated the immediate impact of web-based computer-tailored nutrition education on personal awareness and intentions related to intake of fat, fruit and vegetables. A randomized controlled trial, with a pre-test–post-test control group design was conducted. Significant differences in awareness and intention to change were found between the intervention and control group at post-test. The tailored intervention was appreciated better, was rated as more personally relevant, and had more subjective impact on opinion and intentions to change than the general nutrition information. Computer literacy had no effect on these ratings. The results indicate that interactive, web-based computer-tailored nutrition education can lead to changes in determinants of behavior. Future research should be aimed at longer-term (behavioral) effects and the practicability of distributing tailored interventions via the WWW.

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Introduction

Computer tailoring is a technique that has become quite popular in health education during the last decade (Kreuter *et al.*, 2000). This is not surprising, since computer-tailored interventions were generally found to be more effective in changing relevant health-related behaviors than their non-tailored equivalents (Brug *et al.*, 1999; Skinner *et al.*, 1999; Strecher, 1999). Computer-tailored interventions mimic to some extent a classic tailoring technique: that of interpersonal counseling. In computer-tailored interventions, people are provided with information that is attuned to their personal characteristics, like individual health behaviors, motivations, attitudes and perceived barriers, thus making the information personally relevant. Since computer-tailored interventions document the diagnostic and educational expertise and techniques of the counselor in a computer expert system, they lack the direct social support of interpersonal counseling. Computer tailoring, however, provides the opportunity to reach far more people, for far lower costs, than would be possible with interpersonal counseling. The combination of greater effectiveness than general health education and the possibility of reaching larger groups of people than interpersonal counseling makes computer tailoring an interesting method that is worth being explored both in greater depth and more extensively. Exploration in greater depth is required in order to further reveal the processes responsible for the working mechanisms of

tailored interventions, as it is not yet fully clear why tailored materials are more successful in influencing behavior than non-tailored materials (De Vries and Brug, 1999; Kreuter *et al.*, 1999; Skinner *et al.*, 1999). More extensive exploration is needed in order to examine the possibilities for applying tailored messages to influence different health-related behaviors, using different information sources and communicating through different channels. The present study aims to contribute to the more extensive exploration, in that it explores the immediate impact of computer tailoring via a new channel.

The present paper reports the methods, results and implications of one of the first empirical evaluations of a so-called second-generation computer-tailored intervention: a nutrition education tool that is suitable for interactive use via the World Wide Web (WWW). Before presenting the study we will give a brief summary of why nutrition education is important and why computer-tailored, and therefore individualized, feedback may be especially effective for nutrition education.

Diet and awareness in the Netherlands

Diets low in saturated fat and high in fruit and vegetables are thought to reduce the risk of chronic diseases, like cardiovascular diseases and various cancers (Willet, 1994). Consumption of saturated fat is too high and intake of fruit and vegetables is far too low in the Netherlands (Voedingscentrum, 1998) as well as in most other 'western' countries [e.g. (Beer-Borst *et al.*, 2000)]. In the Netherlands, fat consumption is responsible for approximately 37% of total daily energy intake, with 14% of total energy intake coming from saturated fat. These figures are substantially higher than the Dutch recommended values (30–35% energy from fat; 10% from saturated fat). The most recent Dutch national food consumption survey has shown that between 1988 and 1998, fruit and vegetable consumption decreased from 125 to 105 g of fruit and from 141 to 123 g of vegetables, while Dutch nutrition authorities recommend eating at least two pieces of fruit and 200 g of vegetables per day (Voedingscentrum, 1998). Although the vast majority of the Dutch population eat too much fat and not enough fruit and vegetables, most people are not motivated to change to healthier diets (Brug *et al.*, 1997). This lack of motivation to change has been attributed to the fact that most people are not aware of their unfavorable diets (Brug *et al.*, 1997). A majority of Dutch adults are convinced that their diet is low in fat and provides sufficient quantities of fruit and vegetables, while in fact their intake of these food products is not in line with recommendations (Brug *et al.*, 1994). This lack of awareness of personal (dietary) behavior has also been found in other countries (Glanz *et al.*, 1997) as well as for other complex health risk behaviors (Ronda *et al.*, 2001) and has been identified as a major barrier in motivating people to change to healthier diets. Therefore, it is important to make people aware of their intake levels as a first step to behavioral change.

The importance of raising awareness is emphasized in Weinstein's Precaution Adoption Process model (Weinstein, 1988). According to this model, awareness of risk behavior emerges through three stages. If people are to become fully aware of a risk behavior and are to become motivated to change this behavior, they have to proceed through all three stages. Stage 1 is reached when people agree that they have heard of the (health) risk associated with a particular behavior, e.g. that eating too much fat can cause cardiovascular diseases. Stage 2 is reached when people know that the risk behavior is prevalent, i.e. when they are aware that many (other) people engage in this risk behavior. Finally, Stage 3 is reached when people acknowledge that they are engaging in the risk behavior themselves (Weinstein, 1988). Where fat, fruit and vegetables are concerned, a majority of the Dutch population seems to have reached Stage 2, but not Stage 3. Most people in the Netherlands know that eating too much fat and too little fruit and vegetables is bad for health, and they agree that many people eat too much fat and not enough fruit and vegetables. However, fewer than one-third of the population perceive their own diet to be too high in fat or too low in fruit

and vegetables. According to Weinstein, the third stage of awareness can be achieved by giving personalized feedback on individual risk behavior (personal feedback) as well as information about the risk behavior of others (normative feedback) (Weinstein, 1988). As regards awareness of dietary habits, people should be provided with accurate information about their own fat, fruit and vegetable consumption levels, and those of others.

Computer tailoring

In tailored information, personal dietary habits can be compared with recommended intake levels (personal feedback), with the consumption patterns of peers (normative feedback) and with perceived risk behavior. Furthermore, information can be provided which addresses beliefs and self-efficacy expectations with respect to healthier diets. Matching the information to personal characteristics can be achieved by linking up the results of a personal assessment or diagnosis with a message library, through a set of algorithms documented in a computer program. The algorithms ensure that a set of messages tailored to the individual assessment is collected from the library. This set of messages forms the personally relevant information and can be presented in various ways, e.g. a letter, a newsletter or a magazine.

The impact of computer-tailored interventions

Several reviews of computer-tailored interventions have recently been published (Brug *et al.*, 1999; Skinner *et al.*, 1999; Strecher, 1999). Computer tailoring has proved successful in influencing smoking behaviors (Dijkstra *et al.*, 1998; Strecher, 1999), in encouraging participation in breast cancer screening (Rakowski *et al.*, 1998; Skinner *et al.*, 1994) and also in promoting healthy dietary habits (Brug *et al.*, 1999).

The tailored nutrition interventions that have been described to date (Brug *et al.*, 1999; Skinner *et al.*, 1999) mainly aimed at reducing fat intake and increasing fruit and vegetable consumption. Results with regard to fat consumption have been quite consistent: tailored materials result in a significantly higher reduction of fat intake. Results for fruit and vegetable consumption, however, have been less straightforward. Some studies found a significantly higher increase in fruit and vegetable consumption in the tailored intervention groups (Brug *et al.*, 1998), whereas other studies did not find any intervention effects (Campbell *et al.*, 1994; Lutz *et al.*, 1999). Most studies found that tailored materials were remembered, appreciated and read better than non-tailored materials (Brug *et al.*, 1998; Campbell *et al.*, 1994). These results show that tailored nutrition interventions can have a positive influence on dietary change.

First- versus second-generation tailored interventions

Most computer-tailored interventions that have been used to date have provided people with printed materials. This is referred to as first-generation tailoring (Skinner *et al.*, 1999; Strecher, 1999). As technology proceeds, a second generation of more advanced ways of delivering tailored messages is feasible. The WWW has been proposed as a very promising channel for delivering computer-tailored feedback. However, before disseminating interactive computer-tailored interventions via the web, the effectiveness of this method should first be established. The present study aimed at exploring the immediate impact of a web-based computer-tailored nutrition education program for adults, on awareness of personal intake levels of fat, fruit and vegetables, and on motivation to change these dietary behaviors, as compared with a non-tailored intervention.

We hypothesized that:

- The web-based tailored intervention would have a greater impact on awareness and motivation to change than the non-tailored intervention
- The web-based tailored intervention would be appreciated better than the non-tailored intervention
- Appreciation of the intervention would be higher among respondents who were more experienced in using the computer

Methods

Participants

Participants were recruited from among the employees and students of various institutes for (adult) education. Potential participants received a letter prior to the study, explaining its purpose and general procedure. After this letter, the employees were sent an E-mail, to which they could reply to indicate their willingness to participate in the study. The students were asked during one of their classes if they were willing to participate in the study. The only exclusion criterion was insufficient understanding of Dutch. During recruitment, we made it particularly clear that people with no explicit interest in nutrition should also enroll.

Participants were offered a 9 Euro gift voucher and could win a trip to Paris for two that was to be raffled among all the participants of the study.

Study design and procedure

A pre-test–post-test randomized controlled trial was conducted to compare the tailored intervention with a control condition. Appointments were made with the people that had indicated their willingness to participate in the study. Respondents were exposed to the interventions on site, either in classrooms or offices. In both cases, care was taken that respondents could not see or communicate with each other. After the participants had received information about the study and had given their informed consent, the procedure of the study was explained in further detail. The participants were randomly assigned to one of the conditions by drawing lots. Respondents in the intervention group then started going through the web-based tailored program, i.e. filling out the assessment and reading the feedback. Respondents who were not experienced in using computers were given a brief instruction on how to proceed through the program. After respondents had finished the program, a written post-test questionnaire was handed out. Respondents in the control group were first asked to fill out a written baseline questionnaire. Subsequently a written general nutrition information letter was handed out to them to read, after which they were asked to fill out a post-test questionnaire. In the present study participants could not take a print out of the tailored information or a copy of the letter home with them.

Measurement

The baseline questionnaire was an 84-item self-administered questionnaire, consisting of three parts. The first part assessed information about age, sex, weight, height, educational level, living situation (alone/together), use of special diets and whether or not the respondent regularly did the cooking or the shopping for the household. The second part was a validated food frequency questionnaire, which assessed the frequency of use of 19 products or product categories (i.e. dairy products, bread spreads, cheese, meat, gravy, sweet snacks and savory snacks) that contribute most to saturated fat intake, as well as the quantities and types of product (high fat, medium fat or low fat). The answers to the food frequency questionnaire were used to calculate a score for fat, ranging from 0 to 76. This score is a reflection of total saturated fat intake. One point resembles about 2 g of saturated fat and thus a high score reflects a high saturated fat intake. The advantage of this screening instrument is that it is short and easy to administer, while it still enables the ranking of respondents according to individual fat intake and the detection of changes in individual fat consumption (Van Assema *et al.*, 1992). The frequency and quantity of fruit and vegetable consumption were assessed by a total of 10 questions on the frequency (how many days a week) and quantities of vegetables (cooked and raw) and fruit (citrus fruit, other fruit and fruit juice) usually consumed. This information was used to calculate the average number of servings of vegetables and fruit per day. The contents and validity of this food frequency questionnaire have been described in more detail elsewhere (Van Assema *et al.*, 1992, 2001).

The third part of the questionnaire assessed the respondents' awareness of personal intake levels. Awareness of dietary habits consists of two components: self rated intake and self-rated intake compared to others. Both components were

Table I. *Overview of psychosocial questions*

Awareness[a]	How much fat/fruit/vegetables do you think you eat? (self-rated intake)
	Do you think that the amounts of fat/fruit/vegetables you eat are larger or smaller than those of other people of your age and sex? (self-rated intake compared to others)
General attitude[a]	Do you think it is good or bad to eat less fat/more fruit/more vegetables?
Self-efficacy[a]	Do you think it would be easy or difficult for you to eat less fat/more fruit/more vegetables?
Stages of change[b]	Do you intend to start eating less fat/more fruit/more vegetables within half a year from now?
	Do you intend to start eating less fat/more fruit/more vegetables within a month?
	Do you already eat less fat/more fruit/more vegetables?
	Did you try to eat less fat/more fruit/more vegetables before?
	Did you continue eating less fat/more fruit/more vegetables since you started to do so?

[a]Measured on five-point scales; very little/much smaller–very much/much larger.
[b]Measured in a yes/no format.

measured by means of one question (see Table I). Stage of change, attitudes and self-efficacy related to reducing fat intake and increasing fruit and vegetable consumption were also assessed at baseline, as these factors were used to tailor the feedback (see Table I).

The post-test questionnaire consisted of 49 items (intervention) or 46 items (control). The latter questionnaire was slightly shorter because some specific questions on the attractiveness and usability of the nutrition intervention could not be used in the control group. The post-test questionnaire consisted of two parts. The first part included the same awareness and staging items as the baseline questionnaire, with extra items to assess intention to change fat, fruit and vegetable intake on seven-point scales (see Tables I and II). The second part of the post-test questionnaire consisted of questions on the appreciation, relevance, credibility and use of the intervention (see Table III). These questions had to be answered on 100-mm visual analogue scales with 'completely agree' and 'completely disagree' as the two extremes. Finally, there were questions about the frequency and ease of computer use, and familiarity with the Internet (how often do you use a computer/the Internet? How easy is it for you to use a computer/find something on the Internet?), to be answered on six- and five-point scales, respectively.

The tailored intervention

Generating a computer-tailored nutrition message requires three inter-related components: a theory-driven diagnostic tool to assess feedback goals for each participant, a message library containing feedback messages for all possible diagnoses and a computer program that selects the feedback messages that correspond with each specific diagnosis (Brug *et al.*, 1999). These same elements are necessary for a web-based tailored intervention, but a web-based intervention offers more flexibility as well as more opportunities for interaction. For example, it is not necessary to complete the whole diagnosis before feedback is given; not only the feedback, but also the diagnostic tool can be tailored by skipping questions that are not relevant to a respondent; the amount and specificity of the feedback can be tailored to the respondent's need for information at a specific time, by giving the respondent a choice to answer more questions and receive more specific information on a particular topic.

The diagnostic tool used for the present intervention was the baseline questionnaire described in the previous subsection. The questionnaire was divided into three separate parts, one for fat, one for fruit and one for vegetables, thus creating three short questionnaires.

The program started with a home page describing what a tailored nutrition education program is, for whom this particular program was made, who produced it and how it should be used. After reading this home page, a respondent could start the program by clicking on a button in the menu bar on the left side of the screen (see Figure 1). For the purpose of the present study, we asked

Table II. *Mean values (and SD) for key variables at baseline and post-test for the total study population and for respondents with intake levels of fat, fruit and vegetables not in accordance with recommendations*

Variable	Total group				Respondents with intake levels not in accordance with recommendations[f]			
	Baseline		Post-test		Baseline		Post-test	
	Tailored (n = 96)	Control (n = 102)	Tailored (n = 96)	Control (n = 102)	Tailored[e]	Control[e]	Tailored[e]	Control[e]
Self-rated fat intake[c]	0.03 (0.73)	–0.23 (0.77)[a]	0.17 (0.68)	0.01 (0.81)	0.02 (0.73)	0.07 (0.62)	0.38 (0.66)	0.32 (0.67)
Self-rated fat intake compared to others[c]	–0.31 (0.70)	–0.44 (0.77)	–0.05 (0.80)	–0.33 (0.74)[b]	–0.35 (0.65)	–0.16 (0.68)	0.19 (0.82)	–0.09 (0.65)[b]
Intention to eat less fat[d]	–	–	0.72 (1.21)	0.29 (1.26)[b]	–	–	0.96 (1.15)	0.61 (1.20)
Self-rated vegetable intake[c]	0.20 (0.71)	0.37 (0.73)	0.08 (0.74)	0.30 (0.76)	–0.06 (0.70)	0.11 (0.64)	–0.19 (0.77)	0.04 (0.73)
Self-rated vegetable intake compared to others[c]	0.18 (0.74)	0.30 (0.78)	0.08 (0.82)	0.27 (0.72)	0.00 (0.81)	0.04 (0.76)	–0.21 (0.86)	0.06 (0.63)[a]
Intention to eat more vegetables[d]	–	–	0.22 (1.33)	0.10 (1.21)	–	–	0.64 (1.15)	0.15 (1.23)[a]
Self-rated fruit intake[c]	–0.49 (0.91)	–0.51 (0.98)	–0.27 (0.93)	–0.49 (0.97)[b]	–0.91 (0.85)	–1.00 (0.73)	–0.78 (0.90)	–1.00 (0.73)
Self-rated fruit intake compared to others[c]	–0.31 (0.93)	–0.34 (1.01)	–0.16 (0.89)	–0.34 (0.96)[a]	–0.67 (0.88)	–0.87 (0.84)	–0.64 (0.77)	–0.81 (0.84)
Intention to eat more fruit[d]	–	–	0.58 (1.32)	0.51 (1.34)	–	–	1.27 (1.01)	0.75 (1.27)[a]

[a]Significant difference between tailored intervention and control group at post-test, $P < 0.05$.
[b]Significant difference between tailored intervention and control group at post-test, $P < 0.01$.
[c]Measured on a scale ranging from –2 to +2 (very low/much lower–very high/much higher).
[d]Measured on a scale ranging from –3 to +3 (definitely not–definitely).
[e]Numbers of respondents in each subgroup are mentioned in the baseline measurement section.
[f]Respondents who do not meet the relevant recommendation.

Table III. *Use, subjective impact and appreciation of the tailored and general nutrition information [means (SD)]*

	Tailored (n = 96)	Control (n = 101)
I read all of the nutrition information	7.0 (11.6)	5.1 (11.9)
I would consult the program/read the letter again if I had the opportunity	29.7 (32.5)	41.9 (36.4)[b]
The nutrition information was attractive to read	15.0 (16.7)	19.5 (22.1)
I changed my opinion about my diet as a result of the nutrition information	40.2 (28.5)	56.9 (32.9)[c]
I intend to change my diet as a result of the nutrition information	35.2 (28.6)	49.6 (31.8)[c]

	For fat		For vegetables		For fruit	
	Tailored (n = 95)	Control (n = 101)	Tailored (n = 95)	Control (n = 101)	Tailored (n = 94)	Control (n = 101)
The information was clear	10.8 (16.4)	7.7 (12.0)	9.3 (11.9)	8.7 (13.3)	8.3 (11.0)	8.1 (13.2)
The information was of personal relevance to me	24.9 (23.7)	39.4 (33.7)[c]	29.5 (26.6)	44.1 (35.7)[c]	28.2 (26.5)	36.6 (34.4)[a]
The information was specifically intended for me	25.9 (26.2)	54.8 (32.3)[c]	30.5 (27.9)	60.2 (33.4)[c]	29.6 (27.5)	51.3 (34.1)[c]
The information was credible	14.9 (21.4)	12.0 (18.8)	12.4 (14.6)	9.72 (15.6)	12.2 (16.4)	10.9 (16.2)
The information was new to me	61.9 (34.3)	81.8 (25.2)[c]	66.8 (32.0)	83.1 (23.2)[c]	68.5 (30.5)	83.3 (22.9)[c]
The information was interesting	21.8 (22.2)	25.5 (25.3)	26.7 (26.5)	24.7 (25.5)	24.5 (25.1)	23.0 (24.1)

Scores on visual analogue scales ranging from 0 (completely agree) to 100 (completely disagree).
[a]Significant difference, $P < 0.05$.
[b]Significant difference, $P < 0.01$.
[c]Significant difference, $P < 0.001$.

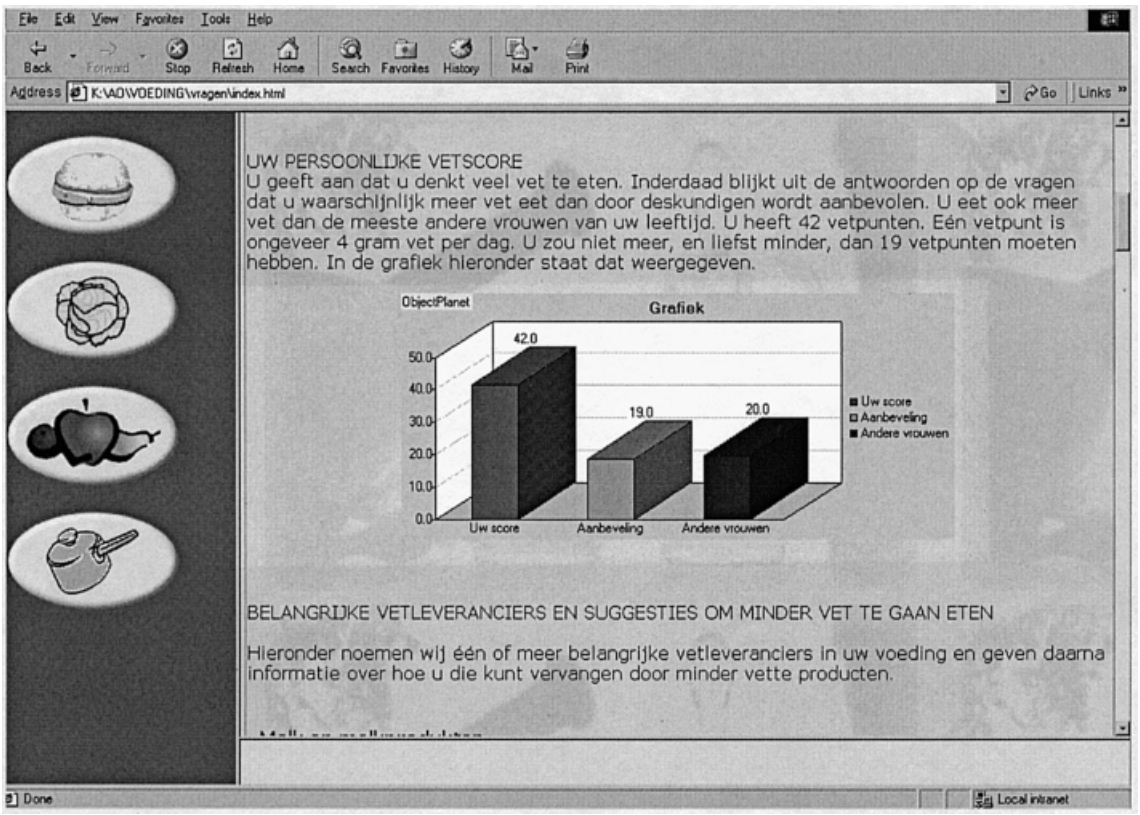

Fig. 1. Part of the feedback section on fat.

respondents to follow the sequence in the menu bar, which starts with fat, followed by vegetables, fruit and recipe suggestions, although a random sequence is possible.

Each topic started with a short introduction on the subject, e.g. why low fat diets are important and that it is important for everybody to have diets low in fat. This introduction was followed by the diagnosis section. Questions appeared on the screen one by one, with the next question appearing as soon as the previous one had been answered. Questions that were irrelevant to a particular person were skipped. For example, vegetarians were not asked questions on meat consumption. Thus the questionnaire could differ in length, depending on the individual diet. After all relevant questions had been answered, the feedback appeared on the screen, in an attractive layout, with a colored background and illustrations accompanying the texts. Respondents could proceed to the next topic by clicking the next button in the menu bar.

Each feedback section started with a short introduction and an overview of topics to be discussed. Feedback messages were given on the respondent's own estimation of fat intake and the fat score computed from the baseline questionnaire. The respondent's personal fat score was compared with recommended intake levels and respondents who underestimated their fat intake were confronted with their misconception. If the fat score exceeded the average fat score of others of the same age and sex, the personal fat score was also compared with that of others. This information was visualized in a graph (see Figure 1). Subsequently, messages were provided on the most important sources of fat in the diet and low fat alternatives. Messages

were available on the major sources of fat in the Dutch diet (milk products, bread spreads, cheese, meat, gravy and sauce, and savory snacks and sweet snacks), but respondents only received information on fat sources that featured prominently in their own diet.

The information on fat ended with a message tailored to stages of change, motivating people in pre-contemplation to reconsider their fat intake, encouraging respondents in contemplation and preparation to proceed to action, and reinforcing respondents in action and maintenance to continue with their changes. Messages differed for positive, negative or neutral attitudes and positive, negative or neutral self-efficacy expectations. Respondents who thought it would be difficult for them to eat low fat food in five particular situations (when in a restaurant, when invited by family or friends, when at a party, when hungry between meals) were given messages on how to face these difficult situations.

Feedback on vegetable intake was given by comparing the computed vegetable intake with the recommended quantity of 200 g of vegetables each day. Respondents who did not meet the recommended levels were given suggestions on how to increase consumption by either eating vegetables more frequently or in larger portions. Suggestions were made to eat vegetables with other meals, as well as tips for easy ways to increase vegetable consumption. For those who did not meet the recommendation for vegetables, portion sizes for three different kinds of vegetables were given, both in words and photographs. The information on vegetable consumption also ended with a message tailored to stage of change.

Computed fruit consumption levels were compared with recommended levels and self-rated intake levels. The messages emphasized the importance of eating at least two pieces of fruit each day. Respondents who did not meet the recommendations were given suggestions how to increase fruit intake, tailored to the time of day fruit was usually eaten. Again, the information ended with a message tailored to stages of change.

Finally, the recipe part offered 56 recipes for low fat and high vegetable main courses, desserts and snacks, which respondents could browse through. This part could be entered either by clicking the button in the menu bar or via links in the information sections on fat, fruit and vegetables. The message library has been tested in earlier studies (Brug *et al.*, 1998; Brug and Van Assema, 2000), and was revised and extended for the present study.

A computer program, written in Visual Basic, enabled the creation and storage of all essential parts of a tailored intervention (screening instrument, message library, tailoring algorithms, and layout of the final feedback). Java script routines generated the tailored messages and created a website consisting of HTML pages. The program was created for use on the Internet, but for the purpose of the present study we had the program installed locally on hard disk, to make sure people would use the program and not surf to other sites. Internet Explorer 5.0 was the browser used to run the program. The web-based program was pre-tested in two sessions and changes were made according to the findings of the pre-tests.

Control condition

Respondents in the control condition received a non-tailored nutrition information letter, with information derived from brochures of the Dutch Nutrition Bureau. The letter provided information on the importance of a healthy diet, and on the fact that Dutch people eat too much fat and not enough fruit and vegetables, but that many people do not know they have unfavorable diets themselves. The section on fat listed the risks of high fat diets and emphasized that everybody who eats too much fat is at risk. Low fat alternatives were given for some high fat products that are very common in the Dutch diet. The fruit and vegetable part emphasized the positive consequences of eating more fruit and vegetables, followed by suggestions for increasing fruit and vegetable intake. The letter ended with two low fat recipes. The four-page letter was illustrated with cartoons.

Statistical analysis

Equality of study groups at baseline was tested by means of logistic regression analyses with the

study group as the dependent variable and age, gender, consumption of fat, fruit and vegetables, self-rated intake and self-rated intake compared to others as the independent variables.

Analyses of variance were used to test for differences in intention to change to low fat and high fruit and vegetable diets between study groups at post-test. To test for differences between study groups in post-test awareness scores analyses of co-variance were conducted, adjusting for baseline awareness scores. Since people with unfavorable diets should profit in particular from nutrition interventions, the same analyses were conducted separately for subgroups which did not meet recommended intake levels at baseline. Chi-square tests were used to test for differences in proportions of respondents who did not meet recommended intake levels in both study groups.

Differences in use, subjective estimation of impact and appreciation of the tailored nutrition information program and the general nutrition information letter were tested using *t*-tests.

To detect differences in the appreciation of the tailored nutrition information program between computer-literate and computer-illiterate respondents, Pearson correlations were computed between computer literacy (calculated as the sum of frequency and ease of computer use, Pearson $r = 0.8$) and the attractiveness as well as ease of use of the program.

Differences with $P < 0.05$ were considered to be significant. Analyses for intervention effects were one-tailed, since the superiority of the tailored intervention was hypothesized. The analyses were only conducted when no substantial violations of normal distribution were found.

Results

Participants

A total of 204 respondents participated in the study. Due to technical problems, the data of four subjects in the tailored intervention group were lost. Information on the fat consumption of two other respondents in the tailored intervention group was not recorded, although the subjects completed the whole program. Two respondents only completed the section on fat. For these four respondents, the data on the completed and recorded topics were included in the analyses. Thus, most analyses were conducted on 96 subjects in the tailored intervention group and 102 subjects in the control group.

Baseline measurements

Approximately two-thirds of the respondents were female (62%). Mean age was 44 years (SD = 9.7). Almost half of the respondents had a college or university degree (47%), while 26% had completed medium-level or lower professional education, 22% had graduated from high school and 5% had no education beyond primary school.

The average fat score was 18.5 (SD = 6.3), while the average vegetable intake and fruit consumption was 198.5 (SD = 103.2) g and 2.2 (SD = 1.7) pieces per day respectively. Logistic regression analyses found no differences between the study groups in these average intake levels or in other key variables at baseline.

Fifty-two (54%) respondents in the tailored intervention group and 44 (43%) in the control group exceeded the recommended levels for fat intake, while 47 (49%) and 45 (47%) respondents in the tailored intervention group and 53 (52%), and 53 (52%) respondents in the control group did not meet the recommended intake levels for vegetables and fruit, respectively. The percentage of respondents in each subgroup did not differ significantly between the study groups.

Impact on awareness and motivation to change

Analyses of (co)variance showed significant differences in the intention to eat less fat and in self-rated fat intake compared to others (Table II). Respondents in the tailored intervention group had a significantly greater intention to eat less fat [$F(1,196) = 5.85$, $P = 0.008$] and were significantly less likely to think that they ate less fat than others [$F(1,195) = 5.52$, $P = 0.010$]. Self-rated fruit intake [$F(1,194) = 7.63$, $P = 0.003$]

and self-rated fruit intake compared to others [$F(1,193) = 2.97$, $P = 0.044$] were significantly higher in the tailored intervention group, indicating that respondents in the tailored intervention group were significantly less negative about their fruit consumption.

Subgroup analyses

Among respondents with a higher than recommended fat intake (Table II), again a significant difference in self-rated fat intake compared to others [$F(1,93) = 10.51$, $P = 0.001$] was found between the study groups, but the difference in intention was now borderline significant [$F(1,94) = 2.08$, $P = 0.077$]. Respondents in the tailored intervention group thought significantly more often that they ate more fat than others compared to respondents in the control group. Intentions to eat more vegetables and more fruit were significantly higher in the tailored intervention group [$F(1,98) = 4.15$, $P = 0.022$; $F(1,96) = 4.76$, $P = 0.016$]. Furthermore, respondents in the tailored intervention group thought more often that they ate less vegetables than others, indicated by the significantly lower self-rated vegetable intake compared to others [$F(1,97) = 5.35$, $P = 0.012$]. The difference in self-rated fruit intake was borderline significant in this subgroup [$F(1,95) = 2.01$, $P = 0.080$].

Use, subjective impact and appreciation

Respondents in both groups read most of the nutrition information and both groups rated the information equally attractive to read (Table III). The tailored nutrition information program, however, was more likely to be used again [$t(192) = 2.47$, $P = 0.008$].

Respondents in the tailored intervention group were more likely to have changed their opinion about their diet [$t(193) = 3.82$, $P = 0.000$] and more likely to express the intention to change their diet [$t(195) = 3.35$, $P = 0.001$] as a result of the nutrition information.

Although both groups were equally positive in their answers to the questions whether the nutrition information was clear, credible and interesting, respondents in the tailored intervention groups rated the information about all three topics as more personally relevant [$t(180) = 3.52$, $P = 0.001$ for fat; $t(184) = 3.27$, $P = 0.001$ for vegetables; $t(187) = 1.91$, $P = 0.029$ for fruit], more specifically intended for them [$t(190) = 6.92$, $P = 0.000$ for fat; $t(191) = 6.76$, $P = 0.000$ for vegetables; $t(189) = 4.91$, $P = 0.000$ for fruit] and newer to them [$t(172) = 4.61$, $P = 0.000$ for fat; $t(171) = 4.05$, $P = 0.000$ for vegetables; $t(172) = 3.81$, $P = 0.000$ for fruit] than did respondents in the control group.

Computer literacy did not correlate significantly with the attractiveness of the web-based tailored intervention (Pearsons $r = 0.02$), indicating that the program was rated equally attractive by both computer-literate and computer-illiterate respondents, but a significant negative correlation was found between computer literacy and ease of use of the program (Pearsons $r = -0.27$, $P < 0.01$), indicating that the program was more difficult to use for computer-illiterate respondents.

Discussion

The web-based tailored nutrition information program we tested in this study resulted in some significant differences between the tailored intervention group and the control group as regards the awareness of intake levels of fat, fruit and vegetables, and in the intention to change to healthier diets. Effects occurred both in the study population as a whole and in the subgroups of respondents with unfavorable diets. Furthermore, the tailored intervention was evaluated more positively on important criteria for effective dietary interventions (Contento *et al.*, 1995): personal relevance, matched to the individual and novelty of information. The tailored intervention was attractive to computer-literate as well as computer-illiterate respondents.

The present study is the first to assess the impact of web-based computer-tailored feedback and one of very few studies to assess the immediate impact of the intervention. Since almost all studies on computer-tailored nutrition education

have assessed short-term (1 month) or longer-term (>4 months) changes as well as primarily behavioral changes (Brug *et al.*, 1999), the present study is not readily comparable to these earlier studies. Nevertheless, similar to other studies on the impact of computer tailoring, tailoring effects on intentions to change to healthier diets were found. The focus of the present study was specifically on increasing awareness of personal dietary intake and tailoring effects were found on the awareness-related variables. Since awareness of personal intake has been identified as a prerequisite for proceeding to dietary change, these results are certainly relevant and are in line with findings from a recent study by De Bourdeaudhuij and Brug (De Bourdeaudhuij and Brug, 2000).

From earlier studies we have learned that tailored nutrition interventions are generally more effective in inducing dietary change than non-tailored interventions. The present study provides some evidence that a second-generation, interactive, computer-tailored intervention also influences factors that are important determinants of dietary change. The web-based tailored intervention that was tested had, at least, a greater immediate impact and was better appreciated on important features than general nutrition information. Although this information on the immediate impact is promising, results are limited to effects on pre-behavioral determinants, and we lack information on longer-term and behavioral effects. Our future research will aim at studying the longer-term effects of the intervention on awareness, intention, transitions in stages of change and behavior.

There are some further limitations to this study that should be taken into consideration in interpreting the results. The impact of the intervention was studied in a highly controlled situation. The program was locally run and there were no possibilities of linking to other pages or sites outside the program. Furthermore, we instructed the respondents to follow the program in a predetermined sequence and to complete the whole program. This gave us the opportunity to study the results of the program, but in real-life settings the program may be used differently, there may be distraction from the program to other sites and there may be other confounding factors which all could lead to different results. Generalizability of the results of this study to other populations is limited, because our sample was not representative of the entire Dutch population. Although we approached potential respondents by direct mail or through face-to-face contact, asking them to participate in our study, the sample was nevertheless self-selected. Even though we emphasized that anybody could participate in the study, including people with no particular interest in food and nutrition, we may have selected a sample of respondents who were more than usually interested in nutrition and diet. Indeed the proportion of respondents with unfavorable diets in the present study was somewhat lower than that in the general Dutch population (Voedingscentrum, 1998), although we still attracted many people who did not meet the dietary recommendations. Further, we used an electronic questionnaire as part of the tailored intervention and a written questionnaire in the control group. Studies investigating the comparability of web-based questionnaires to paper and pencil questionnaires, however, have found no differences between the two (Davis, 1999), but we cannot be certain whether this was also true in our study.

To our knowledge, no other studies on the impact of web-based computer-tailored interventions have been published to date. The level of impact in the present study is therefore hard to judge. Some studies have reported on the impact and appreciation of non-tailored Internet-based programs. These studies showed promising results and the authors were positive about the Internet as a channel to deliver health education messages [e.g. (Celio *et al.*, 2000; Winzelberg *et al.*, 2000)].

The advantages of a web-based, interactive, computer-tailored intervention over a more traditional print version are multiple. First of all, immediate feedback can be given, which makes it more likely that the information is indeed matched to the respondent's level of awareness, dietary pattern, beliefs and motivations at that particular

time. In the more traditional settings, where printed materials were used, an interval of 2 weeks or more between assessment and feedback is not unusual. As beliefs and motivations may very well change in such a period of time, the information may no longer be tailored at the time respondents read their feedback. Furthermore, because of its more interactive properties, second-generation tailored feedback is even more similar to interpersonal counseling, which may enhance the effect of the intervention. Another advantage is that, once on the web, the tailoring program can reach a large group of people with a minimum investment in human effort and may therefore be cost-effective. A web-based computer-tailored intervention is flexible and can be updated continuously, thus making it possible to tailor to the most recent knowledge of, for example, determinants of dietary change or new products on the food market. As regards research applications, web-based tailored interventions can be very useful in experimental studies of the working mechanism of the tailoring process. Because of its flexibility it is relatively easy, for example, to change the assessment or change the messages, thus creating different conditions.

A disadvantage is that an intervention provided via the WWW reaches only people who have access to the Internet. Furthermore information read from a screen may not be as thoroughly processed as information read as printed material.

The present study aimed to investigate the potential immediate impact of a web-based tailored nutrition intervention, as it is important to assess its effectiveness before further dissemination. We did not study how the program could be used on the web, how to reach the target population via the web and how to ensure perceived credibility of the information when provided via the web. It is important, however, to investigate these issues in future research, since merely making a promising program available via the Internet will probably not result in the use of the program by the target audience. For example, it may not be easy to attract people to the website. This applies especially to people who are not aware of their unfavorable diets. They may initially not be interested in websites promoting dietary change, although studies on first-generation computer-tailored feedback do indicate that even people who think their diets are in accordance with recommendations are interested in personal feedback and do volunteer to receive tailored messages (Brug and Van Assema, 2000). Furthermore, when people do visit the website they should be encouraged to stay there long enough to complete the screening questions and to read the feedback, and people should be convinced that the website is produced by a reliable source.

In spite of the limitations of the present study and the issues discussed, it can be concluded that a web-based tailored intervention can have an impact on determinants of dietary change and that the present findings warrant further studies on the impact and advantages of web-based tailored interventions in promoting healthy nutrition.

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