Insights in the Efficacy of Computer-tailored Nutrition Education

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COLOFON

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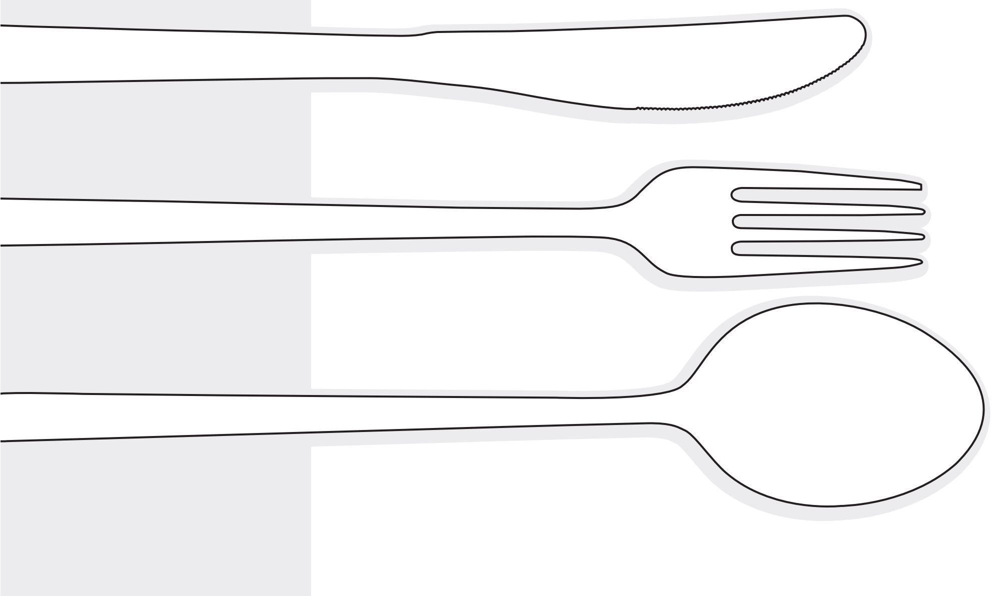
CHAPTER 1

General Introduction



Saturated fat intake is an important risk factor for cardiovascular diseases, one of the main burdens of disease worldwide. Therefore it is important to use population-wide health promotion efforts to target this risk behavior. Computer-tailored nutrition education has been found to be a very promising health education strategy that can be applied in population health promotion. However, several questions remained unanswered on why, where and for whom computer-tailored (nutrition) education is effective.

In this thesis, those questions are addressed to get more insight in the efficacy of computer-tailored nutrition education aimed at the reduction of saturated fat intake. This introductory chapter provides a general background and rationale for the studies presented in this thesis.

THE NEED TO PROMOTE A HEALTHY DIET TO IMPROVE POPULATION HEALTH

To avoid non-optimal use of the sparse resources available for healthy diet promotion, careful evidence-based planning of such interventions should be standard procedure in order to increase the likelihood that the right behavior change goals are pursued by targeting the right behavioral determinants with the right intervention strategy [1]. An integrated planning model of the available health promotion planning models identified five important steps or phases in health promotion planning (Figure 1.1) [2]. The first step in health promotion planning is the identification of health problems that are serious and/or prevalent enough to warrant intervening. In the second and third step the risk behaviors associated with the risk of those health problems and the determinants of these risk behaviors need to be identified, in order to be able to decide which causes of the health problem need to be improved among which target groups. Based on this epidemiological analysis the target groups and the goals for a health education intervention should be formulated. Subsequently, appropriate

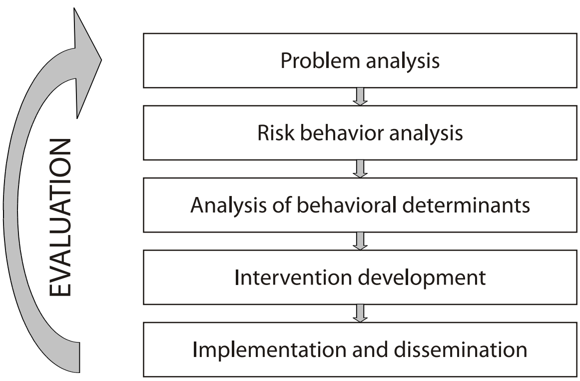


Figure 1.1. Model of planned health education

strategies and methods to change the risk behavior and its determinants among the selected target groups should be designed (step 4). Finally, the intervention needs to be implemented and disseminated so that the target-population is reached and exposed to the nutrition education messages (step 5). Each step should preferably be evidence-based and evaluation of each step is necessary. The studies presented in the current thesis are based on this planning model. The epidemiological evidence for the selected health problems and their risk behaviors and determinants, and possible intervention strategies will be described in more detail in the remainder of this chapter.

Nutrition and burdens of disease

Among the ten leading causes of death and burden of disease in high-income countries are ischemic heart disease, cerebrovascular disease, diabetes mellitus and cancer [3]. In the Netherlands coronary heart disease is the most important cause of death followed by cancer [4]. Within the group of coronary heart diseases, ischemic heart disease and cerebrovascular disease together account for 52% of deaths. Diet contributes to all these health problems; high energy intake that leads to a positive energy balance, high intakes of saturated fat, and low fruit and vegetable intake are regarded as the main dietary risk behaviors [5, 6].

The pathological condition underlying coronary heart disease is atherosclerosis [7], which is affected by high serum cholesterol [7], one of the leading global risk factors [3, 8, 9]. The prevalence of hypercholesterolemia in the Netherlands is substantial. Among the general adult Dutch public about 17-22% had elevated total cholesterol serum levels (≥6.5 mmol/l) and/or used cholesterol lowering medication [10, 11].

High intakes of saturated fat have been found to be associated with such elevated serum cholesterol levels [12, 13]. The consumption of saturated fatty acids contributes to a higher level of LDL-cholesterol [12, 14, 15]; while a high level of LDL-cholesterol is associated with an elevated risk of coronary heart disease [7, 16]. In addition (saturated) fat intake is also associated with an increased risk for a higher body weight, because of the energy density of fat. High-fat diets may induce weight gain, leading to overweight and eventually obesity. Obesity is an independent risk factor for a wide range of diseases including coronary heart diseases [9, 17].

Risk consumption of saturated fat intake among the general public

The dietary guidelines in the Netherlands [18] with respect to fat intake are as follows: 1) a total fat intake of 20-40 percent of total daily energy intake (en%) for non-overweight adults and a total fat intake of 20 to 30-35 en% for overweight adults or those at risk of becoming overweight; 2) a maximum saturated fat intake of 10 en% for all adults; 3) a maximum intake of trans fatty acids of 1 en% for all adults.

Results from the most recent Dutch national food consumption survey in 2003 [19] show that among young adults (age 19-30 years) the average intake of fat was 34.4 en%, of saturated fat 12.9 en% and 1.1en% for trans fatty acids. Although the average total fat intake was within the range of acceptable amounts saturated fat exceeded the recommended amounts. Data for other age groups available from the national survey of 1997-1998 [20] showed that both the average total fat intake (37.2 en%) and saturated fat intake (14.9 en%) exceeded the maximum intakes according to the dietary guidelines. It has been estimated that on average 90% of the general Dutch population had a higher than recommended saturated fat intake [21].
This high prevalence of such an important risk factor for the burden of disease and the fact that saturated fat intake is changeable, warrants nation-wide health education and promotion efforts to reduce saturated fat intake.

Determinants of saturated fat consumption

Behavioral determinants are causal factors that induce an individual to engage in a particular behavior. To be able to change a risk behavior like saturated fat intake, it is important to identify the most important and best changeable determinants of that target behavior [22, 23]. Several studies have been undertaken to identify those determinants of saturated fat intake [23-25], using theories and models including the Theory of Planned Behavior, Health Belief Model, Protection Motivation Theory, Social Cognitive Theory, the Precaution Adoption Process Model and the Trans Theoretical Model. Rothschild proposed a framework [26] to categorize the large and diverse number of potential determinants recognized in the different behavior theories. He identifies three categories of determinants: motivation, ability and opportunity. Below we will mainly describe the determinants of motivation and ability. Opportunity is addressed briefly, since this falls beyond the scope of this thesis.

Motivation and Abilities

Motivation is ascribed as follows in the Collins Cobuild Dictionary: "your motivation for doing something is what causes you to want to do it" [27]. Attitude, taste, health beliefs, normative beliefs, modeling and self-efficacy expectations have been found to be the most important determinants for the intention to reduce (saturated) fat intake and for the actual intake [23]. Motivation itself is identified as the most proximal predictor of behavior and behavior change. Below we will describe some causes of motivation based on the Theory of Planned Behavior (TPB) [28] and the Precaution Adoption Process, which are the models used in the initial development of the computer-tailored interventions evaluated in this thesis [29, 30].

The TPB shows good predictive validity for a range of dietary behaviors such as food choice [31, 32] consumption of fat and sugar [33-35] and dietary change [36]. Furthermore, the TPB has often been used as a theoretical basis for computer-tailored nutrition education interventions aimed at reduction of saturated fat intake [37-43]. The Theory of Planned Behavior posits that behavior is directly predicted by the intention to act and perceptions of control over that behavior [44]. Intentions represent a person's motivation in the sense of her or his conscious plan or decision to exert effort to perform the behavior [44]. Intention is itself determined by three sets of factors: attitudes, subjective norms and perceived behavioral control. Attitude is a weighing of advantages and disadvantages to perform a particular behavior, such as to eat low fat products. Subjective norm is based on normative beliefs of what you think important others want you to do. The weighing of those beliefs results in a feeling of social support or pressure to act or not. Perceived behavior control is the individual's perception of someone's own ability to have control over a behavior. In other words perception of the extent to which performance of the behavior is easy or difficult. It reflects if a person considers himself as being able to change (having enough skills) or not.

In addition the Precaution Adoption Process Model (PAPM) [45, 46] recognized awareness of ones own health risk and the related risk behavior as predictors of motivation to change, because when people are not aware of a problem, they will feel no need to change. Research on determinants of dietary intake indeed showed that awareness of ones own fat consumption or ones own fruit and vegetable consumption was strongly associated with motivation to change behavior [36, 47-50]. Many people underestimate their own fat intake [51], partly because it is rather complex to estimate how much fat you eat; it depends for example on what you buy, how you prepare it and how much you actually eat. Research also showed that an optimistic bias in the comparison with others is strongly associated with lack of awareness of personal dietary fat intake. The less fat people thought they ate compared to peers, the more they underestimated their own fat intake level [45, 48].

To translate motivation into actual behavior change, people need confidence in their skills and abilities (e.g. a positive perceived behavior control) to reduce their saturated fat intake, as well as actual skills and abilities. Skills and abilities are to some extent dependent on practical knowledge. For example, knowledge of recommended intake levels and low-fat alternatives for high-fat products help to enable voluntary dietary change [46].

The factors described above are rational and conscious decision-making factors. However, behavior does not always seem to be under volitional control. In other words, people do not always think before they act. One of the concepts that has been developed and studied in this context is habit [52, 53]. A habit is something that you do often or regularly, without thinking (unaware/automatically) and is difficult to control. A habitual behavior is considered to be 'automatic', triggered by environmental cues instead of conscious evaluations of possible outcomes, the opinion of other people, and confidence about being able to perform the behavior [54]. Food consumption is an every day behavior that has to be repeated over and over again. Food consumption may therefore be at least partly habitual. To date, several studies started to explore the usefulness of habit strength in explaining and understanding diet-related behaviors. For instance, Brug and colleagues [55] and Reinaerts and colleagues [56] showed that habit strength significantly increased the amount of explained variance in fruit consumption, over and above the TPB-concepts. In addition, Verplanken [57] showed that habit strength completely mediated the relationship between previous and later snack consumption. Furthermore, De Bruijn and colleagues [58] found that habit strength moderated the intention-behavior relationship with regard to fruit consumption. Among persons with a strong habitual fruit intake, intention was a weak and non-significant predictor of actual fruit intake, whereas for those with a weak habitual fruit intake, intention was a stronger and significant predictor. In addition, when fat consumption is (partly) habitual, this might also influence a realistic assessment of own fat intake. Until now empirical evidence of the potential role of habit in relation to saturated fat intake is lacking, but given the evidence reported on other dietary behaviors, important to explore.

Opportunities

People's opportunities to reduce fat intake, e.g. make low fat choices, may depend on the environments they live in. The environment can be defined as everything and anything outside the person. Environmental factors are often believed to influence health behavior via the personal determinants (motivation and abilities) but also in a direct way (availability). Environments that offer appealing and tasty opportunities for healthy eating may improve motivation to do so. When the environment offers easy opportunities a person may need less motivation and fewer skills to engage in healthy eating. Besides, people who have strong motivation and self-efficacy will be more likely to pursue healthy eating despite environmental barriers [1]. Even though it may be important to take the environment into account in explaining and changing behavior, environmental influences were not a main topic in this thesis.

HEALTH EDUCATION STRATEGIES TO IMPROVE DIETARY BEHAVIORS

Based on the epidemiological analysis and analysis of risk behavior it has become clear that saturated fat intake is among the major risk factors of the global burden of disease. Therefore, it is important to use population-wide health promotion efforts to target this risk behavior. Health promotion has been defined as: "the combination of educational and environmental supports for actions and conditions of living conducive to health" [59]. The focus of this thesis is on health education aimed at conscious behavior change through improvement of cognitions like motivation and skills. Green and Kreuter [59] defined health education as: "planned learning experiences to facilitate voluntary change in behavior". In other words, all those activities that can be undertaken to stimulate people to get motivated to change and to behave healthier on a voluntary basis. Next to a careful theory-based development, the impact of nutrition education interventions depends on exposure to the intervention and processing of the information. Below, we will continue with some general requirements for effective nutrition education.

Requirements for effective nutrition education

A comprehensive review of Contento et al [60] on the effectiveness of nutrition education concluded that nutrition education was more likely to be effective when behavior change goals were made explicit and when the education strategies were explicitly directed to that goal. In addition, Contento et al's review showed that personal relevance, feedback and interactivity contribute to effectiveness. Below follows a brief description of some of the theories and models that under scribe these aspects and are used for the development of the interventions studied in this thesis.

The Persuasion-Communication Theory [61] states that nutrition education can only be effective if people are exposed and attentive to the health-education message, when the message includes sufficiently strong and convincing arguments, and is communicated by a source that is perceived as credible and trustworthy.

According to the Elaboration Likelihood Model (ELM) [62], processing information from health education messages can be done in two different ways: central processing and peripheral processing. Central processing is a thoughtful and cognitively effortful route that can only occur when the person is both motivated and able to think about the merits of the issue under consideration. Peripheral processing is a less thoughtful route that occurs when motivation or ability is low. Central processing of the information is preferred since that usually leads to more thoughtful, stable and endured changes in attitudes and behavior, compared to information processed through the peripheral route. These thoughtful changes are postulated to be more accessible to memory, persistent over time, resistant to counter persuasive attempts, and predictive of behavior. A person's motivation to thoughtfully consider message arguments can be influenced by a number of variables, including the perceived personal relevance of the message and whether the person enjoys thinking in general [62]. A person's ability to think can also be influenced by a number of variables, including the amount of distraction present in the persuasion context (e.g. redundant information) and the number of times the message is repeated [62].

The Precaution Adoption Process Model proposes feedback as a strategy to increase awareness of personal risk behavior. This framework can be used for understanding situations in which people take deliberate actions to reduce health risks and describes the initiation of new behaviors in terms of progress through a sequence of qualitatively different stages [63]. The PAPM identifies seven stages in precaution taking (behavior change) along the full path from ignorance to action [46]. People first are unaware of a health issue (stage 1), then become aware of the issue without personal engagement (stage 2), further progress to the stage of deciding about acting (stage 3), resulting in a final decision to act (stage 5) or not (stage 4). Once in the acting phase (stage 6), people can progress to the maintenance phase (stage 7). To help people proceed through the different stages, the PAPM proposes personal feedback on ones own fat intake in comparison with dietary guidelines and normative feedback (feedback on own fat intake in comparison with fat intake of peers) as important strategies to improve awareness and motivation to change [46]. In addition, to translate motivation into actual behavior change, people may need to improve skills and self-efficacy, which may require action feedback, that is practical information on how to reduce fat intake and what to do in difficult situations [46].

From mass communication towards individualization

Given the fact that unhealthy dietary behaviors are present among large numbers of the population, effective nutrition education intervention strategies have to reach many people and should have an impact on those people. Health education approaches can be categorized in three levels: mass media, targeted and tailored to the individual.

Mass media interventions have been defined as those interventions that reach groups of individuals by using a medium other than personal contact, and offer a means to reach large numbers of people [64]. The content of mass media interventions is based on the average determinants of a population; meant for everyone, but no one in particular. Mass media is a relatively inexpensive method of exposing the population to health information, since they reduce personnel costs by minimizing face-to-face contact [65]. Mass media communication is good for agenda setting and improving knowledge and attitude, but generally it is not sufficient for actual behavior change [66].

On the next level there is targeted information. Targeting involves development of a single intervention approach for a defined population subgroup that takes into account characteristics shared by the subgroup's members [67]. These subgroups usually share certain demographical, cultural or psychological characteristics like sex, age, socio-economic status, ethnicity, or stages of change. For instance a brochure on the prevention of osteoporosis, which is especially present among the elderly, is adapted to meet the needs and preferences for adults of 55 years and older. The content of the messages is based on characteristics of the target group and graphics are adapted to the audience.

The third level is the individual approach like face-to-face counseling by a dietitian. Usually the individual approach has features that contribute most to the effectiveness of nutrition education interventions [60]. However, it is also the most expensive one, since it requires time and efforts of a professional. Furthermore, this strategy can often not be applied on a large enough scale to reach the 90% of the Dutch people in need of guidance to improve their dietary intake. Furthermore, not all people who may need to change their diets are motivated to participate in individual counseling or advice. With computer tailoring, individualized health education for relatively large target populations can be realized.

COMPUTER-TAILORED INTERVENTIONS

In the early 1990's it was recognized that many conventional health education materials, such as pamphlets and booklets, were designed to reach as wide an audience as possible. Consequently, the information provided was often lengthy and contained information irrelevant to many consumers. This problem could be tackled with the emerging computer technologies that allowed sophisticated tailoring of messages tailored to individual patients and free of irrelevant information. This resulted in the development of the first generation computer-tailored interventions [37, 68-71]. Tailoring health education messages is comparable with patient counseling in which a health professional (e.g. a dietitian) and a patient decide about a treatment plan (e.g. eating less saturated fat) based on the diagnosis made. Kreuter and colleagues defined tailored materials as "intended to reach one specific person, are based on characteristics that are unique to that person, are related to the outcome of interest, and have been derived from an individual assessment" [72, page 276]. In the last decades, several potentially important new channels for health communication have emerged, such as interactive computer programs and the Internet [73]. Using these media to deliver computer-tailored interventions may even reach more people.

The procedure of computer tailoring

In computer tailoring a number of important characteristics of interpersonal counseling are mimicked without the necessity of face-to-face contact [72].
Three components are necessary for generating computer-tailored nutrition education: 1) a diagnostic assessment tool to assess variables on which the tailored feedback would be based; 2) a message source file with feedback messages tailored to all possible screening results; and 3) a computer program that selects specific feedback messages for each individual subject from the source file based on the screening results. The diagnostic assessment necessary for personal feedback is done by means of written or electronic questionnaires and personalized feedback is provided in, for example, personal letters or on computer screens. A schematic overview of the process of computer tailoring is given in Figure 1.2.

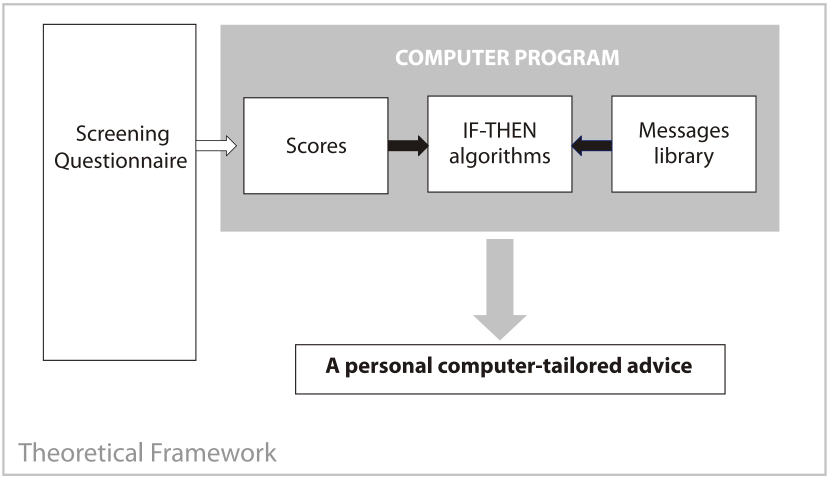


Figure 1.2. The process of computer tailoring

Computer-tailored physical activity and nutrition education can provide people with individualized feedback and advice on personal performance levels (i.e. activity or intake), and awareness of their own performance, as well as personal motivation to change, goals, outcome expectations, subjective norms, self-efficacy and/or other possible behavioral determinants [71, 72]. It has been argued that computer-tailored health education may be especially suited to promote physical activity and dietary changes, since people often lack personal awareness of performance levels for these complex health behaviors [47, 48, 71]. Computer tailoring is a good method to provide feedback on personal behavior, the most important strategy to improve awareness of one's own behavior. Computer tailoring enables easy and valid self-assessment and comparison of one's own performance to recommendations or peer group performance levels. And, since the expertise of the counselor, or in fact the pooled expertise of many counselors as well as the underlying behavior-change theories is documented in a computerized expert system, computer tailoring enables personalization of health education without the high costs of interpersonal counseling.

The effectiveness of computer tailoring

Computer-tailored nutrition education has been recognized as a very promising health education strategy for various behaviors [22, 74-77]. From the review presented in Chapter 2 of this thesis, it appeared that three out of eleven of the physical activity studies and twenty out of twenty-six of the nutrition studies found significant effects in favor of the tailored interventions mainly based on self-reported food consumption data [74].

Recall and reading of the computer-tailored interventions was found to be higher than non-tailored materials. The tailored materials were found to be better remembered, read and/or perceived as relevant compared to non-tailored materials [37, 39, 70, 78]. In addition, no difference in impact of computer-tailored fat-feedback on fat intake was found between educational groups. However, respondents with low education were more positive about how interesting and how personally relevant the tailored letters were [79].

Even though computer tailoring seems to be a very promising technique, several unanswered questions on why, where and for whom computer-tailored (nutrition) education is effective were identified by reviews on the effectiveness of computer-tailored education published between 1999 and 2006 [22, 74, 76].
First, it is not yet clear why tailored materials are more successful in influencing behavior than non-tailored materials. The question remains which elements and features of computer-tailored interventions are responsible for the effect. Second, we do not know if the second generation of computer tailoring, delivered by interactive media such as a CD-ROM or the Internet is as effective as the first generation print-delivered computer tailoring. Third, the evidence for computer-tailored interventions is based on self-reported outcome measures with all its disadvantages. What is the efficacy of computer-tailored nutrition education measured by means of more objective outcome measures? And fourth, there is lack of evidence on how the relatively small effects of computer-tailored interventions can be explained or improved. Answering these questions can help in improving the efficacy and applicability of computer-tailored (nutrition) interventions.

Working mechanisms of computer tailoring

Limited research has been directed toward investigations of why computer-tailored interventions are often more effective than generic information. To further develop tailored materials, their working mechanisms must be identified. Working mechanisms can be explored by looking at the characteristics of the tailored information and by looking at the psychological processes that are caused by the information [80]. Some studies explored what caused the effect of computer-tailored interventions by looking at differences in information processing (e.g. using, saving and discussing the information; perceived personal relevance) and examining associations between the unique characteristics of computer-tailored interventions (e.g. personalization, less-redundant information, feedback) and intervention effects [37, 42, 70, 80, 81]. Even though these findings are useful in opening the 'black box' of computer-tailored interventions, they do not give information on how we can optimize these interventions and make them more efficient. Insight into what content-related elements of computer-tailored feedback determine their effectiveness can guide us in the development of possibly shorter, more efficient tailored interventions [82].

Computer tailoring & Interactive media

Most of the evidence for the effectiveness of computer-tailored interventions is based on the first generation interventions, the paper and pen method. The field of computer tailoring is moving from the so-called first generation to the so-called second generation (interactive media) because of the many advantages of interactive media. In the last decades, several potentially important new channels for health communication have emerged, such as interactive computer programs [83], mobile technologies like mobile phones with text messaging and hand-held computers, interactive television, and maybe most importantly, the Internet with its World Wide Web and e-mail applications [42, 84-86]. The WWW can be used as a channel to easily distribute nutrition education information and to make nutrition education materials more available and accessible, and the WWW is a preferred source of health information for many consumers [87, 88].

Despite these promising characteristics, there is lack of empirical evidence on the merits of interactive computer tailoring. The few studies that have evaluated the effects of web-based or multi-media computer-tailored nutrition interventions targeting dietary intake have found mixed results [42, 43, 49, 89-92]. Most of these studies compare the effects of interactive media with no intervention or generic information. There are no studies that evaluated the effects of a print-delivered and an interactively delivered computer-tailored intervention in one study. There is a need for additional well-designed studies to evaluate the efficacy of interactive computer-tailored nutrition interventions compared to generic nutrition education and to print-delivered computer tailoring. Apart from differences in efficacy, there may also be differences in use and processing of print or interactively delivered interventions. Such differences are worth to explore, since this may guide the choice for interactive or print-format for particular groups.

Data of the 'Sociaal en Cultureel Planbureau' [93] show that the vast majority (>80%) owns a computer, except for the elderly aged 65 years or older, among that age group only 33% owns a computer. Also the majority of less educated persons owns a computer (70% in 2003). Internet access at home increased enormously, from 4% of the Dutch population in 1995 to 68% in 2003. Higher educated and higher income groups own a computer more often than lower educated or lower income groups and have more often access to Internet at home [93].

However, having a computer at home is not the same as actually using a computer and/or Internet. From data on computer and Internet use it appeared that elderly people (0.6 hours/week) and women (1.0 hours/week) spent considerably less time in using the computer than younger people (1.6 – 3.4 hours/week) and men (2.5 hours/week). Similar gender, age and educational differences were also found for Internet use. On average, half an hour was spent on using the Internet [93]. Finally, research showed that women, lower educated and elderly people have less digital skills than respectively men, higher educated and younger people [93].

It is important to pay attention to the differences in use of and skills for using computers and the Internet in choosing the right media channel for dissemination of interventions as attention to the message is one of the main conditions for effective nutrition education. We should make sure that socio-economically disadvantaged groups and other hard to reach populations that are in need of more healthy lifestyles will be reached by nutrition education, to prevent an increase of socio-economic health differences.

AIMS & OUTLINE OF THIS THESIS

The current thesis describes a series of studies in which important questions that have to be answered to better understand the effects, working mechanisms and applications of the computer-tailoring technique in the domain of nutrition have been addressed. The separate studies were conducted in one large trial. Respondents (n=764) who completed the screening questionnaire were randomly allocated to one of four computer-tailored feedback conditions or the control condition, receiving: 1) Personal-feedback in print format, 2) Personal-Normative feedback in print format, 3) Personal-Normative-Action feedback in print format, 4) Personal-Normative-Action feedback in interactive format or 5) generic information in print format. Outcome measurements were cognitions, self-reported dietary intake, blood lipids and process measures. This design enabled comparison of different delivery modes, differences in feedback topics, and different measures of effect. Different selections of study conditions were used to answer the different research questions.

Chapter 2 presents a systematic review on the effectiveness of computer-tailored interventions aimed at modifying dietary and physical activity behaviors. The purpose of the study in **chapter 3** was to identify the essential feedback elements (personal feedback, normative feedback, action feedback) for a computer-tailored intervention to be effective in improving awareness of ones own (saturated) fat intake, intention to reduce (saturated) fat intake and the actual reduction of (saturated) fat intake. **Chapters 4, and 5** deal with the effect and process evaluation of a web-based computer-tailored intervention aimed at reduction of saturated fat intake in comparison with an identical-content computer-tailored intervention delivered in print, and generic information. **Chapter 4** explores the efficacy of these interventions on self-reported dietary intake data. To gain further insight in the possible differences in efficacy and potential reach of interactive and print-delivered computer-tailored interventions **chapter 5** describes differences in use and appreciation of those interventions, taking into account specific target groups based on gender, age and educational level. To date, the effects of computer-tailored interventions have been mainly evaluated with self-reported dietary intake data. In **chapter 6** the efficacy of computer-tailored interventions aimed at the reduction of saturated fat intake were evaluated with blood lipids as objective outcome measures. **Chapter 7** explores habit strength as a factor associated with saturated fat intake, which may be a potential theoretical explanation of small effect sizes of interventions. Finally, the general discussion (**Chapter 8**) summarizes and integrates the results of the studies, discusses methodological and intervention related issues and provides implications for practice and suggestions for further research.

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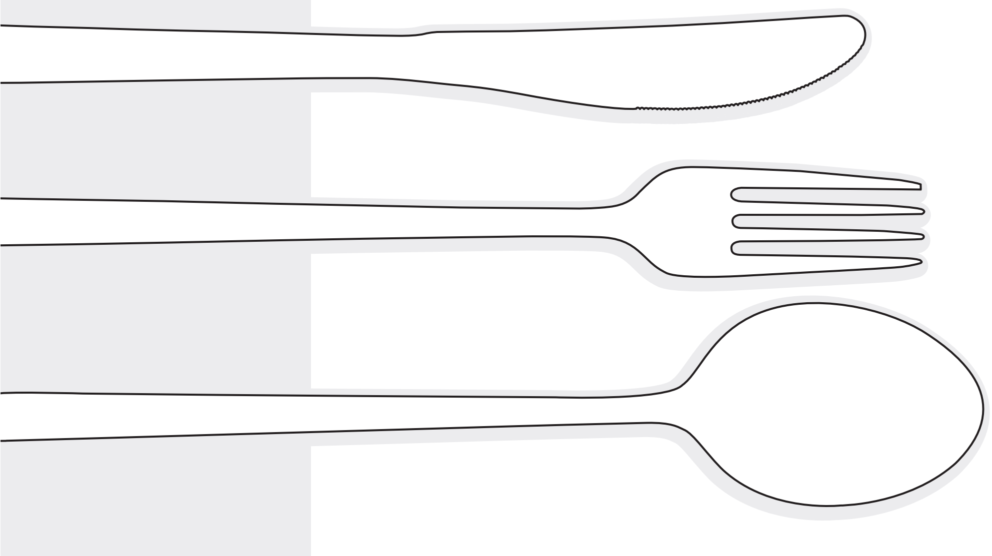
CHAPTER 2

A systematic review of randomized trials on the effectiveness of computer-tailored education on physical activity and dietary behaviors



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ABSTRACT

Background: Although computer-tailored promotion of dietary change and physical activity has been identified as a promising intervention strategy, there is a need for a more systematic evaluation of the evidence.

Purpose: The present study systematically reviews the scientific literature on computer-tailored physical activity and nutrition education.

Methods: Intervention studies published from 1965 up to September 2004 were identified through a structured search in PubMed, PsycInfo and Web of Science, and examination of reference lists of relevant publications. Studies were included that applied a pretest-posttest randomized-controlled trial design, were aimed at primary prevention among adults, used computer-tailored interventions to change physical activity and dietary behaviors, and were published in English. The search resulted in 30 publications; 11 on physical activity behaviors and 26 on nutrition behaviors, some studies investigated multiple behaviors.

Results: Three out of eleven of the physical activity studies and 20 out of 26 of the nutrition studies found significant effects of the tailored interventions. The evidence was most consistent for tailored interventions on fat reduction.

Conclusions: Overall, there seems to be potential for the application of computer tailoring for promoting healthy diets, but more research is needed to test computer-tailored interventions against other state-of-the-art intervention techniques and to identify the mechanisms underlying successful computer tailoring.

INTRODUCTION

Physical activity and nutrition are related to important burdens of disease [1, 2] such as obesity [3], cardiovascular diseases [4], diabetes mellitus and cancer [5]. Large proportions of the populations of many countries world-wide engage in too little physical activity [6-8] and have undesirable eating habits, such as high intakes of energy, salt and saturated fat and low intakes of fruits, vegetables and fiber [9, 10]. Therefore, there is a need for effective intervention strategies to motivate people to adopt healthier diets and to increase physical activity.

Many such attempts have been made [11-13], but not all have been successful. One promising intervention strategy is computer-tailored health education. In computer tailoring a number of important characteristics of interpersonal counseling are mimicked without the necessity of face-to-face contact [14]. The diagnostic assessment necessary for personal feedback is done by means of written or electronic questionnaires and personalized feedback is provided in, for example, personal letters or on computer screens. Detailed descriptions of the development of computer-tailored information can be found elsewhere [14-17].

Since the expertise of the counselor, or in fact the pooled expertise of many counselors as well as the underlying behavior-change theories is documented in a computerized expert system, computer tailoring enables personalization of health education without the high costs of interpersonal counseling. Computer-tailored physical activity and nutrition education provides people with individualized feedback and advice on personal performance levels (i.e. activity or intake), and awareness of their own performance, as well as personal motivation to change, goals, outcome expectations, subjective norms, self-efficacy and/or other possible behavioral determinants [14, 17]. It has been argued that computer-tailored health education may be especially suited to promote physical activity and dietary changes, since people often lack personal awareness of performance levels for these complex health behaviors [18, 19]. Computer tailoring enables easy and valid self-assessment and comparison of one's own performance to recommendations or peer group performance levels.

Not only because of the features of computer tailoring mentioned above, but also because of its applicability in electronic non-print media (like the world wide web or computer kiosks), enabling wide distribution against relatively little costs, it is contemplated as a promising health education strategy [15, 20].

Although computer-tailored promotion of dietary change and physical activity has been identified as a promising intervention strategy [21-23], there is a need for a more systematic evaluation of evidence for the effectiveness of this intervention approach. The present study, therefore, systematically reviews the scientific literature on expert-driven computer-tailored physical activity and nutrition education.

METHODS

We developed and used a study protocol based on guidelines extracted from the Cochrane Reviewers' Handbook [24]. In the study protocol the procedures to identify primary studies based on eligibility criteria, and relevant study- and intervention characteristics were made explicit. WK and AW independently reviewed the articles and extracted general information on objectives, design, intervention characteristics and outcomes. Disagreements were discussed with JB until consensus was reached.

Search strategy and Data sources

Intervention studies published from 1965 up to September 2004 were identified through a structured electronic database search in PubMed, PsycInfo and Web of Science.
The following search strings were used for interventions on nutrition: (((nutrition OR feeding OR food OR diet OR dietary OR intake) AND (education OR behavior OR behavio*)) OR feeding behavior OR food consumption) AND (tailored OR tailoring OR tailor* OR expert system). For physical activity: ((exercise OR motor activity OR leisure activities OR physical activity OR physical activit*) AND (education OR behavior OR behavio*) AND (tailored OR tailoring OR tailor* OR expert system)). These search strings were further limited to the adult age (18 years and older). Furthermore, reference lists of relevant publications that were found through the computerized searches were examined.

Selection of studies

For inclusion in this review the studies had to examine a computer-tailored intervention aimed at physical activity or nutrition behaviors in primary prevention. Primary prevention was defined as the initiation of lifestyle or behavioral changes to prevent the onset of chronic diseases in apparently healthy subjects. Only randomized controlled trials with pretest and posttest were included. Furthermore, this review is restricted to studies among adults and to publications in the English language.
We used the definition suggested by Kreuter, Strecher & Glassman [14, page 276]: Tailored materials are "intended to reach one specific person, are based on characteristics that are unique to that person, are related to the outcome of interest, and have been derived from an individual assessment". We did not include studies that evaluated targeted generic materials, defined as "intending to reach some specific subgroup of the general population usually based on one or more demographic characteristics shared by its members". We considered studies computer-tailored, if the tailored advice was generated through a computerized process. Furthermore, the information had to be delivered in a 'non-personal' way (printed

format, direct interaction with computer or other media device) without person-to-person interference of a counselor.
Studies that tested the tailored intervention as part of a larger generic strategy or combined it with interpersonal counseling in a research design that made it impossible to isolate the effect of tailoring in the analysis were excluded.

Data extraction

Detailed information was extracted only from studies that met the aforementioned inclusion criteria. WK and AW independently summarized the studies for content and methods. We extracted intervention and study characteristics, as well as effect indicators.
Specific intervention characteristics that have been identified previously by health education experts as being associated with behavior change (through computer tailoring) interventions were extracted [15, 17, 25]. These characteristics included: theories used for intervention development, the variables that were used to tailor the computer-tailored information, the feedback tool, the frequency of feedback, and health-education activities that were provided next to the computer-tailored intervention.
To review the characteristics of the evaluation studies, we extracted the following information: the country where the study was conducted, size and source of the study population, eligibility criteria, comparison group, the primary outcome measures, and follow-up period.
Finally, in order to interpret and compare results from different outcome measures better, we calculated effect sizes (ESs) when data were available according to the formula suggested by Cohen [26] and applied by Dolan and colleagues [27]. Effect sizes were interpreted according to Cohen's guidelines [26] with cut-off points of 0.2-0.5 for small effect size, 0.5-0.8 for moderate effect size and > 0.8 for large effect size.
Measurement periods were divided into three categories: short-term (< 3 months), medium-term (3 – 6 months) and long-term (> 6 months). When two measurements within one defined category were included in one study, only the results of the last measurement in that category were included in this review. We summarized the main findings separately for physical activity, for the two categories of dietary behavior that have been addressed most often in computer tailoring studies: fat intake, and fruit and vegetable consumption, and for remaining dietary topics less frequently addressed.
Reviewers were not blinded to authorship, journal, or other information in the study, but assessment of publications was done based on criteria defined a priori. The heterogeneity of the included studies hindered the pooling of data. Our findings, therefore, resulted in a descriptive systematic literature review. Studies varied, among others, in recruitment method, characteristics of the study population, time frame, setting, measurement of effects, and intervention goals.

RESULTS

Study Selection

The initial cross-database search yielded 693 publications. After eliminating duplicates and reviewing the titles and abstracts of all these publications, the total amount was reduced to 72. Checking references in these papers identified another 24 references and two were brought up by colleagues. After completely reviewing the 98 articles, 68 publications were excluded because they did not meet one or more of the inclusion criteria. Almost half of the excluded publications turned out not to be effect evaluation studies of computer tailoring, either they were design papers or theoretical papers or just recommended tailoring of health education in their discussion section. Other important reasons for exclusion were that the intervention was group targeted rather than individually tailored or that the intervention was not fully computerized. Finally, some studies applied a computer-tailored intervention in a package with several other educational strategies that hampered the isolation of the tailoring effect. Definite inclusion in the review followed after agreement among all authors about meeting the inclusion criteria. Thus, 30 publications were included, 11 on physical activity behaviors and 26 on dietary behaviors. Two of these publications were on a single physical activity study [28, 29] and two publications were on the same weight-loss study [30, 31]. In several publications more than one behavior of interest for this review was addressed.

Data Extraction

The characteristics of the reviewed tailored interventions are summarized in the next paragraph. Table 2.1 shows an extensive overview of the intervention characteristics. The study characteristics and results are shown in Table 2.2. The results and characteristics of studies on physical activity can be found in section A of that same table. Within the diet category a further distinction was made between studies aimed at fat reduction (section B, Table 2.2), studies aimed at fruit and vegetable promotion (section C, Table 2.2), and other diet related studies (section D, Table 2.2). Finally, we explored differences in the effects of single-component interventions studies versus multiple-component interventions in Table 2.3.

Intervention characteristics

Eleven studies investigated a computer-tailored intervention aimed at promoting physical activity [28-38], 20 studies at decreasing fat intake [30, 33-36, 39-52], and 14 at effects on increasing fruit and vegetable intake [33, 39-44, 47, 50-55]. Five studies dealt with fiber intake [39, 50-52, 56], one with calcium intake [32] and two studies with weight loss [31, 36]. Many of these studies investigated interventions that addressed more than one health behavior, especially combinations of dietary behaviors.

The interventions used in the studies were sometimes very similar and closely related. For example Bock et al [28] and Marcus et al [29] report on the same intervention, and the same evaluation study, but on different measurement periods. The study reported by De Bourdeaudhuij and colleagues [45], was based on the intervention reported by Brug et al [40], but was adapted for use in a Belgian population. Furthermore, the intervention reported by Brug et al [41] was very similar to their 1996 intervention [40] but enriched with a second follow-up computer-tailored feedback tool. Anderson and colleagues [39] and Winett et al [52] both used the same intervention, which was an adapted version of the interventions used by Winett and colleagues in different studies in the late eighties and early nineties [49-51]. Most of the interventions were explicitly informed by one or more behavioral theories. The Trans Theoretical Model [57], Social Cognitive Theory [58] and the Theories of Reasoned Action and of Planned Behavior [59] were used most often.

All interventions gave tailored feedback on the current behavior of the respondents. One physical activity intervention [32] and five of the dietary interventions [32, 40, 41, 45, 55] provided feedback on the participant's awareness of own performance. Most interventions also gave feedback on intentions (stage of change or readiness to change) and self-efficacy. Furthermore, variables like knowledge, outcome expectations, and benefits and barriers of changing a behavior were used for providing further tailored information.
Almost all interventions were delivered by means of computer-tailored letters, pamphlets or brochures. Two physical activity studies [35, 36] and nine dietary interventions [35, 36, 39, 44, 47, 50, 52, 55, 60] used computers not only to generate the messages but also to deliver the tailored information, often with the possibility of an additional print-out. Four of these computer-delivered interventions used multimedia (text and video) [44, 47, 52, 60]. None was implemented through the Internet.

Most interventions used single contacts, i.e. one tailored letter, brochure or interactive feedback moment. Five of the physical activity intervention studies used multiple feedback, ranging from two [32] to four [28, 29, 33]. In the fifth study [36] the respondents determined the frequency of feedback moments themselves, however the mean or range of feedback frequency was not reported. Thirteen of the dietary-change studies used multiple feedback, ranging from two [32, 41, 44, 46] to fifteen [39].

Study characteristics

Most of the studies were conducted in the USA, three in The Netherlands, two in Belgium, two in the UK and one in Australia.
Study populations usually consisted of healthy volunteers without a prescribed diet, recruited from the general population, through worksites or through health-maintenance organizations and general practices. Study population size varied from 84 to 1317 participants.

Table 2.1: Intervention characteristics

1st author	Intervened behavior(s)	Theories[a]	Tailoring variables	Tools	Feedback frequency	Additional strategies / Notes
Section A: Physical activity (PA)						
Blalock 2002 [32]	Exercise	PAPM	1st information packet Exercise level Perceived adequacy of exercise level Stage of change 2nd information packet based on telephone session Behavioral goals Behavioral contract(s) Potential barriers	Information packets	2	Telephone counseling three weeks after receiving first packet aimed at goal setting, behavioral contracting, identifying potential barriers to change and relapse prevention strategies
Bock 2001 [28]	Physical activity	Decisional Balance Theory SCT TTM	Report 1 Readiness to change Self-efficacy Decisional balance Report 2, 3 and 4 Identical to report 1 + progress in PA participation	Feedback reports	4	Self-help stage-matched manuals on use of cognitive and behavioral processes associated with PA adoption
Bull, Jamrozik 1999 [37]	Physical activity	SCT TTM	Preferred type of PA Stage of change Self-efficacy Benefits of regular exercise Three most important barriers for exercise Gender	Two page, double-sided pamphlet	1	Verbal advice for 2-3 minutes from family physician in tailored and control group
Bull, Kreuter 1999 [38]	Physical activity	Goal setting TTM	Stage of change Preferred type of PA Motives for and perceived barriers Exercise goal	Letter	1	-
Bull 2001 [31]	Physical activity	ELM TRA	Physical activity Learning style Preferred media Motives for losing weight Goal setting Self-efficacy Beliefs Barriers Triggers Body Mass Index (kg/m^2) Gender	Booklet	1	-

1st author	Intervened behavior(s)	Theories[a]	Tailoring variables	Tools	Feedback frequency	Additional strategies / Notes
Campbell, James 2004 [33]	Physical activity	HBM TTM SCT Social support models	Physical activity Stage of change Social support Barriers Beliefs Age Gender	Newsletter	4	Newsletters were further targeted to issues relevant to participants' church Videotapes (four) targeted at participants' church
Kreuter 1996 [34]	Physical activity	HBM Relapse Prevention Model TTM	Risk status Stage of change Past attempts and failures to change Reasons for wanting to change Self-efficacy Perceived health risks and benefits Perceived barriers Demographics	Letter	1	The intervention aims at several risk behaviors
Kreuter 2000 [30]	Physical activity	ELM TRA	Physical activity Learning style Preferred media Motives for losing weight Goal setting Self-efficacy Beliefs Barriers Triggers Body Mass Index (kg/m^2) Gender	Booklet	1	-
Marcus 1998 [29]	Physical activity	Decisional Balance Theory SCT TTM	Report 1 Readiness to change Self-efficacy Decisional balance Report 2, 3 and 4 Identical to report 1 + progress in PA participation	Printed reports	4	Self-help stage-matched manuals on use of cognitive and behavioral processes associated with PA adoption
Vandelanotte 2005 [35]	Physical activity	TPB TTM	Physical activity Intentions Knowledge Attitude Social support Self-efficacy Perceived benefits Perceived barriers	On screen and printout	1	-

1st author	Intervened behavior(s)	Theories[a]	Tailoring variables	Tools	Feedback frequency	Additional strategies / Notes
Wylie-Rosett 2001 [36]	Physical activity	TTM	Physical activity Previously set goals Readiness to change Self-efficacy for exercise Barriers to lifestyle change	Touch screen computer	1 – 12	Workbook
Section B: Diet						
Anderson 2001 [39]	Fat intake Fiber intake Fruit and vegetable intake	SCT	Intake Food purchases Self-efficacy Outcome expectations	Touch screen computer in supermarket	15	Price reduction coupons
Baker 2002 [53]	Fruit and vegetable intake	TTM	Intake Stage of change Knowledge of recommendations Two most negative attitudes	Two page leaflet	1	-
Blalock 2002 [32]	Calcium intake	PAPM	1st information packet Intake Perceived adequacy of calcium intake Stage of change 2nd information packet based on telephone session Behavioral goals Behavioral contract(s) Potential barriers	Information packets	2	Telephone counseling three weeks after receiving first packet aimed at goal setting, behavioral contracting, identifying potential barriers to change and relapse prevention strategies
Brinberg 2000 [56]	Fiber intake	BAM	Intake Consumption frequency of preferred foods Individualized goals Fiber content of favorite foods Dietary recommendation	Brochure	1	30-minutes session with nutrition educator to explain brochure
Brug 1996 [40]	Fat intake Fruit and vegetable intake	SCT TPB TTM	Intake Awareness of intake Low self-efficacy expectations to recognize low-fat alternatives and to sustain a low-fat diet Outcome expectancies	Letter	1	-

1st author	Intervened behavior(s)	Theories[a]	Tailoring variables	Tools	Feedback frequency	Additional strategies / Notes
Brug 1998 [41]	Fat intake Fruit and vegetable intake	SCT TPB TTM	<u>Initial feedback</u> Intake Awareness of intake Most important fat sources Low self-efficacy expectations in high-risk situations Most prevalent and salient negative beliefs about eating less fat <u>Iterative feedback</u> Change in intake Change in intention Most important fat sources	Letter	1 or 2	-
Bull 2001 [31]	Fat intake		Diet Learning style Preferred media Motives for losing weight Goal setting Self-efficacy Beliefs Barriers Triggers Body Mass Index (kg/m^2) Gender	Booklet	1	-
Campbell 1994 [42]	Fat intake Fruit and vegetable intake	HBM TTM	Intake Stage of change Level of interest in changing Self-efficacy Beliefs on susceptibility to diet related diseases, perceived benefits of and motives for changing diet Barriers	Leaflet	1	-
Campbell, Bernhardt 1999 [43]	Fruit and vegetable intake	TTM	Intake Stage of change Social support Perceived benefits Perceived barriers Perceived risk of cancer	Eight-page booklet	1	Part of cancer-screening program

1st author	Intervened behavior(s)	Theories[a]	Tailoring variables	Tools	Feedback frequency	Additional strategies / Notes
Campbell, Honess-Morreale 1999 [60]	Fat intake	SCT TTM	Intake Breastfeeding/pregnancy status Stage of change Knowledge of low-fat food choices Perceived weight	Computer kiosk with a computer-based intervention consisting of a video soap opera with interactive 'info-mercials' with tailored nutrition feedback	1	Recipe book after completing the program or as an incentive for control group participants
Campbell, Carbone 2004 [44]	Fat intake Fruit and vegetable intake	SCT TTM	Intake Stage of change to decrease fat intake Knowledge Self-efficacy Strategies to improve eating habits Strategies to decrease fat intake focused on problem foods (dairy, meats or snacks) Breastfeeding/pregnancy status Demographical variables Interest in weight control	Video soap opera with tailored feedback 'breaks' Info-mercials on participant's knowledge Take – home print materials (dietary feedback)	2	
Campbell, James 2004 [33]	Fat intake Fruit and vegetable intake	HBM TTM SCT Social support models	Intake Stage of change Social support Barriers Beliefs Age Gender	Newsletter	4	Newsletters were further targeted to issues relevant to participants' church Videotapes (four) targeted at participants' church
De Bourdeau-dhuij 2000 [45]	Fat intake	SCT TPB TTM	Intake Awareness of intake Intention to reduce fat intake Attitude toward fat reduction Perceived support toward fat reduction Self-efficacy toward fat reduction	Letter	1	-
Greene 1998 [46]	Fat intake	TTM	Intake Fat reduction behaviors	Report	1 or 2	Tailored feedback at baseline, and feedback report after 12 months
Irvine 2004 [47]	Fat intake Fruit and vegetable intake	HCT SCT TRA TTM	Intake Eating habits Eating strategies Barriers to healthy eating Skills Demographic characteristics	Interactive multimedia program on computer	1	Optional recipes

1st author	Intervened behavior(s)	Theories[a]	Tailoring variables	Tools	Feedback frequency	Additional strategies / Notes
Kreuter 1996 [34]	Fat intake	HBM TTM RPM	Risky health related behaviors 10-year mortality risk Health status indicators Stage of change Reasons for wanting to change Perceived health risks and benefits Self-efficacy Past attempts and failures to change Perceived barriers Demographics	Letter	1	The intervention aims at several risk behaviors
Kreuter 2000 [30]	Fat intake	ELM TRA	Diet Learning style Preferred media Motives for losing weight Goal setting Self-efficacy Beliefs Barriers Triggers Body Mass Index (kg/m^2) Gender	Booklet	1	-
Lutz 1999 [54]	Fruit and vegetable intake	Group A TTM HBM SCT Group B Identical to group A + Goal Setting Theory	Group A Intake Eating behaviors Readiness to change Self-efficacy Perceived benefits and barriers Specific characteristics, i.e. eating out or not Group B Identical to group A + tailored sub-goals	Newsletter	4	-
Oenema 2005 [55]	Fruit and vegetable intake Saturated fat intake	PAPM SCT TPB	Intake Awareness Stage of change Normative and peer comparison Self-efficacy Implementation intentions	On screen and/or printout	1	Optional recipes
Raats 1999 [48]	Fat intake	TPB TTM	Intake Recommendations for fat intake	Letter	1	-

1st author	Intervened behavior(s)	Theories[a]	Tailoring variables	Tools	Feedback frequency	Additional strategies / Notes
Vandelanotte 2005 [35]	Fat intake	TPB TTM	Intake Intentions Knowledge Attitude Self-efficacy Social support Perceived benefits Perceived barriers	On screen and printout	1	-
Winett 1988 [49]	Fat food purchase Fiber food purchase	Modeling Communication Strategies	Weekly food purchases Percentage breakdown from baseline figures Norms according to NCI goals Evaluative statements for change relative to the goals for each nutrient and monetary expenditure	Written report	7	-
Winett, Moore 1991 [50]	Fat food purchase Fiber food purchase Fruit and vegetable intake	Communication principles HBM SCT	Intended purchases Suggested substitutes for high-fat products Suggested substitutes for low-fiber products Praise of new purchases	Printed on initial shopping list	6	-
Winett, Wagner 1991 [51]	Fat food purchase Fiber food purchase Fruit and vegetable intake	Modeling Communication Strategies	Intended purchases Suggested substitutes for high-fat products Suggested substitutes for low-fiber products Praise of new purchases	On screen and printout	4	-
Winett 1997 [52]	Fat food purchase Fiber food purchase Fruit and vegetable purchase	TPB TTM	Purchases	Multimedia on screen and/or printout	14	Reduction coupons for low-fat or high-fiber products
Wylie-Rosett 2001 [36]	Fat intake	TTM	Intake Readiness to change Dietary knowledge Dietary self-efficacy Barriers to lifestyle change	Touch screen computer	1 - 12	Workbook Staff consultation in closed-group workshops

[a]BAM = Behavioral Alternatives Model; ELM = Elaboration Likelihood Model; HBM = Health Belief Model; HCT = Health Communication Theory; PAPM = Precaution Adoption Process Model; RPM = Relapse Prevention Model; SCT = Social Cognitive Theory; SLT = Social Learning Theories; TPB = Theory of Planned Behavior; TRA = Theory of Reasoned Action; TTM = Transtheoretical Model

Three studies promoting physical activity recruited only sedentary respondents [28, 29, 37], while two studies were specifically aimed at participants who were overweight [30, 36]. Age [32] and motivational stage [37] were further eligibility criteria used in the physical activity promotion studies. Some of the fat-reduction studies also used additional eligibility criteria such as income [60], gender [32, 44], ethnicity [33, 43], household characteristics [45, 51], health behaviors [46], or body-weight status [30, 36]. Three of the fruit and vegetable promotion interventions had specific eligibility criteria, such as age [53], gender [44] and ethnicity [33, 43].

Effects on physical activity (section A, Table 2.2)

Physical activity was measured with different questionnaires, varying in length from 3-31 items. In about half of the studies the use of validated questionnaires was explicitly mentioned.

Three studies looked at short-term effects [29, 30, 37]; one found a significant tailoring effect [29]. Five studies assessed medium-term effects [29, 32, 35, 37, 38]; two studies reported significant differences in favor of the tailored intervention for respondents who were not physically active at baseline [29, 35]. However, effects in favor of the control group were also found [32, 35]. Six studies conducted long-term measurements [28, 32-34, 36, 37]; one found a significant effect of tailoring with a small effect size.

Effects on fat consumption (section B, Table 2.2)

Almost all studies measured fat consumption with a validated food frequency questionnaire (FFQ). Many of the studies conducted in the USA used the FFQ developed by Block and colleagues [61], all studies conducted in the Netherlands used the FFQ designed by Van Assema and colleagues [62, 63], and the three studies conducted in Belgium used an adapted version of the FFQ developed by Feunekes et al [64] that was further validated for use in a Belgian population [65]. The FFQs consisted of 16 – 60 items to measure dietary fat intake and enabled calculation of percentage of energy from fat or total fat intake, either a fat-score or grams of fat. Two studies used a so-called 'Dietary Habit Questionnaire' [30, 47], one study used a 7-day food record [48] and four studies used shopping receipts [39, 50-52] to assess fat intake. Most studies reported on total fat, while some studies reported on saturated fat intakes [42, 45, 49] and only one study assessed intake of unsaturated fat [45].

Eleven of the 14 fat-reduction studies that tested short-term effects, showed a significant effect in favor of the tailored interventions. Of the eleven studies, six compared the tailored intervention with no intervention [39, 47, 50-52, 60] and four compared tailoring with generic information [30, 40, 41, 45]. In all six studies that allowed calculation of effect size (ES) at short-term a small ES was found. Winett et al [52] also found a moderate ES for cooking-fats and a large ES for fat from dairy products. Five of the seven studies testing medium-term effects found a significant effect in favor of the tailored intervention compared to no-intervention comparison groups [35, 39, 42, 46, 52]. Most of the calculated ESs were small, but Winett et al [52] also found a large ES for changes in fat from dairy foods. The two studies on long-term follow-up, did not find a significant effect on fat intake [36, 46].

Effects on fruit and vegetable consumption (section C, Table 2.2)

Fruit and vegetable consumption was also typically measured with validated FFQs; many of the studies conducted in the USA used the FFQ developed by Block and colleagues [61]. The Dutch studies used the FFQ validated by Van Assema and colleagues [66] and Bogers et al [67]. The number of items in the FFQs varied between two and seventeen. Fruit and vegetable consumption was quantified by the number of servings per day. Two studies quantified fruit and vegetables by purchased daily servings/ 1000 kcals [39, 52].

Ten studies measured short-term intervention effects. In six studies a significant effect on fruit and vegetable consumption (combined and/or separately) in favor of the tailored intervention group was found, five in comparison with no intervention [39, 47, 52, 53, 55] and two in comparison with generic information [41, 55]. Calculated ESs were small [39, 41]. Four out of five studies testing medium-term effects found a significant difference in favor of the tailored intervention compared to no intervention with small ESs, but only on the combined fruit and vegetable-outcome [39, 43, 52, 54]. Two studies that reported long-term effects [33, 43] found a significant tailoring effect.

Effects on other diet-related behaviors (section D, Table 2.2)

Fiber intake was measured with a variety of methods, though all validated. The one study on calcium intake used a validated self-report instrument as well. Weight loss was measured with self-reported weight-loss behavior.

Significant positive short-term effects for fiber intake (or fiber-rich products) were found in three studies [39, 50, 52] out of a total of four studies testing short-term effects. The calculated ESs from Anderson et al [39] and Winett et al [52] were moderate. The three studies testing medium-term effects found significant differences in favor of the tailored intervention group [39, 52, 56], with moderate ESs reported by Anderson et al. [39].

Effects on calcium intake were not significant, neither at medium- or long-term [32]. At short-term Bull and colleagues [31] did not find a significant effect on the self-reported item 'use of weight loss behavioral suggestions'. Wylie-Rosett and colleagues [36] found a significant long-term effect on weight loss with a small ES.

Effects of single -component and multi -component studies

From the 15 studies on fat intake, 10 also addressed other dietary behaviors, and 3 of the 14 studies on fruits and vegetables also included at least one other dietary behavior. Although

Table 2.2: Study characteristics and effects

1st author	Country	Study population (N)	Tailoring compared to	Validated measure	Outcome measurement instruments	Outcome measurement units	Results[1] and Effect Sizes[2] at short-, medium- or long-term[3]
Section A: Physical activity (PA) promotion							
Blalock 2002 [32]	USA	Women (714), 40-56 yrs, recruited from the general population	Generic info	?	Self-report on type, frequency and duration of PA	Total number of hrs/wk engaged in weight-bearing exercise activities	No significant effects at medium- or long-term in unengaged participants Significant adverse effect at medium-term and no significant effect at long-term in engaged participants No significant effects at medium- or long-term in participants in action
Bock 2001 [28][4]	USA	Sedentary participants (120) recruited from the general population	Generic info	Yes	Self-report adapted from the 7-day PA recall questionnaire [91]	Total PA (min/wk)	No significant effect at long-term
Bull, Jamrozik 1999 [37]	AUS	Sedentary participants (658) recruited from family practices	Generic info	Yes	Assessment (3-item) derived from the National Heart Foundation of Australia Risk Factor Prevalence Survey [1991]	Total time spent exercising in previous 2 weeks	No significant effects at short-, medium- or long-term
Bull, Kreuter 1999 [38]	USA	Participants (203) in contemplation or preparation stage who have set a PA goal, without contra-indications for PA, recruited from primary care practices	No info Generic info	?	Number of days / week on which participants spent at least 30 min divided in 8 PA categories	Leisure Time Activity score (LTAs) PA of daily living score (PADLs) Total Activity (sum of LTAs and PADLs)	No significant effect at medium-term Note: Tailoring was compared with the no info and generic info groups combined
Campbell, James 2004 [33]	USA	Church members (587) of African-American churches in rural area	No info	Yes	16-item questionnaire derived from existing instruments and modified for cultural appropriateness	MET hours/week	Significant effect at long-term for recreational activity (moderate + vigorous) ES[7] at long-term: 0.32 No significant effect for total PA

1st author	Country	Study population (N)	Tailoring compared to	Validated measure	Outcome measurement instruments	Outcome measurement units	Results[1] and Effect Sizes[2] at short-, medium- or long-term[3]
Kreuter 1996 [34]	USA	Participants (674) recruited from family medical practices	No info	?	1 item	Engaging in regular aerobic exercise	No significant effect at long-term
Kreuter 2000 [30]	USA	Overweight participants (198) interested in losing weight recruited from the general population	Generic info	?	1 item	Frequency of moderate PA for 30 minutes or more	No significant effect at short-term
Marcus 1998 [29][4]	USA	Sedentary participants (150) recruited from the general population	Generic info	Yes	Self-report adapted from the 7-day PA recall questionnaire [91]	Total PA (min/wk)	Significant effect at short- and medium-term ES at medium-term: 0.42
Vandelanotte 2005 [35]	B	Participants (771) recruited from the general population	No info	Yes	31-item IPAQ [92]	Total PA (min/wk)	<u>Results in the total population</u>[5] Significant adverse effect at medium-term for total PA No significant effect on moderate + high intensity PA at medium-term ES for total PA: -0.01 <u>Results for the population not meeting PA recommendations</u> Significant effect at medium-term for total PA No significant effect on moderate + high intensity PA at medium-term ES for total PA: 0.02
Wylie-Rosett 2001 [36]	USA	Participants (280) with BMI > 25 kg/m^2 or BMI > 24 kg/m^2 + 1 risk factor for cardiovascular diseases, recruited from health maintenance organizations and the general population	Self-help workbook[6]	?	Self-report adapted from Paffenbarger *et al* [93]	Walking time Number of blocks walked and stairs climbed	No significant effects at long-term
Section B: Fat reduction							
Anderson 2001 [39]	USA	Participants (277; 163 participants left at medium-term) recruited among supermarket customers	No info	?	Block 95 FFQ [94] Shopping receipts	% kcal from daily fat intake	<u>Results measured with FFQ</u> Significant effect at short-term and at medium-term ES at short-term: -0.36 ES at medium-term: -0.38 <u>Results measured with shopping receipts</u> Significant effect at short-term ES at short-term: -0.25

1st author	Country	Study population (N)	Tailoring compared to	Validated measure	Outcome measurement instruments	Outcome measurement units	Results[1] and Effect Sizes[2] at short-, medium- or long-term[3]
Brug 1996 [40]	NL	Participants (347) recruited from worksites	Generic info	Yes	25-item FFQ covering 12 (groups of) food products [62]	Fat score	Significant effect at short-term among the total population and among participants not meeting recommendations ES at short-term among total population: - 0.06 ES at short-term among risk consumers: - 0.25
Brug 1998 [41]	NL	Participants (646) recruited from the general population	Generic info	Yes	25-item FFQ covering 12 (groups of) food products [62]	Fat score	<u>Single computer-tailored feedback compared to generic info</u> Significant effect at short-term ES at short-term: -0.24 Iterative computer-tailored feedback compared to generic info Significant effect at short-term ES at short-term: -0.37
Campbell 1994 [42]	USA	Participants (394) recruited from family medical practices	No info Generic info	Yes	13-item FFQ derived from Health Habits and History questionnaire assessing fat intake [59] and 5 additional items on high-fat foods consumed in southern US	Total fat (g/day) Saturated fat (g/day)	<u>Compared to no info</u> Significant effect at medium-term on total and saturated fat ES[7] at medium-term total fat: - 0.22 ES[7] at medium-term saturated fat: - 0.22 Note: tailoring versus generic info was not tested
Campbell, Honess-Morreale 1999 [60]	USA	Low-income women (378) recruited among Food Stamp Program participants	No info	Yes	16-item FFQ derived from Block *et al* [61, 95] and 2 additional items on low-fat foods	Fat (g/day)	No significant effect at short-term for fat intake Significant effect at short-term for eating meat baked in oven and eating low-fat snacks
Campbell, Carbone 2004 [44]	USA	Women (306) receiving benefits for themselves or their child(ren) from the 'Special Supplemental Nutrition Program for Women, Infants and Children'	No info	Yes	25-item fat, fruit, vegetable and fiber screener [96]	Fat (g/day)	No significant effect at short-term

1st author	Country	Study population (N)	Tailoring compared to	Validated measure	Outcome measurement instruments	Outcome measurement units	Results[1] and Effect Sizes[2] at short-, medium- or long-term[3]
Campbell, James 2004 [33]	USA	Church members (587) of African-American churches in rural area	No info	Yes	60-item FFQ [61]	Total fat Fat (en%)	No significant effect at long-term
De Bourdeaudhuij 2000 [45]	B	Participants (140) from 2-parent families with at least 2 adolescents, recruited from the general population	Generic info	Yes	56-item FFQ derived from Feunekes *et al* [64]	Total fat, saturated fat, mono-unsaturated fat, poly-unsaturated fat in % of total energy intake	Results at short-term for mothers Significant effect on total fat intake, saturated fat intake and mono-unsaturated fatty acids No significant effect on poly-unsaturated fatty acids Results at short-term for fathers No significant effects
Greene 1998 [46]	USA	Non-smoking participants (296) with fat intake > 30 en% recruited from the general population	No info	Yes	46-item FFQ derived from Kristal *et al* [97] 24-item Dietary Behaviors [97, 98]	Fat (en%) Dietary behavior	Significant effect at medium-term No significant effects at long-term
Irvine 2004 [47]	USA	Participants (463) recruited from worksites	No info	Yes	21-item Diet Habits Questionnaire [97]	Fat eating habits/ behaviors	Significant effect at short-term for fat eating behaviors ES at short-term: -0.49
Kreuter 1996 [34]	USA	Participants (1317) recruited from medical practices	No info	Yes	18-item FFQ derived from Block *et al* [61, 95]	Fat (g)	No significant effect for risk consumers motivated to change at medium-term
Kreuter 2000 [30]	USA	Overweight participants (198) interested in losing weight, recruited from the general population	Generic info	?	Actual dietary habits, e.g. use of diet or reduced-calorie foods)	Choosing low-fat alternatives Choosing meals low in fat Eating smaller portions Cutting calories	Significant effect at short-term on choosing low-fat alternatives
Oenema 2005 [55]	NL	Participants (616) recruited at factories, institutes for health and social care and local government institute	No info Generic info	Yes	35-item FFQ	Fat score	No significant effect at short-term for computer-tailored feedback versus both comparison groups for total group, for those not meeting the recommendations at baseline, nor for those unaware of personal intake at baseline

1st author	Country	Study population (N)	Tailoring compared to	Validated measure	Outcome measurement instruments	Outcome measurement units	Results[1] and Effect Sizes[2] at short-, medium- or long-term[3]
Raats 1999 [48]	UK	Participants (115) recruited from university staff	No info	Yes	7-day Food and drink diary UK Nutrient Databank	Total fat (en%)	No significant effect at short- or medium-term in the total population No significant effect at short- or medium-term in the population that is unaware of own consumption and not meeting recommendations
Vandela-notte 2005 [35]	B	Participants (771) recruited from the general population	No info	Yes	48-item FFQ [65]	Fat (g/day)	Results at medium-term Significant effect on fat intake measured as g/day and measured as en% for total population and for the population not meeting recommendations ES fat g/day for total population: -0.29 ES fat en% for total population: -0.33 ES fat g/day for risk consumers: -0.49 ES fat en% for risk consumers: -0.51
Winett 1988 [49]	USA	Primary shoppers of a household (126) recruited from the general population	Video-Modeling[6] Video-Lecture[6]	?	6-page checklist for weekly purchases and standard nutritive and caloric values	Total fat and saturated fat (en%) of total weekly purchase	Significant effect at short-term on total fat for computer-tailored feedback + video-lecture versus video-lecture ES for tailoring versus video-lecture: -0.22
Winett, Moore 1991 [50]	USA	Participants (77) recruited among supermarket customers	No info	Yes	Shopping receipts	In frequency purchased: Low fat meat High fat meat Low fat dairy High fat dairy Low fat fish/poultry	Results at short-term No significant effect on low-fat meat, high-fat meat and low-fat fish/poultry Significant effect on low-fat dairy and high-fat dairy
Winett, Wagner 1991 [51]	USA	Participants with a household with 2 or more people (61), no medically prescribed diet for all household members, recruited among supermarket customers	No info	Yes	Weekly shopping receipts	Low fat meat (g) High fat meat (g) Low fat dairy (g) High fat dairy (g) Low fat fish/poultry (g) Total fat in % of total energy	Results at short-term No significant effects on low-fat meat, high-fat meat, high-fat dairy, low-fat fish/poultry and total fat Significant effect on low-fat dairy

1st author	Country	Study population (N)	Tailoring compared to	Validated measure	Outcome measurement instruments	Outcome measurement units	Results[1] and Effect Sizes[2] at short-, medium- or long-term[3]
Winett 1997 [52]	USA	Participants (105; 53 participants left at medium-term) recruited among supermarket customers	No info	?	Shopping receipts [99]	% kcal from fat	Significant effects on fat from total food purchases at short- and medium-term ES at short-term: -0.47 ES at medium-term: -0.41 Significant effects on fat from dairy food purchases at short- and medium-term ES at short-term: -0.85 ES at medium-term: -0.96 Significant effects on fat from table and cooking fats purchased and on fat from prepared foods purchased at short-term No significant effects at medium-term ES at short-term cooking fats: -0.61 ES at short-term prepared foods: -0.26 No significant effects on fat from fat meat and from fat snack foods at short- or medium-term
Wylie-Rosett 2001 [36]	USA	Participants (280) with BMI > 25 kg/m^{2}or BMI > 24 kg/m^2 + 1 risk factor for cardiovascular diseases, recruited from health maintenance organizations and the general population	Self-help workbook[6]	Yes	Block FFQ [61]	kcal /day % kcal from fat	No significant effect on total fat intake at long-term
Section C: Fruit and vegetables consumption promotion							
Anderson 2001 [39]	USA	Participants (277; 163 participants left at medium-term) recruited among supermarket customers	No info	?	FFQ [94] Shopping receipts	Purchased daily servings of fruit and vegetables per 1000 kcal daily	Results measured with FFQ Significant effect at short- and medium-term ES at short-term: 0.45 ES at medium-term: 0.38 Results with shopping receipts No significant effect at short- or medium-term
Baker 2002 [53]	UK	Participants of bowel screening trial (742), 55-64 yrs, recruited from cancer screening clinics	No info	Yes	2-item fruit & vegetables tool [100]	Fruit: servings/day Vegetables: servings/day	Significant effects at short-term for vegetable intake and for fruit intake
Brug 1996 [40]	NL	Participants (347) recruited from worksites	Generic info	Yes	3-item FFQ [101]	Fruit: pieces/day Vegetables: servings/day	No significant effects at short-term on fruit or vegetable intake for total population and for population not meeting recommendations

1st author	Country	Study population (N)	Tailoring compared to	Validated measure	Outcome measurement instruments	Outcome measurement units	Results[1] and Effect Sizes[2] at short-, medium- or long-term[3]
Brug 1998 [41]	NL	Participants (646) recruited from the general population	Generic info	Yes	3-item FFQ [101]	Fruit: servings/day Vegetables: servings/day	Single computer-tailored feedback compared to generic info No significant effect at short-term for fruit intake nor vegetable intake Iterative computer-tailored feedback compared to generic info Significant effect at short-term on fruit and vegetable intake ES at short-term for fruit: 0.26 ES at short-term for vegetables: 0.31
Campbell 1994 [42]	USA	Participants (394) recruited from family medical practices	No info Generic info	Yes	10-item FFQ derived from Health Habits and History questionnaire [61]	Fruit: servings/day Vegetables: servings/day	No significant effects at medium-term on fruit or vegetable intake Note: comparison computer-tailored feedback with generic info was not tested
Campbell, Bernhardt 1999 [43]	USA	Participants (459) recruited from African American churches	No info	Yes	7-item FFQ '5-a-day community studies' approach [102]	Servings/day	Spiritual computer-tailored feedback compared to no info Significant effects at medium- and long-term on fruit and vegetable intake ES[7] at medium-term: 0.39 Expert computer-tailored feedback compared to no info Significant effects at medium- and long-term on fruit and vegetable intake ES[7] at medium-term: 0.48
Campbell, Carbone 2004 [44]	USA	Women (306) receiving benefits for themselves or their child(ren) from the 'Special Supplemental Nutrition Program for Women, Infants and Children'	No info	Yes	25-item fat, fruit, vegetable and fiber screener [96]	Fruit: servings/day Vegetables: servings/day	No significant effect at short-term
Campbell, James 2004 [33]	USA	Church members (587) of African-American churches in rural area	No info	Yes	60-item FFQ [61]	Fruit: servings/day Vegetables: servings/day	Significant effect at long-term on fruit and vegetables ES[7] at long-term: 0.18

1st author	Country	Study population (N)	Tailoring compared to	Validated measure	Outcome measurement instruments	Outcome measurement units	Results[1] and Effect Sizes[2] at short-, medium- or long-term[3]
Irvine 2004 [47]	USA	Participants (463) recruited from worksites	No info	Yes	5-item FFQ '5-a-day for better health studies' approach [103]	Fruit: servings/day Vegetables: servings/day	Significant effect at short-term on fruit and vegetable intake ES at short-term: 0.21
Lutz 1999 [54]	USA	Participants (573) recruited from health maintenance organizations	No info Generic info	?	17-item FFQ	Fruit: servings/day Vegetables: servings/day	Computer-tailored feedback compared to no info Significant effect at medium-term ES[7] at medium-term: 0.23 Computer-tailored feedback and goal setting compared to no info Significant effect at medium-term ES[7] at medium-term: 0.35 No significant effect on fruit and vegetable intake at medium-term for computer-tailored feedback compared to generic info or for computer-tailored feedback + goal setting compared to generic info
Oenema 2005 [55]	NL	Participants (616) recruited at factories, institutes for health and social care and local government institute	No info Generic info	Yes	14-item FFQ including raw and cooked vegetables, fruit and fruit juice	Fruit: servings/day Vegetables: servings/day	Computer-tailored feedback compared to generic info Significant effect at short-term for vegetable intake for total group and for those not meeting the recommendations at baseline Computer-tailored feedback compared to no info Significant effect at short-term for fruit intake for those not meeting the recommendations at baseline and those unaware of personal intake at baseline
Winett, Moore 1991 [50]	USA	Participants (77) recruited among supermarket customers	No info	Yes	Shopping receipts	Fruit and vegetable frequency purchased	No significant effect at short-term
Winett, Wagner 1991 [51]	USA	Participants with a household with 2 or more people (61), no medically prescribed diet for household members, recruited among supermarket customers	No info	Yes	Weekly shopping receipts	Fruit and vegetable purchased (g)	No significant effect at short-term

1st author	Country	Study population (N)	Tailoring compared to	Validated measure	Outcome measurement instruments	Outcome measurement units	Results[1] and Effect Sizes[2] at short-, medium- or long-term[3]
Winett 1997 [52]	USA	Participants (105; 53 participants left at medium-term) recruited among supermarket customers	No info	Yes	Shopping receipts [99]	Fruit and vegetable servings/1000 kcal purchased	Significant at short-term and at medium-term ES at short-term: 0.34 ES at medium-term: 0.14 Note: medium-term effect might be due to seasonal trend
Section D: Other dietary topics							
Anderson 2001 [39] Fiber	USA	Participants (277; 163 participants left at medium-term) recruited among supermarket customers	No info	?	FFQ [94] Shopping receipts	g/1000 kcal	Results measured with FFQ Significant effect at short-term and at medium-term ES at short-term: 0.55 ES at medium-term: 0.62 Results measured with shopping receipts No significant effect at short-term or at medium-term
Blalock 2002 [32] Calcium	USA	Women (714), 40-56 yrs, recruited from the general population	Generic info	Yes	15-item FFQ derived from Block [61] Non-dietary sources of calcium Calcium-fortified orange juice	mg/day	No significant effect at medium-term or at long-term measured for unengaged and engaged participants, respectively Significant adverse effect at long-term for participants in action
Brinberg 2000 [56] Fiber	USA	College students not living with their parents (133), recruited from a university	Generic info Generic info + intake feedback No info	Yes	FFQ [104]	g/day	Significant effect on fiber consumption in all three comparison groups at medium-term No significant effects on food choice at medium-term
Bull 2001 [31] Weight loss	USA	Participants with a BMI > 27 kg/m^2 (198), interested in losing weight and without the use of prescribed weight loss medication at any time during the previous 6 months, recruited from the general population	Generic info	Yes	1-item [105]	Weight loss suggestions tried yes/no	No significant effect at short-term

1st author	Country	Study population (N)	Tailoring compared to	Validated measure	Outcome measurement instruments	Outcome measurement units	Results[1] and Effect Sizes[2] at short-, medium- or long-term[3]
Winett, Moore 1991 [50] Fiber	USA	Participants (77) recruited among supermarket customers	No info	Yes	Shopping receipts	High-fiber grains/cereals amount purchased	Significant effect on purchase of high-fiber grains/ cereals at short-term
Winett, Wagner 1991 [51] Fiber	USA	Participants with a household with 2 or more people (61), no medically prescribed diet for household members, recruited among supermarket customers	No info	Yes	Weekly shopping receipts	High-fiber grains/cereals in grams daily per capita fiber	No significant effect on purchase of high-fiber grains/ cereals nor on fiber intake at short-term
Winett 1997 [52] Fiber	USA	Participants (105; 53 participants left at medium-term) recruited from supermarket customers	No info	Yes	Shopping receipts [99]	Fiber g/ 1000 kcal Fiber from bread g/1000 kcal Fiber from cereal g/1000 kcal	Significant effect on total fiber intake at short-term and at medium-term ES at short-term: 0.48 ES at medium-term: 0.36 Significant effect on fiber from cereals at short-term, no significant effect at medium-term ES at short-term: 0.65 No significant at fiber from bread at short-term or at medium-term
Wylie-Rosett 2001 [36] Weight loss	USA	Participants (280) with BMI > 25 kg/m^2or BMI > 24 kg/m^2 + 1 risk factor for cardiovascular diseases, recruited from health maintenance organizations and the general population	Self-help workbook[6]	Yes	Weight parameters Metabolic parameters	Body Mass Index (kg/m^2) Waist circumference (in) % Body fat	Significant effect on weight loss at long-term ES at long-term: 0.21

Note: ES = effect size; PA = physical activity; USA = United States of America; AUS = Australia; LTAs = Leisure Time Activity score; PADLs = PA of daily living score; MET = metabolic equivalents; B = Belgium; IPAQ = International Physical Activity Questionnaire; BMI = Body Mass Index; FFQ = Food Frequency Questionnaire; NL = The Netherlands; UK = United Kingdom; en% = percentage of daily energy intake.
[1] Significant effect = effect in favor of tailoring that reached statistical significance. Significant adverse effect = effect in favor of comparison group(s) that reached statistical significance. [2] Effect sizes were calculated when mean and SD of both groups were available at posttest and a significant effect in favor of tailoring had been found. ES is interpreted according to Cohen's guidelines [24] based on an application in Dolan *et al.* [27]; cut-off values of 0.2-0.5 = small, 0.5-0.8 =moderate and > 0.8=large effects. [3] Short-term: < 3 months; medium-term: 3-6 months; long-term: > 6 months. [4] Bock 2001 deals with the long-term effects of the same study as Marcus 1998. [5] Reported results and effect sizes from Vandelanotte [35] are derived from the comparison sequential tailored feedback versus no information. [6] The computer-tailored intervention group and the control group received the same, but the intervention group received additional tailored feedback. [7] SD used in calculation is a proximate, derived from the SE reported in paper ($SD = SE * \sqrt{n}$)

Table 2.3: Results for single-component and multi-component interventions

Target behavior	Number of studies: Total	Significant effect	Mixed effects#	No effect
Physical activity – single component study	4	1	–	3
Physical activity in a multi-component study addressing dietary behaviors as well	6	1	1	4
Fat consumption – single component study	5	1	3	1
Fat consumption in a multi-component study addressing other dietary behaviors as well	10	5	3	2
Fruit and vegetable consumption – single component study	3	2	1	–
Fruit and vegetable consumption in a multi-component study addressing other dietary behaviors as well	11	4	2	5

within one study both significant and non-significant results were found for either different subgroups or different outcome measures related to the target behavior

the number of studies was too small to draw any firm conclusions, it appears that targeting more than one behavior does not reduce the chances for significant effects, while for fat intake the available evidence may indicate that combining fat reduction with other goals may even improve chances of success (see Table 2.3).

DISCUSSION

Based on a systematic review of the relevant literature, the evidence for the effectiveness of computer-tailored nutrition-education interventions is quite strong. Nevertheless, effect sizes were mostly small and the evidence is mostly restricted to short and medium-term, with a follow-up period of up to six months. The majority of studies on fat consumption and on fruit and vegetable consumption showed significant favorable effects of tailoring, and no studies found effects in favor of one of the control groups. The effects of computer-tailored nutrition education on fat reduction were found in comparison with no intervention as well as generic information. The interventions aimed at fruit and vegetable consumption were mainly compared with 'no intervention' control groups. Based on the few studies available on the effect of computer-tailored interventions to promote physical activity, no conclusions in favor of tailoring can be drawn. Furthermore, given the still relatively small number of studies for each of the health behaviors addressed, the present review provided only limited information on mediators and working mechanisms of computer tailoring.

The review was conducted according to a systematic protocol in line with most of the Cochrane instructions, using objective criteria for inclusion and exclusion of studies, but no blinding of authorship or journal was done before reviewing the papers. There is, however, no unequivocal scientific evidence that blinding is essential to obtain a more objective assessment of the quality of a paper [68, 69]. Furthermore, the review was restricted to publications available via established electronic literature data-bases, and no attempts were made to also incorporate the 'grey literature', such as publications in the form of internal or locally distributed reports, or manuscripts that were not accepted for publication. A common problem with reviews is the possibility of a 'publication bias', causing an overestimation of positive findings [24], but the relatively large number of studies that did not report any tailoring effects may indicate that lack of effects was generally not a reason to judge a paper to be unacceptable for publication in studies on computer tailoring. Finally, a review is dependent on the information reported in the publications and also on the interpretation of this information by the reviewers, which may limit the validity of the review results.

Notwithstanding these potential limitations, the present review provides the most detailed overview of the content and effects of computer-tailored interventions in the field of physical activity and healthy diet promotion to date. Earlier, and somewhat less systematic, reviews [23, 70] were conducted more than five years ago, and a number of studies on tailoring have been published since [28, 30-32, 35-39, 43-45, 47, 48, 53, 54, 56, 60].

The two studies on physical activity promotion that did find medium-term positive effects, may have been somewhat more intensive than most other, non-effective, interventions: Vandelanotte et al [35] include a detailed survey and detailed feedback on determinants of motivation and behavior in their computer-tailored advice, while Marcus et al [29] used an intervention with four feedback moments. The fat-reduction interventions included in this review appear to be quite similar and thus provide no information on what made most interventions effective but others not. Differences in study designs or effect measures can also not explain the differences in effects. Effects of interventions aimed at increasing fruit and vegetable consumption might be partially explained by the fact that most of the studies that found a positive effect of computer tailoring made the comparison with a no-intervention control group, which may indicate that computer tailoring may be effective for fruit and vegetable promotion, but there is no evidence that computer-tailored fruit and vegetable education is more effective than generic fruit and vegetable education.

Although the evidence available points to the conclusion that computer tailoring has its merits for healthy diet promotion, it remains difficult to draw more definite conclusions. Effectiveness of interventions depends on more than only the use or amount of tailoring. Interventions, whether tailored or not, should be based on a detailed planning process that should include a careful epidemiological analysis and an assessment of the most important and best changeable determinants of the target behaviors [21, 71]. Furthermore, persuasion-communication theory points out that nutrition education that meets these effectiveness-enhancing criteria can only be effective if people are exposed and attentive to the health-education message, when the message includes sufficiently strong and convincing arguments, and is communicated by a source that is perceived as credible and trustworthy [72]. The studies reviewed here varied in how they were developed, the theoretical framework used, behavioral determinants addressed, and based on the papers reviewed, it is in most cases impossible to judge the actual exposure to the tailored feedback, the strength of the arguments in the feedback, or the trust in the message source.

The outcomes of both the physical activity and the dietary computer-tailored interventions were mostly based on self-report measures. Although most of these self-report measures were validated instruments, studies would be strengthened when self-reports were verified with more objective monitoring. However, objective measures of dietary intake that can be used in external valid and population-based studies are basically non-existent and the existing objective measures for physical activity, such as accelerometers, are not gold standards [73]. Using where possible combinations of validated self-reports and more objective measures or biomarkers of behavior change, to ensure a sort of triangulation in evaluation, should be recommended [73, 74]. The ability to detect effects varies according to the reliability, validity and sensitivity of the effect indicator used, and although many studies did use validated questionnaires, this does not necessarily mean that these were valid enough to be used to measure behavior changes [11].

The present review further does not show that one theoretical framework improves the chances for effects, or that certain feedback strategies are more effective than others. In most studies more than one theory was used as a basis for the tailored intervention. Such a problem-driven multiple-theory approach is indeed advocated in recent books and papers on applying theory in health education [75-77]. The Trans Theoretical Model [57] was reported most often as one of the theories used. Although this model is under debate, especially for applications in the nutrition and physical activity field [78, 79], its application in individually tailored interventions is still regarded as promising [80].
As we argued in the Introduction to this paper, computer tailoring incorporates a number of characteristics that have been found to improve the effectiveness of health education interventions, but more research is needed on why and when computer tailoring will initiate changes in diet or physical activities. Some evidence exists that perceived personal relevance and interestingness, and more intensive cognitive processing mediate the effects of computer-tailored interventions [55, 81].

De Bourdeaudhuij et al [82] investigated the effect of individually-tailored dietary advice versus family-based tailored advice, and Campbell and colleagues [43] varied the message-source (the local preacher or a public health expert) and context (religious or scientific) of the information in a church-based intervention for African-Americans. No significant differences in effects between the different tailored interventions were found.

It is also unclear how elaborate a computer-tailored intervention should be to have effects. It is not possible to relate the effects of the interventions to the amount of information given (the dose), since interventions are usually not described in enough detail to make meaningful comparisons possible. Only few studies have explicitly compared more elaborate computer tailoring with more restricted versions [34, 56, 83], but did not find significant differences, and one study that included explicit goal-setting in the tailored intervention could not prove the additional effect of this strategy [54].

A possible problem with more elaborate tailoring is that the amount of feedback may become too extensive for people to process, remember and put into use. This may be especially true for interventions aimed at multiple behaviors. A study that explored this issue [35], by investigating if tailored feedback on different health behaviors (fat intake and physical activity) was more effective if provided simultaneously or sequentially, did not find significant differences in effects between the two intervention approaches.

Exploring the effects of tailoring on potential mediators of behavior change, instead of behavior change itself, may possibly provide more insight in why and when tailored feedback is effective. A number of studies [31, 37, 40, 41, 44, 45, 47, 48, 60, 84] evaluated the effectiveness of computer-tailored interventions on motivation to change, either as goal intentions or stages of change. Only one study on physical activity [37] reported changes in motivation. Higher motivation for decreasing fat intake due to the computer-tailored intervention was found in four studies [40, 47, 60, 84]. Three other studies did not find a significant effect on motivation to eat less fat [44, 48, 82].

The tailored feedback in the interventions reviewed is mostly print computer-tailored personal feedback letters or newsletters. Only very few of the studies published to date used more interactive systems [35, 36, 39, 44, 47, 50, 52, 55, 60]. However, computer-tailored print materials only utilize part of the potential of computer tailoring, since interactivity and immediate feedback is not possible [21, 30]. It has been argued that more interactive systems, such as web-based computer tailoring may hold more promise.

The individualization is most probably an important reason why computer-tailored nutrition education is effective [15, 17, 55]. However, computer tailoring has also been criticized for its lack of social components [21]. It has also been argued that personalized advice may not be enough because dietary habits may not always be volitional or personally determined. Interactive technology in computer tailoring may offer some opportunities for combining computer-tailored feedback with Internet-based social support. Computer-tailored physical activity and nutrition education for primary prevention may also become more effective if it is incorporated in ongoing or routine preventive community services [42, 43, 85].

A comprehensive review of Contento et al [25] concluded that nutrition education was more likely to be effective when behavior change goals were made explicit and when the education strategies were explicitly directed to that goal. Furthermore, Contento et al's review showed that personal relevance, feedback and interactivity contributes to effectiveness. Computer tailoring enables incorporation of these characteristics in combination with a wide distribution against relatively low costs. For physical activity comparable findings were concluded in a review of Kahn et al [13]. In contrast with education strategies like mass media campaigns there is strong support for the effectiveness of individually-adapted health behavior change programs.

The results of the present systematic review confirm the conclusions drawn in earlier reviews and position papers: computer tailoring is a promising means to promote healthy diets and possibly physical activity. Tailoring, however, is not a guarantee for success, and more research is needed on what makes tailoring effective. Unfortunately, authors of recent papers have often not complied with recommendations made in those earlier reviews (e.g. extensive description of intervention used, objective outcome measures, comparison with generic information, long-term follow up).

Campbell and colleagues proposed a stepwise approach to the development and evaluation of complex interventions, from exploration, via tests in controlled settings, to field studies and implementation research, and such a stepwise approach should be recommended for computer tailoring studies too [86]. This stepwise approach should also include studies comparing computer-tailored interventions to other state-of-the-art intervention strategies as well as cost-effectiveness studies. Finally, to improve the quality of the scientific evidence of the effectiveness of behavioral change interventions it is important that studies are reported according to certain standards so that studies can be better compared [24]. A good example is The Consolidated Standards for Reporting Trials, developed to improve the design and reporting of interventions involving randomized controlled trials [87]. We recommend that future papers on studies on computer tailoring adhere to these standards.

We are only beginning to explore the possibilities of using the world-wide-web and other interactive media for computer tailoring and future studies should explore and evaluate these channels for computer-tailored nutrition and physical activity education [20, 88, 89]. A review on the effectiveness of physical activity interventions highlights two key challenges for approaches using Internet communication technologies: 'engagement' and 'retention' of participants [88]. This touches upon implementation of computer-tailored interventions in real-life settings; true implementation studies are much needed to further explore the public health effects of computer tailoring.

We conclude that computer-tailored interventions have promise, especially in dietary change interventions. And although the present review indicates that effects of tailored interventions are mostly small, when such small effects can be reached in the population at large, public health effects may be substantial [90].

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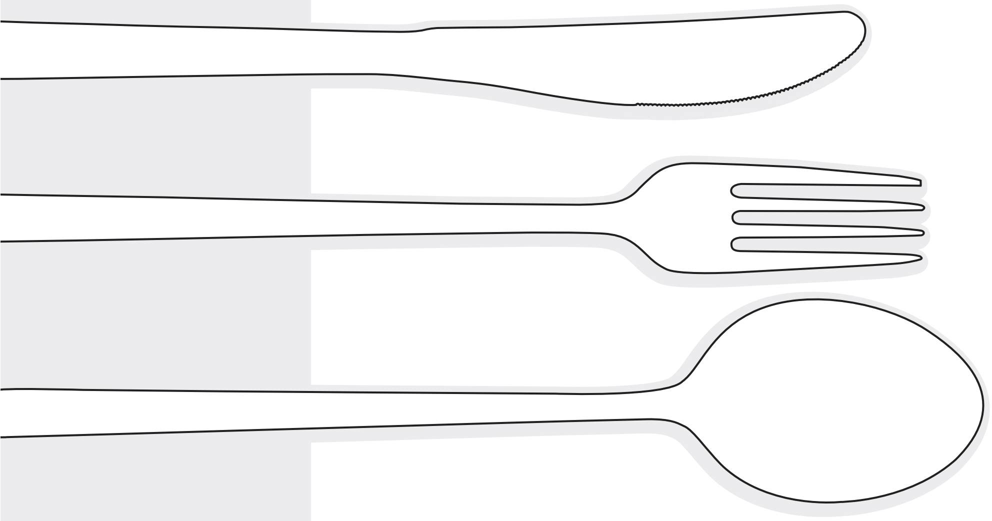
CHAPTER 3

Examining the minimal required elements of a computer-tailored intervention aimed at dietary fat reduction



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ABSTRACT

This study investigated the minimally required feedback elements of a computer-tailored dietary fat reduction intervention to be effective in improving fat intake. 588 Healthy Dutch adults were randomly allocated to one of four conditions in an RCT: 1) feedback on dietary fat intake (Personal-feedback), 2) P-feedback and feedback on one's own behavior relative to that of peers (Personal-Normative-feedback), 3) PN-feedback and practical suggestions on how to change fat intake (Personal-Normative-Action-feedback), 4) generic information. Data on fat intake, awareness of one's own fat intake and intention to change were collected one and six months post-intervention. Between-group differences were tested with Analysis of Variance. Among respondents with high fat intakes at baseline (risk consumers) and those who underestimated their fat intake at baseline (under estimators), differences in awareness and (saturated) fat intake were found between the generic and PNA-feedback conditions. Compared to generic information P-feedback was more effective in changing awareness and intention among the under estimators, and PN-feedback was more effective in changing intention among both risk consumers and under estimators. In conclusion, the combination of personal, normative and action feedback is required for inducing change in fat intake and improving awareness of fat intake.

INTRODUCTION

Computer tailoring matches the educational information to each individual's unique characteristics, behaviors, perceptions or motivation to change as derived from an individual assessment [1]. Many studies have tested the efficacy of computer-tailored interventions in behavior change [2-4]. A recent systematic review of computer-tailored interventions aimed at improving dietary and physical activity behaviors confirmed that there is compelling evidence for efficacy of such interventions in improving a variety of dietary behaviors, fat intake in particular [2].

Much less research has been directed toward investigations of why computer-tailored interventions are often more effective than generic information. Some studies explored what caused the effect of computer-tailored interventions by looking at differences in information processing (e.g. using, saving and discussing the information; perceived personal relevance) and examining associations between the unique characteristics of computer-tailored interventions (e.g. personalization, less-redundant information) and intervention effects [5-9]. Even though these findings are useful in opening the 'black box' of computer-tailored interventions, they do not give information on how we can optimize these interventions and make them more efficient. Insight into what content-related elements of computer-tailored interventions determine their effectiveness can guide us in the development of possibly shorter, more efficient tailored interventions [10].

There are some studies comparing more elaborate computer-tailored interventions with more restricted versions. Kreuter and colleagues [11] found some modest evidence that typical health risk appraisal feedback, for instance addressing dietary fat consumption, only resulted in dietary change if accompanied by individually tailored behavior change information. Furthermore, a study of Brinberg and others [12] indicated that changes in knowledge and behavior related to fiber intake only occurred if tailored feedback on total daily dietary fiber intake was accompanied by tailored feedback on all specific products in the personal diet and their fiber content. Finally, Brug and colleagues [13] found that the effects of extensive consumption, normative and action feedback for reducing fat intake, were not improved by additional psychosocial information.
In these previous studies various types of feedback were provided, such as feedback on health risk status, feedback on behavior, feedback on psychosocial factors and feedback on negative consequences of a behavior. The contribution of various types of behavioral feedback in inducing behavior change has not been unraveled.

In previous studies we have successfully evaluated computer-tailored dietary interventions that comprised of personal feedback, normative feedback and action feedback elements [5, 9]. The theoretical rationale behind providing these types of feedback was the Precaution Adoption Process Model (PAPM) [14]. The PAPM identifies seven stages in taking precautious actions (behavior change) along the full path from ignorance to action [15]. Awareness of a personal risk or risk behavior is an important first step toward behavior change, because when people are not aware of a problem, they will not perceive a need to change. The PAPM proposes that personal behavioral feedback and normative feedback are important strategies to improve awareness and motivation to change [15]. However, to translate motivation into actual behavior change, people may need to improve skills and self-efficacy, requiring action feedback, that is practical information on how to reduce fat intake and what to do in difficult situations [15]. Lack of awareness of one's own dietary behavior, insufficient skills and low self-efficacy [16-19] have been identified as important barriers of dietary behavior change.

The purpose of this study was to investigate which feedback elements (personal feedback, normative feedback, action feedback) were necessary for a computer-tailored fat reduction intervention to be effective in improving awareness of ones own fat intake, increasing intention to reduce fat intake and reducing fat intake.

METHODS

Study design and procedure

This study is part of a larger randomized controlled trial (RCT) with five study arms and two post-tests, investigating different aspects of computer-tailored interventions aimed at dietary fat reduction (Trial registry: ISRCTN01557410). The rationale for using post-tests only in this RCT was that we aimed to assess the outcome measure for the larger trial in a sophisticated manner (mean daily (saturated) fat intake measured in g/d and percentage of daily energy intake), which meant the use of a very elaborated questionnaire. Using this elaborate questionnaire as a pre-test would have been an intervention in itself and would have increased respondent burden, with the risk of compromising the study. In an RCT with a control group, a baseline assessment of the outcome measure is not strictly necessary, since the randomization procedure should ensure equality of groups at baseline [20]. Approval for the research project was obtained from the medical ethics committee of Erasmus University Medical Center Rotterdam. All participants gave written informed consent after receiving written information.
The information packages contained an invitation letter, an information leaflet, a statement of approval of the study by the medical ethics committee of Erasmus MC Rotterdam, an application and informed consent form, and the bylaw on health insurance for participants. Persons could enroll by returning the completed application and informed consent form.

Eligibility criteria were: 18-65 years of age, sufficient understanding of the Dutch language, no diet prescribed by a dietitian or physician, and no treatment for hypercholesterolemia.
After having provided their informed consent, participants had to complete and return a baseline paper & pen screening questionnaire, which was sent to the respondents' home address. A computer program randomly assigned the participants to the five experimental conditions, stratified by recruitment source (company or neighborhood).
The feedback and generic information letters were sent by regular mail to the respondents' home address within two weeks after returning the screening questionnaire. One month and six months after the intervention, the post-test questionnaires were sent to the respondents' home address. Participants who did not return their questionnaire were contacted by e-mail or telephone once.

Recruitment of participants

Recruitment was conducted in 2003 and 2004 using two strategies: approaching employees of large companies after gaining permission of their employer and/or the department of Human Resources, and door-to-door advertising in two neighborhoods in the urban-area of Rotterdam. Nine out of 31 invited companies allowed us to approach their employees by sending them an information package, and 574 out of 4118 employees volunteered to participate. Nine thousand leaflets with brief information about the study were spread door-to-door in the two neighborhoods. Citizens could express their interest in the study by postal mail, e-mail or telephone, upon which they received the information package. This approach resulted in enrollment of 224 citizens.
Thus, a total of 798 (574 + 224) volunteers were recruited of which 764 respondents (drop-out 4.3%) filled out the screening questionnaire, 610 respondents were assigned to the conditions presented in this paper: a condition receiving computer-tailored Personal feedback (n=155), Personal-Normative feedback (n=160), or Personal-Normative-Action feedback (n=141), or a control condition receiving generic information (n=154). With 82 participants in each condition at posttest a relative difference of 8.7 grams per day in saturated fat intake (with an assumed saturated fat intake in the generic information group of 43.5 g/d), could be detected with a power of 0.90 (two-tailed; $p<0.05$).
Persons who were not willing to participate were asked to indicate their reasons not to enroll. Only 300 persons indicated their reasons not to enroll, which were: lack of time or interest, afraid of giving blood or not eligible.

Intervention materials

Computer-tailored interventions

All necessary components for generating a computer-tailored intervention were derived from earlier work of Brug et al [5] and Oenema et al [9] and adjusted for the present study. The intervention was informed by the Precaution Adoption Process Model and the Theory of Planned Behavior, as described in more detail elsewhere [5, 9].
The feedback was provided as a letter addressed to the participant's home address and can thus be considered as first-generation computer tailoring. The structure of the letters in the three computer-tailored feedback conditions was similar, including a general introduction on the topic of saturated fat consumption and the relation with health, the individualized feedback section and a closing, in which the reader was encouraged to make changes to his/her diet. The letters were signed by the principal investigators. The individualized-feedback sections in the three computer-tailored feedback conditions were based on different determinants and differed in extensiveness, as is described in more detail below.

Screening questionnaire

The screening questionnaire was designed to assess fat intake and the most important sources of fat, perceived fat intake and attitude, self-efficacy and intention toward reducing fat intake, in order to be able to provide the computer-tailored feedback. Fat intake was assessed with a validated 35-item food frequency questionnaire (FFQ), covering the 19 (categories of) food items with the largest contribution to saturated fat intake in the Dutch diet. Participants were asked how frequently, how much and what kind (high - medium – low fat content) of the food items was usually consumed during the past four weeks. Based on this questionnaire (the so-called 'Fat list'), an individual total fat score ranging from 0 (lowest) to 80 (highest) was calculated [21], indicating how much fat a person consumes. Age and gender specific cut-off points were used for determining whether the fat intake meets recommended levels, scores of on average 14 for women and 17 for men correspond with the approximated upper levels of recommended dietary saturated fat intake in the Netherlands, and whether this intake is equal to, higher or lower than that of peers.
Participants' perception of their own fat intake was measured with one item on a five-point scale developed by Brug, Lechner and colleagues [19, 22]: How much fat do you think you eat (very little – very much). Furthermore, attitude ('is it bad or good to eat less fat'), self-efficacy ('is it difficult or easy to eat less fat'), and readiness to reduce fat intake (planning to reduce fat definitely: no/yes) were assessed as well as self-efficacy ('is it difficult or easy to eat less fat') in four potential difficult situations (eating out, eating at someone else's home, eating at parties, eating snacks). These items from the Theory of Planned Behavior were developed based on

instructions provided by Conner and Sparks [23]. Measurement of socio-demographic and background characteristics included questions on gender, age and education level.

Condition 1: Personal feedback ('P-feedback')

Participants in the condition of P-feedback received feedback on their personal fat intake, a comparison with the recommended intake for his/her age and whether his/her perceived intake was correct. The feedback was visualized in a graph depicting the personal fat score and the recommended fat score. The length of the letter was about one page.

Condition 2: Personal and normative feedback ('PN-feedback')

The feedback section in the condition of PN-feedback included the personal feedback described in the previous section, but also compared the respondent's fat intake with that of others of the same age and sex (normative feedback). The graph accompanying this feedback message also depicted the fat score of peers. The length of the letter was about one page.

Condition 3: Personal, normative and action feedback ('PNA-feedback')

The PNA-feedback condition included the provision of personal feedback as described in the previous section, normative feedback for respondents of whom personal fat consumption was higher than the consumption of peers of the same age and sex, and action feedback introduced with brief feedback on attitude, self-efficacy and intention to change. The action feedback comprised of suggestions of what the participant could change to his/her diet, based on an analysis of the products that contributed most to the saturated fat intake of this participant. Furthermore, suggestions were given for how to deal with situations in which a participant thought it would be difficult to reduce saturated fat intake. If interested, respondents received some recipes on low-fat starters, main courses and desserts. The length of the letter was 1.5 – 4 pages (excluding recipes).

Generic condition

The control condition consisted of non-personalized, non-tailored generic nutrition information ('generic condition'). The information leaflet started with the importance of a healthy diet and more specific fat in the diet, followed by fat intake of the average Dutch male/female and the comment that the fat intake of the reader might also be too high. The next part of the information aimed at how to reduce fat intake with information on low-fat alternatives for different product groups, tips how to cook with less fat and what to do when eating out. The information closed with an encouragement to eat less fat. The length of the generic information was two pages.

Measurements

Baseline characteristics of respondents

The following baseline population characteristics were derived from the screening questionnaire: gender, age, ethnicity, education level, BMI and fat score. Based on personal fat score, recommended intake level and perception of own fat intake, participants were categorized into two risk groups: 'risk consumers' (intake above gender-age specific cut off levels of fat score) or 'under estimators' (respondents who think their fat intake is very low/ low/ not low, not high, while their fat score is above recommended cut off levels) [22].

Post-test questionnaires

Both the 1-month and 6-months post-test questionnaire assessed awareness of own fat intake, intention to reduce fat intake and (saturated) fat intake.

Perceived fat intake was measured with one item on a five-point scale 'How much fat do you think you eat', (very little (-2) – very much (+2)). Perceived intake gives an indication of awareness of one's own fat intake, when this measure is evaluated in combination with fat intake as assessed with a FFQ. Intention to reduce fat intake was assessed with one item on a five-point bipolar scale 'How (un)likely is it that you will eat less fat than you do now?' (very unlikely (-2) – very likely (+2)).

Daily intake of total fat and saturated fat (g/d) were assessed using an extensive paper & pen food frequency questionnaire which was validated [24] and last revised based on the Dutch National Food Consumption Survey of 1998 [25]. The questionnaire consisted of 104 items assessing frequency and quantity of food items usually consumed, and was structured according to meal pattern.

Statistical Analyses

To explore equality of study groups at baseline Pearson Chi-Square tests for categorical variables (gender, ethnicity, education, percentage risk consumers, percentage under estimators) and one-way ANOVAs for continuous variables (age, BMI and fat score) were conducted. Logistic regression analyses with drop out (yes/no) as the dependent variable and intervention condition, gender, age and fat score at baseline as the independent variables were conducted to identify predictors of drop out at one and six months post intervention.

Analyses of Variance (ANOVA) and Covariance (ANCOVA) with post-hoc Bonferroni corrections (two-tailed, $\alpha = .05$) were conducted to test group differences in awareness of own fat intake (ANCOVA), intention to reduce fat intake and daily total fat and saturated fat intake (g/d) (ANOVA). In the analyses the post-test value of the outcome measure was the dependent variable and study group was the independent variable. For the analyses on awareness, perception of own intake was the dependent variable and study group and fat intake at the relevant posttest the independent variables. The analyses were run separately for the outcomes at one month and six months.

The analyses were performed among the total study population and among the risk consumers and under estimators. The subgroup analyses were performed since these groups especially needed to profit from the intervention. Results were only regarded as statistically relevant when the overall test was significant with a p-value <.05 and at least one Post Hoc comparison had a p-value <.05. Complete case analyses were performed using SPSS11.

Finally, in order to compare the effect sizes of the different feedback conditions relative to the generic condition we calculated effect sizes (ESs) as the standardized differences in group means at one and six months post intervention, by dividing the difference between a feedback condition and the generic condition by the pooled standard deviation. Effect sizes were categorized as small (ES 0.2-0.5), moderate (ES 0.5-0.8) or large (ES > 0.8) [26].

RESULTS

Participants

No differences in baseline characteristics were found between the study conditions (Table 3.1). About half of the respondents were female (55%), the majority was of native Dutch origin (85%), mean age was 44.4 years (SD ± 10.11), mean BMI was 25.6 (SD ± 4.27), 41.6% had a high education level (i.e. college or university training), 50.7% of the population was categorized as a risk consumer and 42.3% under estimated their own fat intake.

Table 3.1: Baseline characteristics of the computer-tailored feedback (fb) conditions and the generic information group

	personal fb (n = 155)	**personal & normative fb** (n = 160)	**personal, normative & action fb** (n = 141)	**generic information** (n=150)
gender (% female)	53.5	55.0	55.3	56.0
age (years, mean ± SD)	45.2 ±10.22	45.0 ±10.37	43.4 ±10.07	44.1 ±9.75
ethnicity (% Native Dutch origin)	83.9	83.1	86.5	87.2
education - elementary	2.7	1.9	3.6	2.0
- lower secondary	19.3	16.6	18.6	18.4
- higher secondary	40.7	37.6	35.0	37.4
- tertiary (bachelor degree or higher)	37.3	43.9	42.9	42.2
BMI (kg/m^2, mean ± SD)	25.8 ± 4.36	25.8 ± 4.58	25.5 ± 4.29	25.3 ± 3.81
fat score (mean ± SD)	18.3 ± 6.33	18.0 ± 5.76	16.9 ± 5.51	17.9 ± 6.55
risk consumption (% above gender-age specific cut off point)	53.9	48.1	50.0	50.7
underestimators (% that underestimates own fat intake)	44.1	41.8	40.0	43.2
Perception of own fat intake	-0.34 ±0.86	-0.33 ±0.76	-0.34 ±0.86	-0.37 ±0.78
Intention to reduce fat intake	0.05 ±1.04	0.11 ±1.09	0.02 ±1.12	0.05 ±1.09

Note: there were no statistically significant differences between study conditions at baseline.

A total of 571 respondents (response rate 94 %) completed and returned the 1-month post-test questionnaire and 537 (response rate 88 %) the 6-months post-test questionnaire. Older respondents were somewhat more likely to drop out at one month (OR1-year increase = 1.04; 95% CI = 1.00-1.08) and at six months (OR1-year increase = 1.04; 95% CI = 1.02-1.07) post intervention. Information on perception of own fat intake and intention to reduce fat intake was missed for 37 respondents at 1-month post intervention, due to a randomly missing page in these respondents' questionnaires.

Effects on awareness, intention and intake

There were no differences among the total study population and no differences between the computer-tailored feedback conditions on any of the outcome measures either at one month (Table 3.2) or at six months post intervention (Table 3.3). However, significant effects were found among those who needed to change: the 'risk consumers' and 'under estimators'.

At one month post intervention (Table 3.2) significant group effects were found for awareness of own fat intake among the group of 'risk consumers' ($F(3,264)=4.57$; $p=.004$) and among the 'under estimators' ($F(3,221)=5.05$; $p=.002$). Post-hoc analyses showed that 'risk consumers' and 'under estimators' who received either P-feedback or PNA-feedback had a significantly more realistic perception of their own fat intake compared to the generic condition.
Furthermore, a significant group effect was found for fat intake ($F(3,288)=3.64$; $p=.013$) and saturated fat intake ($F(3,288)=3.14$; $p=.026$) among the 'risk consumers', the Post-hoc analysis showed that 'risk consumers' who received PNA-feedback had a lower total fat and saturated fat intake compared to the generic condition.
Among the 'risk consumers' and among the 'under estimators' the effect sizes for awareness of own fat intake, intention to reduce fat intake and total and saturated fat intake in all feedback-conditions at one month post-test were small, except for fat intake among 'risk consumers' receiving PNA-feedback where the effect size was moderate.

At six months post intervention (Table 3.3) significant group effects were found for intention to reduce fat intake among the group of 'risk consumers' ($F(3,264)=3.94$; $p=.009$) and among the 'under estimators' ($F(3,218)=4.31$; $p=.006$). Post-hoc analyses showed that 'risk consumers' who received PN-feedback or PNA-feedback had a significantly higher intention to change compared to the generic condition. In the group of 'under estimators' participants in the P-feedback, the PN-feedback and the PNA-feedback conditions had a significantly higher intention to change compared to the generic condition. Among the 'risk consumers' and the 'under estimators' the effect sizes of the feedback conditions compared to the generic condition were small for awareness, and moderate for intention, except for P-feedback among 'risk consumers' which was small.

Table 3.2: **One month post-test** differences between the computer-tailored feedback conditions and the generic information group among the total population and among risk consumers and under estimators.

	Mean (SD)				ANCOVA[a]		ES[c] feedback vs generic		
	P-feedback	PN-feedback	PNA-feedback	generic information	Overall F; p-value	Post Hoc with Bonferroni correction	P	PN	PNA
Total Population	n=147	n=151	n=132	n=141					
Awareness of own intake[b]	-0.12 (0.90)	-0.14 (0.81)	-0.11 (0.93)	-0.17 (0.90)	0.574; 0.632	-	.06	.04	.07
Intention to reduce fat	-0.10 (1.26)	0.03 (1.15)	0.07 (1.21)	-0.08 (1.17)	0.639; 0.590	-	-.02	.09	.13
Fat intake (g/d)	80.1 (31.30)	82.4 (27.92)	80.0 (25.23)	88.0 (40.56)	1.708; 0.164	-	-.22	-.16	-.24
Saturated fat intake (g/d)	28.3 (11.13)	30.2 (11.02)	28.7 (9.48)	31.2 (15.17)	1.451; 0.227	-	-.22	-.08	-.20
Risk Consumers	n=78	n=73	n=66	n=72					
Awareness of own intake[b]	0.21 (0.80)	0.09 (0.76)	0.31 (0.80)	-0.05 (0.94)	**4.572; 0.004**	**P and PNA > C**	.30	.16	.41
Intention to reduce fat	0.39 (1.17)	0.35 (1.03)	0.44 (1.18)	0.12 (1.17)	0.991; 0.398	-	.23	.21	.27
Fat intake (g/d)	88.8 (32.01)	92.8 (28.96)	85.8 (21.97)	104.5 (45.13)	**3.639; 0.013**	**PNA < C**	-.40	-.31	-.52
Saturated fat intake (g/d)	31.3 (10.60)	33.5 (11.71)	30.9 (8.74)	37.3 (17.34)	**3.137; 0.026**	**PNA < C**	-.42	-.26	-.46
Under estimators	n=64	n=64	n=52	n=62					
Awareness of own intake[b]	0.10 (0.69)	-0.03 (0.67)	0.10 (0.75)	-0.25 (0.82)	**5.049; 0.002**	**P and PNA > C**	.46	.29	.44
Intention to reduce fat	0.41 (1.16)	0.34 (1.01)	0.38 (1.23)	0.14 (1.20)	0.639; 0.590	-	.23	.18	.20
Fat intake (g/d)	88.8 (31.64)	90.9 (29.00)	84.3 (22.68)	100.8 (41.18)	2.271; 0.081	-	-.33	-.28	-.48
Saturated fat intake (g/d)	31.4 (10.78)	32.7 (11.86)	30.5 (8.75)	35.5 (15.54)	1.449; 0.229	-	-.31	-.20	-.39

[a] significant outcomes (overall test $p<0.05$ and Post Hoc test $p<0.05$) are printed in bold font. [b] Corrected for total fat intake at one month post test; [c] Standardized differences between feedback and generic conditions at 1 month; standardized effect sizes can be categorized as small (ES = 0.2-0.5), moderate (ES = 0.5-0.8) or large (ES > 0.8).

Table 3.3: **Six months post-test** differences between the computer-tailored feedback conditions and the generic information group among the total population and among risk consumers and under estimators.

	Mean (SD)				ANCOVA[a]		ES[c] feedback vs generic		
	P-feedback	PN-feedback	PNA-feedback	generic information	Overall F; p-value	Post Hoc with Bonferroni correction	P	PN	PNA
Total Population	n=140	n=140	n=124	n=133					
Awareness of own intake[b]	-0.24 (0.85)	-0.15 (0.82)	-0.18 (0.84)	-0.24 (0.83)	0.705; 0.549	-	.00	.11	.07
Intention to reduce fat	-0.29 (1.15)	-0.14 (1.25)	-0.20 (1.09)	-0.49 (1.11)	2.308; 0.076	-	.18	.30	.26
Fat intake (g/d)	81.7 (30.76)	78.7 (27.73)	77.5 (26.46)	83.2 (34.77)	1.176; 0.318	-	-.05	-.14	-.18
Saturated fat intake (g/d)	28.5 (10.68)	28.3 (10.42)	27.5 (9.86)	29.4 (13.87)	1.065; 0.364	-	-.07	-.09	-.16
Risk Consumers	n=74	n=67	n=63	n=69					
Awareness of own intake[b]	0.06 (0.80)	-0.05 (0.87)	0.05 (0.85)	-0.18 (0.84)	1.631; 0.183	-	.29	.15	.27
Intention to reduce fat	-0.07 (1.13)	0.13 (1.05)	0.08 (0.92)	-0.44 (1.04)	**3.938; 0.009**	**P, PN, PNA > C**	.34	.55	.53
Fat intake (g/d)	90.3 (32.52)	87.4 (27.60)	80.6 (26.26)	97.1 (37.52)	**3.382; 0.019**	**PNA < C**	-.19	-.29	-.51
Saturated fat intake (g/d)	30.8 (10.89)	31.4 (10.74)	28.4 (9.36)	35.0 (15.65)	**3.768; 0.011**	**PNA < C**	-.31	-.27	-.51
Under estimators	n=60	n=58	n=50	n=59					
Awareness of own intake[b]	-0.09 (0.77)	-0.20 (0.78)	-0.13 (0.79)	-0.30 (0.83)	1.361; 0.256	-	.26	.12	.21
Intention to reduce fat	0.02 (1.17)	0.13 (1.11)	0.06 (1.00)	-0.54 (1.04)	**4.309; 0.006**	**P, PN and PNA > C**	.51	.62	.59
Fat intake (g/d)	89.8 (32.27)	86.5 (28.09)	77.7 (23.80)	98.6 (38.98)	**4.474; 0.005**	**PNA < C**	-.25	-.36	-.64
Saturated fat intake (g/d)	30.4 (10.83)	30.8 (10.98)	27.1 (7.45)	35.4 (16.56)	**4.910; 0.003**	**PNA < C**	-.36	-.33	-.63

[a] significant outcomes (overall test $p<0.05$ and Post Hoc test $p<0.05$) are printed in bold font. [b] Corrected for total fat intake at six months post test; [c] Standardized differences between feedback and generic conditions at 6 months; standardized effect sizes can be categorized as small (ES = 0.2-0.5), moderate (ES = 0.5-0.8) or large (ES > 0.8).

Furthermore, significant group effects were found for fat intake (F(3,272)=3.38; p=.019) and saturated fat intake (F(3,272)=3.77; p=.011) among the 'risk consumers' and for fat intake (F(3,226)=4.47; p=.005) and saturated fat intake (F(3,226)=4.91; p=.003) among the 'under estimators'. Post-hoc analyses showed that among the 'risk consumers' and among the 'under estimators' total fat and saturated fat intake were significantly lower in the PNA-feedback condition compared to the generic condition.
Among the 'risk consumers' and 'under estimators' the effect sizes of total fat and saturated fat intake of the feedback-conditions compared to the generic condition were small (P- and PN-feedback) to moderate (PNA-feedback).

DISCUSSION

In this study we investigated which combination of feedback elements (Personal-feedback, Personal-Normative-feedback or Personal-Normative-Action-feedback) was required for a computer-tailored fat reduction intervention to be effective in improving awareness of one's own dietary fat intake, intention to reduce fat intake and fat intake itself, at one and six months post-intervention. Our results indicate that the combination of PNA-feedback is necessary to achieve significant changes in awareness of one's own fat intake (one month post-intervention) and in intention to reduce fat intake and (saturated) fat intake levels (most apparent at six months post-intervention). P-feedback only had some effects on awareness and intention to reduce fat intake, while the combination of PN-feedback had some effect on intention. Effects were only found among respondents who should profit most: those with higher than recommended fat intakes at baseline and those who underestimated their fat intake levels.

The finding that the most elaborate combination of feedback elements was effective in inducing changes in fat intake is comparable with previous computer-tailored intervention studies in which similar combinations of feedback elements resulted in behavior change [2]. Investigation of dismantling an elaborate feedback intervention into its smaller components that contribute to bringing about a behavior change process has not often been done before. Some studies compared brief versus more elaborated interventions, but these studies did not unravel the effects of various types of feedback on behavior [11, 13], as we did in our study. The study most comparable to ours was that by Brinberg and colleagues [12]. They investigated the difference between personal feedback (daily dietary fiber intake) and personal feedback combined with detailed feedback (somewhat comparable to our action feedback element) on all products in the personal diet. They concluded that the combination of the two feedback types was most effective in changing behavior, similar to the results of this study.

Our observation that PNA-feedback was needed to result in behavior changes is consistent with insights from theories that consider the behavior change process as consisting of a motivational and a volitional phase [27]. Action feedback, which is information on how to change, may be considered a strategy supportive to the initiation of behavior change. According to the Precaution Adoption Process Model, behavioral feedback (personal and normative feedback) is required to make a person aware of his/her risk behavior and to increase intention. Once people are in the phase of having decided to act, information guiding them to make actual changes is needed [15]. In practice, all people seem to have a need for this type of information. One of the most often heard complaints of participants of a brief computer-tailored intervention on smoking cessation was a lack of practical information about 'how-to-stop-smoking' techniques [28].

Based on the PAPM we would have expected that personal feedback and normative feedback by themselves were sufficient to improve awareness and intention. In this study the effect of P-feedback on awareness of one's own fat intake and intention to change seems limited at first sight. However, the effects we did find were in the subgroup of respondents who were not aware of their risk behavior, and this is quite consistent with the theory. Therefore, we conclude that personal feedback can contribute to improving awareness and intention to change in this subgroup, but is not sufficient to induce behavior change.

In contrast to expectations, we did not find the combination of PN-feedback to affect awareness, even though it is known that many people have an optimistic bias with respect to fat consumption (i.e., think they eat less fat than others) [14, 16]. The normative feedback that we used in this study (comparing one's behavior with that of peers) can be regarded as social comparison information and was aimed at decreasing an optimistic bias in one's own risk behavior. Possible explanations for the lack of an effect of this feedback on awareness may be that people can respond to discrepant social comparison information either by doubting the accuracy of the information or by minimizing the importance of the health behavior [29]. Minimizing the importance of dietary fat intake has been found to occur in a study by Fries and colleagues [30]. They argue that this tendency may enable people to maintain a cognitive buffer (e.g. maintain the unrealistic perception of own fat intake) that could keep them from changing risky diet behavior [30]. Getting feedback on a risk behavior without having the knowledge or skills to actual change might enhance this defensive coping mechanism [14]. This may explain why in the group who received PNA-feedback awareness improved. In this condition participants received normative feedback only when they had diets higher in saturated fat than their peers and additional information on how to change was provided. The design does, however, not allow us to determine whether it is the fact that only normative feedback when performing 'worse' than peers contributes to increasing awareness, or

whether it is the combination with additional information about how to change that contributes to increased awareness.
The finding that PN-feedback had an effect on intention to change six months post-intervention may indicate that the normative feedback resulted in inducing elaboration likelihood later on [31]. People may have become more attentive to the behavior of others [32].

One issue that remains to be explained is why we did not find any significant effects of the feedback conditions in the total study population. The differences between feedback conditions and the generic information condition among the total population may be diluted by the outcomes among the respondents whose fat intake complied with the guidelines and who had a realistic perception of their own fat intake. In agreement with the feedback that these respondents would have received they would not be likely to have changed perceptions or behavior.

The sizes of the intervention effects were mostly small, some were moderate. This is consistent with results of previous studies on computer tailoring [2]. We provided only one dose of the intervention, and based on this, probably no larger effect sizes can be expected. Two studies have shown that multiple doses of a tailored dietary intervention produced greater behavioral effects compared to only one dose [33, 34].

Several characteristics of the study have to be taken into account in interpreting the findings. First, the present study was based on a self-selected sample of volunteers. This resulted in a study population in which highly educated respondents were over-represented (43 finished a bachelor degree or higher versus 25% in Dutch population at large) [35] and with a higher proportion of people with lower fat intake levels at baseline (53% had a higher than recommended saturated fat intake versus 90% in Dutch population at large) [36]. Furthermore, only a small percentage of potentially eligible people volunteered and we may assume that people who were most engaged in the topic of healthy eating were more likely to participate. In addition, we used a self-reported fat intake measure, which is liable to various measurement problems [37] and measured cognitions with single items, which decreased the reliability. Our study deviated somewhat from a true dismantling study, since the normative feedback in the PN and PNA condition were not strictly the same. Therefore, the findings should be interpreted as results from a comparison between three separate conditions that provided various forms of feedback. Finally, to reduce the burden for respondents to participate in this study, we decided not to do a pretest with the extensive food frequency questionnaire used at the two posttests. An RCT with post-test only is a valid study design, since the randomization procedure should result in equality of study groups [20]. Based on our study design and the test of equivalence on other participants' characteristics, we assume that randomization indeed resulted in equal groups at baseline. However, we cannot completely rule out that there were baseline differences in the outcome measure when assessed with the elaborate instrument, since we were not able to test that.

Based on these findings we can conclude that adults with high levels of fat intake at baseline and/or those who underestimate their fat intake benefit more from interventions with a combination of personal, normative and action feedback in inducing changes in fat intake and improving awareness of personal risk behavior. The separate feedback elements contribute to these effects, but are not sufficient on their own. Therefore, future interventions should continue to incorporate these different individualized feedback elements.

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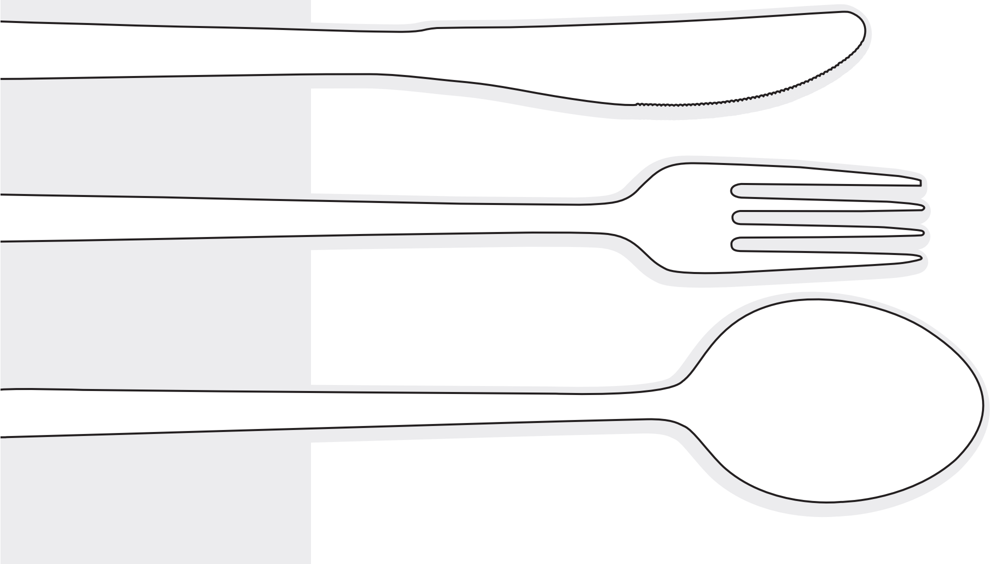
CHAPTER 4

The efficacy of web-based and print-delivered computer-tailored interventions to reduce fat intake



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ABSTRACT

Objective: To test and compare the efficacy of interactive- and print-delivered computer-tailored nutrition education targeting saturated fat intake reduction.
Design: A 3-group randomized controlled trial [2003-2005] with posttests at 1 and six months post-intervention.
Setting/Participants: A convenience sample of healthy Dutch adults recruited via worksites and 2 neighborhoods in the urban area of Rotterdam (n=442).
Interventions: An interactive computer-tailored intervention delivered on a CD-ROM (interactive-tailored condition), a print-delivered computer-tailored intervention (print-tailored condition), and print-delivered generic information.
Main Outcome Measures: Total and saturated fat intake (grams/day [g/d] and percent-energy) and energy intake per day assessed with validated food frequency questionnaires at one and six months post intervention.
Analysis: Multilevel linear regression analyses.
Results: Mean total fat (g/d), saturated fat (g/d) and energy intakes were significantly lower in both the tailored conditions compared to the generic condition at one month follow-up. These differences were still significant for the print-tailored condition at six months follow-up. Effects were most pronounced among participants with unfavorable fat intakes at baseline. There were no significant differences between the two tailoring conditions.
Conclusions: The results indicate that interactive and print-delivered computer-tailored interventions can have similar short-term effects on fat intake and that the effects of the print delivered tailored feedback are maintained in the longer term.

INTRODUCTION

Computer-tailored health education, the technique by which the educational information is matched to each individual's unique characteristics, behaviors, perceptions of behavior and/or motivation to change as derived from an individual assessment [1], is a promising health education technique, particularly for nutrition education [2]. However, the evidence regarding the efficacy of computer-tailored interventions is mainly based on studies of print-delivered interventions, whereas the Internet is becoming an increasingly popular medium for the delivery of nutrition education interventions.

Providing computer-tailored interventions through interactive delivery channels such as the Internet is recommended because such interactive media allow for a greater extent of interactivity in providing the computer-tailored feedback, which may potentially enhance the efficacy of the intervention [3]. Second, Internet-delivery enables access to up-to-date interventions wherever there is an Internet connection [4, 5]. Thirdly, population-wide distribution is possible with relatively low costs.

Despite these promising characteristics, there is lack of empirical evidence on the merits of interactive computer tailoring. The few studies that have evaluated the effects of web-based or multi-media computer-tailored nutrition interventions targeting dietary intake have found mixed results [6-12]. There is a need for additional well-designed studies to evaluate the efficacy of interactive computer-tailored nutrition interventions compared to generic nutrition education and to print-delivered computer tailoring. Print-delivered interventions may have advantages over interactive delivery modes, because it may be easier to read and process information from a paper print than from a computer screen [13, 14], and people may be more likely to save and reread such print-delivered feedback [13]. Differential effects of computer-tailored nutrition interventions through print or interactive delivery modes have not been examined to date.

This study aimed to 1) evaluate the effects of an interactive computer-tailored fat reduction intervention (delivered on a CD-ROM, but ready to be disseminated through the Internet) and a print-delivered version of identical content, compared to generic fat reduction information and 2) to compare the efficacy between both computer-tailored interventions, especially among those for whom it is particularly important to reduce their fat intake, i.e., people with higher than recommended fat intake levels at baseline (called 'risk consumers').

The study focused on saturated fat intake as the target behavior, since this is one of the prominent dietary risk factors associated with a number of chronic diseases (cardiovascular diseases in particular) [15, 16] and undesirable intake levels have a high prevalence in Western countries

[17-19]. Moreover, computer tailoring is a technique well suited to include behavior change strategies (e.g. feedback) that are appropriate for modifying complex health related behaviors such as saturated fat intake. A problem often observed in relation to complex health related behaviors [20-22] is that many people are not aware of their own risk behavior. According to the Precaution Adoption Process Model [23] awareness of ones risk behavior is a prerequisite for the intention to change. Feedback about ones risk behavior is an appropriate strategy for improving awareness, an important first step towards behavior change. To proceed from intention to actual performance of a behavior improved self-efficacy and skills for how to change are needed and individualized feedback about personal change options can be provided to achieve this.

METHODS

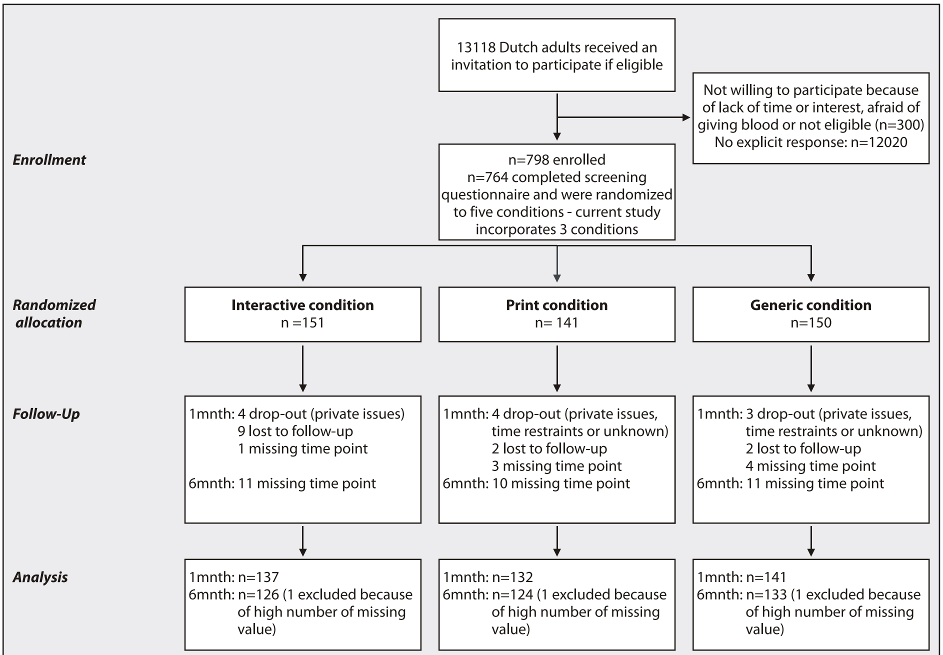
Design and Procedure

This study involves 3 arms of a larger randomized controlled trial with 5 study arms. The aim of the larger study (conducted between 2003 and 2005) was to investigate different aspects of computer-tailored interventions aimed at dietary fat reduction (Trial registration: ISRCTN01557410). The current study included the study groups that received CD-ROM or print-delivered computer-tailored nutrition education or generic nutrition education and used self-reported total and saturated fat intake measured by a food frequency questionnaire as outcome measures. The groups in the other 2 study-arms not included in this study received less extensive forms of the print-delivered computer-tailored information.
All participants gave written informed consent after receiving written information about the study. After completion of the baseline paper and pen screening questionnaire, respondents were randomized to 1 of 5 study conditions in a computer-determined sequence, stratified by source (each company or community). The intervention materials were sent to the respondents' home addresses within two weeks after returning the screening questionnaire. One and six months later posttest questionnaires had to be completed. Participants who did not return their questionnaires were contacted by e-mail or telephone once. Approval for the research project was obtained from the medical ethics committee of Erasmus University Medical Center Rotterdam.

Recruitment of Participants

Recruitment was conducted in 2003 and 2004 using 2 strategies: recruiting employees through large companies and door-to-door advertising in 2 neighborhoods in the Rotterdam area, the second largest city in the Netherlands. The information packages contained an invitation letter, an information leaflet, a declaration of approval of the study by the medical ethics committee of Erasmus MC Rotterdam, an application form, an informed consent form, and the bylaw on health insurance for participants. Eligibility criteria were: 18-65 years of age, sufficient understanding of the Dutch language, no diet prescribed by a dietitian or physician, and no treatment for hypercholesterolemia.

Nine out of 30 companies agreed to distribute the information package among their employees, and 574 out of 4118 employees volunteered to participate. Nine thousand leaflets with brief information about the study were spread door-to-door among citizens in the 2 neighborhoods. Citizens who expressed their interest in participating (by pre-stamped response card, telephone or e-mail) received the information package, and 224 respondents enrolled in the study. Recruitment activities resulted in a total of 798 (574 + 224) participants that started the study of which 764 respondents filled out the screening questionnaire (Figure 4.1). A total of 442 respondents (310 from companies and 132 from communities) were assigned to the 3 conditions presented in this paper; 151 to the CD-ROM condition, 141 to the print-condition and 150 to the generic information condition.
A power calculation showed that with 82 participants in each condition at posttest a relative difference of 8.7 grams/day (g/d) in saturated fat intake (with an assumed intake of saturated fat in the generic information group of 43.5 g/d), could be detected with a statistical power of 0.90 (2-tailed; p < .05).



Notes: Drop-out and lost to follow up, cases with missing data at 1 month and 6 months. Drop-out notified us, lost to follow-up did not. Missing time point reflects cases with missing data on specific time point. n = sample size; mnth = month(s)

Figure 4.1. Recruitment and retention flow chart

Intervention Materials

Computer-Tailored Interventions

All necessary components for generating a computer-tailored intervention (screening instrument, tailoring algorithms and feedback library) were adapted from earlier work of Brug et al [24] and Oenema et al [11]. The computer-tailored interventions were informed by the Precaution Adoption Process Model and the Theory of Planned Behavior, as previously described in more detail in these studies [11, 24].

The screening instrument

Fat intake was assessed with a short validated food frequency questionnaire (FFQ) of 35 questions covering the 19 (categories of) food items that contribute most to saturated fat intake in the Dutch diet (Pearson correlation with a 7-day diet record = 0.70). Participants could indicate how frequently, how much and what type (high-medium-low fat) of the food items they usually consumed in the past 4 weeks. An individual fat score can be calculated by adding up the 19 fat scores for each subject (ranging from 0-80) [25].

Furthermore, perception of own fat intake in terms of high and low, attitude (bad or good to eat less fat), self-efficacy (difficult or easy to eat less fat), readiness to reduce fat intake were assessed as well as self-efficacy (difficult or easy to eat less fat) in four potential difficult situations (eating out, eating at someone else's place, eating at parties, eating snacks). This screening instrument was used for generating the tailored feedback.

The feedback library

The feedback library contained messages aimed at increasing awareness of own fat consumption by providing feedback on fat intake. Messages were tailored on fat score and the recommended intake for a person of the recipient's gender and age (intake is good or higher than recommended) and his/her own perception of that intake (under estimator, realist or over estimator). Feedback about the fat intake of same age, same sex peers was given when personal fat consumption was higher than the consumption of peers. The consumption levels of peers were derived from national consumption data of the Dutch adults [26]. The feedback was visualized in a graph with bars for personal fat score, recommended fat score and (if relevant) the fat score of peers.

Another series of messages addressed motivational feedback, based on attitude (reducing fat intake is good - neutral - bad), self-efficacy (reducing fat intake is difficult - neutral - easy) and readiness to reduce fat intake.

To provide suggestions for how to change, practical product feedback addressed the most important sources of fat (based on frequency of consumption and type of products derived from the screening instrument) in the recipient's diet and provided information on low-fat alternatives. Furthermore, feedback was given on how to lower fat intake in situations perceived as difficult, such as eating out or being at a party. A schematic overview of the computer-tailored information and some examples of feedback messages is given in Table 4.1.

The interactive-tailored condition

In the 'interactive-tailored condition', the whole program consisted of html pages and appeared as a web-based intervention, but was stored on a CD-ROM for the present study, to improve exposure and avoid contamination between groups. The program started with a homepage, explaining the nature and goal of the program and how to use it. By clicking the button in the menu bar, the screening questionnaire started. Immediately after completion the individualized computer-tailored information appeared on-screen. The information started with a personalized opening, followed by a general introduction to the topic of fat in the diet and it's relation with health. The program also contained a page with low-fat recipes for starters, main courses and desserts. It was possible to print the feedback, but the program did not (automatically) save the generated advice. Respondents in the interactive condition received the CD-ROM at their home address with the request to use the program that same week. The program could be used on any computer with Internet Explorer 5.0 or higher.

The print-tailored condition

The paper and pen screening questionnaires from the computer-tailored print condition (from now on called print-tailored condition) were scanned and imported into the computer-tailoring program that generated individualized computer-tailored print feedback letters, which were 1.5 – 4 pages in length. The information started with a personalized opening, followed by a general introduction to the topic of fat in the diet and it's relation with health. If interested, respondents received recipe suggestions for low-fat starters, main courses, or desserts. The letter was sent to the home address of the respondent within 2 weeks after returning the screening instrument.

Generic Condition

The control condition consisted of non-personalized, non-tailored generic nutrition information (from now on called generic condition). The information explained the importance of a healthy diet and more specifically the importance of a limited amount of fat in the diet. It furthermore stressed that the fat intake of the average Dutch male/female is generally higher than recommended and higher than they expect and that this might be the case for the reader as well. Practical information on high-fat products and suggestions to reduce fat intake were provided. The length of the generic information was 2 pages in print. The lay-out of the generic condition and the print-condition letters was the same.

Table 4.1: Overview of the computer-tailored information and examples of individualized messages for a 29-year-old male

Section	Content of the messages and examples	Diagnostic variables for tailored feedback
Introduction	• Personalized (name, gender) heading and introduction • Generic basic information on dietary fat and health; Emphasis that the information and feedback following this introduction is based on and tailored to the personal answers provided on the questionnaire ***Example:*** *Dear Mr. Doe*	Name and gender
	• Encouragement to take responsibility for own consumption and to discuss the information with the person who does the shopping and/or cooking (if applicable). – 1 message/person ***Example:*** *You have indicated that you do not cook meals or do the grocery shopping regularly. Maybe, you wonder if this information can therefore be of use to you. Well, in the end it is you who decides what you eat, and how much. So do discuss the information and feedback with the person who does most of the cooking and shopping for you.*	Cooking (yes/no) and Grocery shopping (yes/no)
Feedback about personal fat intake	• Increase awareness of own fat intake by providing feedback on personal fat score compared to recommended intake level for someone of his/her gender and age and to his/her own perception of that intake level – 1 message/person • Reduce optimistic bias ('my consumption is better than that of peers') by comparing the personal fat score to the average fat score of peers in case fat score was higher than fat score of those peers – maximum 1 message/person • Graphical representation of fat score with a bar for personal fat score, recommended fat score and fat score of peers (if relevant) ***Example a):*** *You have indicated that you think that you eat a lot of fat. Indeed, from your answers to the questionnaire it appears that you probably eat more fat than recommended by experts. You have 21 fat points. One fat point is the equivalent of about 4 grams of fat per day. You should not eat more, and preferably less, than 19 fat points a day. This is also shown in the graph.* ***Example b):*** *You have indicated that you think that you eat little fat. However, from your answers to the questionnaire it appears that you do eat more fat than recommended by experts. You also eat more fat than most other men of your age. You have 25 fat points. One fat point is the equivalent of about 4 grams of fat per day. You should not eat more, and preferably less, than 19 fat points a day. This is also shown in the graph.*	Gender; age (<30y; 30-40y; 40-50y; >50y); fat score; recommended fat score; fat score of peers; perception of own intake ('How much fat do you think you eat?', 5-point scale very little/very much)

Section	Content of the messages and examples	Diagnostic variables for tailored feedback
Motivation and suggestions for Changing fat intake	• Motivational feedback; feedback tailored to readiness to reduce fat intake and cognitions regarding reduction of fat intake, related to evaluation of personal fat score with an encouragement to reduce fat intake (if necessary) – 1 message/person ***Example:*** *You indicated in the questionnaire that you do not intend to eat less fat – that is unfortunate. However, you did indicate that you do not find it difficult to eat less fat. After reading the information about the amount of fat you eat, you have possibly changed your mind about reducing fat intake. If so, please read more below on the most important sources of fat in your diet and how you can replace these with low-fat products.*	Readiness to eat less fat than you do now (motivation to reduce fat intake within half a year, within a month, already trying to reduce fat intake, past attempt, maintenance of past attempt); Attitude ('Do you think that it is bad or good to eat less fat than you do now?', 5-point scale very bad/very good); Self-efficacy ('Do you think it is difficult or easy to eat less fat than you do now?', 5-point scale very difficult/very easy)
	• Action feedback; practical behavior change information addressing the most important sources of fat in the personal diet and suggestions for low-fat alternatives with encouragement to change – 0 to 17 messages/person ***Example:*** *You use full fat milk. Semi-skimmed milk contains less fat; it saves almost 4 grams of fat per glass of milk. If you drink low-fat milk it even saves up to 7 grams of fat per glass. However, many people do not really like low-fat milk. You could at least use low-fat milk when cooking sauces, porridge or pancakes. Further, buttermilk contains much less fat compared to full fat or semi-skimmed milk.*	Sources of fat identified based on the screening instrument categorized by milk and milk products, sandwich fillings, dinner entrees and snacks (examples of products: full fat milk, porridge, butter, cheese, meat eaten at dinner, gravy, cake, chocolate)
	• Feedback on how to deal with perceived difficult situations – 0 to 4 messages/person ***Example fragment a):*** *Making your choice from the menu; Grilled or roasted meat, fish or poultry is usually less fat.* ***Example fragment b):*** *When you would like to order a dish with a sauce, ask if they can serve the sauce in a separate bowl. That way, you can decide yourself how much sauce you would like to take. In addition, red sauces usually are less fat than 'white' sauces.* ***Example fragment c):*** *Do you think it is hard to refuse a snack at a party? Save a bit of the snack you already have as long as possible so you have an easy excuse when saying no (you already have something).*	Situational self-efficacy for 4 specific situations ('Do you think that it is difficult or easy for you to eat less fat when: eating out / eating at someone else's home / at parties / eating snacks in between meals)
Recipes	• Recipes tailored to preferences – 0 to 10 recipes/person in the print condition; participants in the interactive could choose from a web page with a list of 56 recipes	Interest in recipes for starters (yes/no), main courses (yes/no) and desserts (yes/no); Per course recipe options for main ingredients chicken, meat, fish or vegetarian and for rice, potatoes or pastas

Measurements

Baseline characteristics

The paper and pen screening questionnaire included questions on gender, age, education level, height and weight (to calculate body mass index [BMI]) and fat score. Based on the fat score assessed with the screening instrument, participants were categorized as 'risk consumers' when their fat intake exceeded the recommended level of fat intake for their gender and age.

Food frequency outcome measures

Daily intake of total fat and saturated fat (grams and percentage of daily energy intake (en%)) and energy (Mega Joules) at one month and six months post intervention were assessed using an extensive paper and pen FFQ. This questionnaire was validated (Pearson correlations compared to dietary history were 0.83, 0.78 and 0.75 for the intakes of energy, total fat (g/d) and saturated fat (g/d) respectively) [27] and last revised according to the Dutch National Food Consumption Survey of 1998 [26]. The questionnaire consisted of 104 food items and was organized according to meal pattern. Participants recorded their frequency of consumption and portion size for a selection of food items eaten during meals or in between meals. This more extensive FFQ was used for posttest measurements since it allows calculation of total energy intake and percent energy from fat.

Process evaluation outcome measures

Use of the intervention materials at one month post intervention was measured in terms of whether the information was read ('I read all of the nutrition information' [yes/no]), saved ('I saved the nutrition information' [yes/no]) and discussed ('I discussed the nutrition information with others' [yes/no]).

Statistical Analyses

To explore equality between groups at baseline Chi-Square tests for categorical variables (gender, education, percentage 'risk consumers'), and one-way ANOVA (2-tailed, $p < .01$) for continuous variables (age, BMI and fat score) were conducted. Logistic regression analyses were conducted to examine intervention condition, gender, age and fat score as predictors of dropout at both one and six months posttest (2-tailed, $p < .05$, SPSS version 11.0, Chicago, IL).

Participants were nested within companies or communities, with the probability of interdependence between participants and their source. To take this into account, multilevel linear regression analyses with random intercepts for the two levels (companies/communities and individual) were conducted to test for differences between the conditions on daily total fat

intake, saturated fat intake (both in grams and en%) and energy intake at one and six months post intervention. For each outcome measure one regression analysis was conducted with the intervention condition variable dummy coded (generic condition was the reference group), to test the effects of both tailoring interventions compared to the control group. In a second regression analysis the intervention condition variable was dummy coded with the print computer-tailored condition as the reference group to compare both tailoring conditions. The complete case analyses were performed for the total study population and for the subgroup 'risk consumers' (2-tailed, $p < .05$, MLwiN version 1.10.0007, Bristol, UK).
Chi-Square tests were used to examine group differences in use (read, saved and discussed – discussed only among respondents who had read the information) of the information among the total population and among the 'risk consumers' in SPSS version 11.0, Chicago, IL.

RESULTS

Participants

A total of 410 respondents (93% response) completed and returned the 1-month posttest questionnaire and 386 the 6-month posttest questionnaire (87% response). No baseline differences in gender, age, education level, BMI, fat score and percentage of 'risk consumers' were found between the study conditions (Table 4.2). No differences in dropout were found between study conditions, but older respondents (OR= 1.03; 95% CI = 1.001-1.061) and women (OR= 2.01; 95% CI = 1.100-3.676) were more likely to drop out six months post intervention than younger and male respondents respectively.

Table 4.2: Baseline population characteristics of the interactive and print computer-tailored conditions and the generic information condition

		Interactive (n=151)	**Print** (n = 141)	**Generic** (n=150)	**Differences between study groups, p-values**
gender (% female)		53.6 %	55.3 %	56.0 %	.915[a]
age (years, mean ± SD)		44.0 ± 10.56	43.4 ± 10.1	44.1 ± 9.7	.815[b]
education	elementary	2.6%	3.6%	2.0%	.985[a]
	lower secondary	19.2%	18.6%	18.4%	
	higher secondary	33.8%	35.0%	37.4%	
	tertiary	44.4%	42.9%	42.2%	
BMI (kg/m^2, mean ± SD)		25.5 ± 3.8	25.5 ± 4.3	25.3 ± 3.8	.864[b]
fat score (mean ± SD)		17.5 ± 6.2	16.9 ± 5.5	17.9 ± 6.6	.422[b]
risk consumers[c]		48.3 %	50.0 %	50.7 %	.917[a]

n = sample size; SD = standard deviation; BMI = body mass index; [a.] p-value derived from Pearson Chi-Square; [b.] p-value derived from One-way ANOVA; [c.] percentage with pretest fat score above gender-age specific cut off point

C H A P T E R 4

Effects on Total Fat, Saturated Fat and Energy Intake

Descriptive statistics for one and six months follow-up are presented in Table 4.3.

Table 4.3: Daily consumption of total fat, saturated fat and energy in computer-tailored and generic conditions

	1 month post-test ~ Mean (SD)			6 month post-test ~ Mean (SD)		
	Interactive	**Print**	**Generic**	**Interactive**	**Print**	**Generic**
Total Population	n=137	n=132	n=141	n=126	n=124	n=133
total fat (g)	77.4 (30.9)	80.5 (25.7)	88.4 (39.9)	77.9 (30.4)	76.1 (26.9)	83.0 (34.2)
saturated fat (g)	28.3 (12.9)	28.9 (9.8)	31.4 (15.0)	28.5 (10.0)	27.0 (10.0)	29.5 (13.7)
energy (MJ)	8.6 (2.5)	8.3 (2.7)	9.4 (3.1)	8.4 (2.5)	8.2(2.4)	8.9 (3.0)
total fat (en%)	35.1 (6.2)	35.6 (6.4)	35.0 (6.7)	34.8 (5.9)	34.9 (5.6)	35.0 (5.7)
saturated fat (en%)	12.7 (3.0)	12.8 (3.1)	12.4 (2.8)	12.6 (2.9)	12.4 (2.5)	12.4 (2.5)
Risk Consumers	n=68	n=66	n=72	n=63	n=63	n=69
total fat (g)	87.9 (35.1)	86.6 (23.6)	104.2 (44.1)	86.1 (32.5)	79.6 (26.7)	96.7 (36.8)
saturated fat (g)	32.8 (15.2)	31.3 (9.4)	37.1 (16.9)	32.2 (14.3)	28.1 (9.5)	35.0 (15.3)
energy (MJ)	9.1 (3.0)	8.8 (2.2)	10.7 (3.4)	8.9 (2.7)	8.3 (2.3)	10.2 (3.2)
total fat (en%)	36.1 (6.1)	37.5 (6.8)	36.5 (6.5)	36.2 (6.0)	36.1 (5.1)	35.9 (5.6)
saturated fat (en%)	13.4 (3.0)	13.6 (3.4)	13.0 (2.7)	13.4 (3.1)	12.8 (2.3)	12.9 (2.4)

SD = standard deviation; n = sample size; g = grams; MJ = Mega Joules; en% = proportion of total energy intake

Interactive tailoring versus generic information

At one month post intervention mean total fat (g/d), saturated fat (g/d) and energy intake were significantly lower in the interactive-tailored condition in the total study population (Table 4.4). Total fat and energy intake also were significantly lower for the interactive-tailored condition in the subgroup of 'risk consumers'. At six months post-intervention energy intake was significantly lower for the interactive-tailored condition in the 'risk consumer' subgroup only.

Print tailoring versus generic information

At one month post-intervention mean total fat (g/d) and energy intake were significantly lower in the print-tailored condition among the total study population and among the 'risk consumers'. Saturated fat (g/d) was also significantly lower in this subgroup (Table 4.4). At six months post-intervention energy intake remained significantly lower in the print-tailored condition in the total study population. Total fat, saturated fat and energy intake also were significantly lower in the print-tailored condition among the subgroup of 'risk consumers'.

Interactive versus print tailoring

No significant differences were found between the interactive-tailored condition and the print-tailored condition on any of the outcome measures, at any point in time, neither in the total population nor among 'risk consumers' (results not shown).

Table 4.4: Results of multi-level regression analysis, testing post-test differences in DAILY fat and energy intake levels between the interactive and print computer-tailored conditions and the generic condition

		Interactive vs Generic						Print vs Generic					
		1 month			6 months			1 month			6 months		
		b	95% CI		b	95% CI		b	95% CI		b	95% CI	
Total population	total fat (g)	**-10.93**	**-18.63**	**-3.23**	-5.14	-12.61	2.33	**-7.82**	**-15.59**	**-0.04**	-6.90	-14.40	0.60
	saturated fat (g)	**-3.15**	**-6.15**	**-0.15**	-1.08	-4.06	1.91	-2.43	-5.46	0.60	-2.48	-5.47	0.51
	energy (MJ)	**-1.07**	**-1.72**	**-0.43**	-0.52	-1.16	0.12	**-0.78**	**-1.43**	**-0.12**	**-0.70**	**-1.34**	**-0.05**
	total fat (en%)	0.10	-1.40	1.59	-0.17	-1.56	1.21	0.60	-0.90	2.11	-0.16	-1.55	1.23
	saturated fat (en%)	0.10	-1.40	1.59	0.22	-0.42	0.86	0.60	-0.90	2.11	0.03	-0.67	0.61
Risk Consumers	total fat (g)	**-16.45**	**-27.84**	**-5.05**	-10.83	-21.77	0.12	**-18.79**	**-30.32**	**-7.27**	**-17.62**	**-28.57**	**-6.67**
	saturated fat (g)	-4.40	-9.03	0.23	-2.71	-7.26	1.84	**-6.21**	**-10.89**	**-1.52**	**-6.77**	**-11.32**	**-2.23**
	energy (MJ)	**-1.51**	**-2.46**	**-0.57**	**-1.25**	**-2.18**	**-0.31**	**-1.87**	**-2.83**	**-0.92**	**-1.85**	**-2.78**	**-0.91**
	total fat (en%)	-0.54	-2.63	1.54	0.14	-1.72	2.00	0.68	-1.43	2.79	-0.10	-1.97	1.76
	saturated fat (en%)	0.39	-0.61	1.39	0.47	-0.41	1.35	0.62	-0.38	1.63	-0.15	-1.03	0.73

Model – multilevel linear regression analyses with random intercept at company/neighbourhood level; b = unstandardized regression coefficient; 95% CI = 95 % Confidence Interval; g = grams; MJ = Mega Joules; en% = proportion of total daily energy intake; Significant outcomes are printed in **bold** font. Interpretation example: Among the total population participants in the interactive-tailored condition ate almost 11 grams of total fat/day less compared to participants in the generic condition 1 month after the intervention; this difference was significant.

Use of the intervention materials

There was a significant difference between the groups with respect to information read. Of the participants, 81% in the interactive-tailored condition, 95% in the print-tailored condition, and 94% in the generic condition reported to have read all the information (Pearson Chi-Square = 17.35, P = .00). With respect to information saved, 77% in the interactive-tailored, 97% in the print-tailored, and 84% in the generic condition saved the information (Pearson Chi-Square = 20.67, P = .00). No significant differences were found between the groups with respect to information discussed (Pearson Chi-Square = 2.12, P = .35). The same patterns of use were found among the risk consumers.

DISCUSSION

This study provides evidence that, in the short-term, interactive and print-delivered computer-tailored fat reduction education have similar effects on total fat, saturated fat and energy intakes compared to generic information. Effects for saturated fat intake were found for the interactive-tailored group in the total study population and for the print-delivered intervention among the 'risk consumers'. In both tailoring conditions, the effects were most pronounced in the subgroup of 'risk consumers'. Even though these effects on the fat outcome measures were maintained at longer term in the print-delivered condition only, there were no significant differences between the interactive-tailored and the print-tailored condition at any point in time.

Our findings are consistent with previous studies and add to the body of evidence of efficacy of computer-tailored interventions delivered through both interactive and print media. A systematic review on computer-tailored dietary interventions [2] showed that 5 out of 9 included studies evaluating interactive-tailored programs against a no-information control group found significant effects on fat intake up to six months post intervention in favor of the computer-tailored interventions. The majority of the included tailored-print interventions also reported significant effects compared to no-information or generic information.
In the current study the effects were especially found among the subgroup of 'risk consumers', i.e. the group that preferably should profit most from the intervention. This is probably due to the fact that this group received feedback that clearly stated that it would be important for them to change (as opposed to those who already comply with the guidelines). Further, among the 'risk consumers' there was more room for improvement in their diet resulting in a larger choice of products in which changes could be made. We did, however, not explore in further detail what changes this group exactly made.

Our study is novel in simultaneously evaluating the effects of an interactive and an identical content print-delivered computer-tailored intervention compared to generic information. This design provides the opportunity to compare the efficacy of both delivery modes. We did not find differences between the delivery modes, which implies that both modes can be chosen for an intervention aimed at promoting lower fat diets in adults. The finding that the effects of the interactive-tailored intervention were not maintained over the longer term warrants further investigation. One possible explanation that previously has been advanced [11] is that participants are more likely to keep and reread print-delivered information. In this study there seems to be evidence to support this. Process evaluation data indicate that the print-delivered information (and even the generic information) is read and saved more often. Other explanations, however, should be considered, such as greater memorability and/or cognitive processing of printed information compared to on-screen info.

As far as we know there are no studies comparing the effect of a web-based intervention with an identical content intervention delivered in print-format aimed at improvement of diet. There are two studies in the domain of physical activity [28, 29] that compared web- and print delivered information. Marshall et al [29] compared stage-targeted interactive with print-delivered information among adults and Marks and colleagues [28] compared generic interactive with print-delivered information among adolescent girls; both found print-information to be more effective. Their explanations to these findings include that the use of a web-based intervention might be more complicated and therefore limited [29] or that differences in the mode of delivery may account for the variability in outcomes because the characteristics of the print intervention may elicit greater attention to and processing of messages than the web-based intervention [28].

The strengths of the current study include the use of a randomized design, comparing identical content computer-tailored interventions delivered in interactive format or print-format, using a control group receiving generic information (i.e. 'standard practice').
Our study also has limitations. First we had a self-selected sample of volunteers from mostly white-collar companies and middle-class communities, who were relatively highly educated, compared to the Dutch adult population at large (43% vs. 25% finished bachelor or higher) [30] and had a lower fat score at baseline (53% vs. 90% with a higher than recommended saturated fat intake) [31]. Furthermore, only a small percentage of potentially eligible people volunteered and we may assume that people who were more engaged in the topic of healthy eating were more likely to participate. This selective sample may limit the external validity of the results. To reduce the burden for respondents to participate in this study, we decided not to do a pretest with the extensive food frequency questionnaire used at the two post-tests. However, a pretest is basically not necessary for evaluation since we used a randomized

controlled design, assuming equal groups at baseline as was indicated based on the fat score of our screening instrument.

Even though we found some significant effects of both computer-tailored interventions on absolute total and saturated fat intake, there were no significant group effects for the proportion of total energy intake. A potential explanation of this finding is that respondents reduced their total energy intake, rather than the intake of specific nutrients in the diet. As a result, the proportions of the different nutrients did not change.

In addition, only one dose of the tailored intervention was provided. Heimendinger and colleagues have shown that multiple doses of a tailored dietary intervention produced greater behavioral effects compared to only 1 dose [32].

Finally, although the interactive-tailored intervention was designed and ready to be web-delivered, it was not provided over the Internet during the present study to improve exposure and avoid possible between-group contamination. Therefore, we cannot be sure whether the effects found in this study also apply if the intervention were provided over the Internet, where browsing to other websites is more likely.

To conclude, interactive and print-delivered computer tailored interventions can have similar short-term beneficial effects on total fat, and saturated fat intake in specific subgroups compared to generic information.

The results indicate that the differences in total and saturated fat intake between the print-delivered tailored feedback and the generic information may persist longer. Future studies should explore the users' preference for channel (interactive or print) and investigate strategies to sustain the effects of interactive interventions over the longer-term, for instance by using multiple feedback sessions. In addition data on cost-effectiveness of computer-tailored interventions should be collected.

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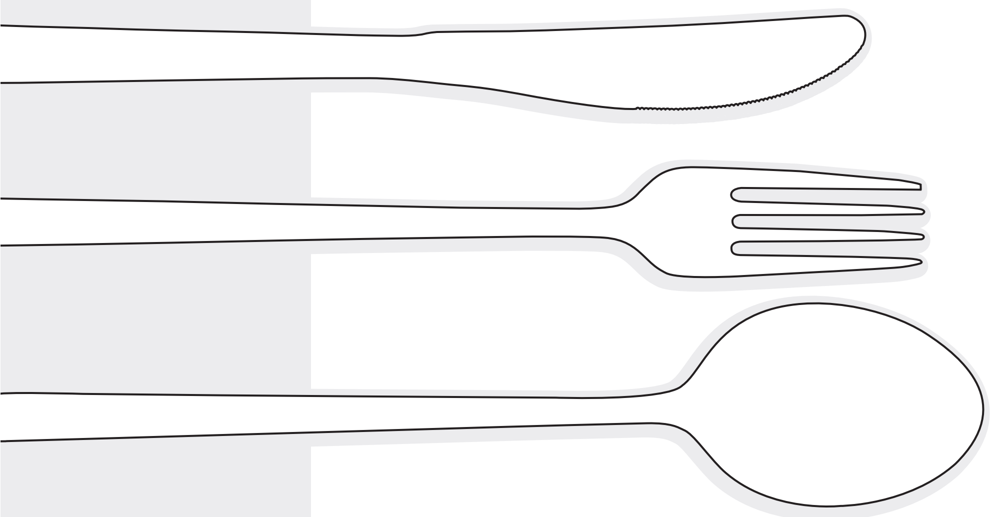
CHAPTER 5

Comparison of use and appreciation of a print-delivered versus CD-ROM-delivered computer-tailored intervention targeting saturated fat intake



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ABSTRACT

Background: Computer-tailored health education, a promising health education technique, is increasingly being delivered interactively, for example, over the Internet. It has been suggested that there may be differences in use and appreciation between print and interactive delivery of computer-tailored interventions, which may influence information processing. This may especially be the case for women, older people and people of lower socioeconomic status. Knowledge about differences in use and appreciation could help in choosing the appropriate delivery mode for a particular target audience.
Objective: The study investigates a content-identical computer-tailored intervention addressing saturated fat intake delivered via print or CD-ROM. We analyzed consumer use and appreciation of the feedback information and explored whether possible differences exist among gender, age and education subgroups.
Methods: Healthy Dutch adults (18-65 years), none of whom were under treatment for hypercholesterolemia, were randomly allocated to receive a computer-tailored program on CD-ROM (n = 151) or computer-tailored feedback in a printed letter (n = 141). At baseline, data were collected on gender, age, and education level. One month post-intervention, data were collected on the use (read, saved, discussed) and appreciation (trustworthiness, perceived individualization, perceived personal relevance and user-friendliness). Statistical analyses on the use and appreciation items were performed with Chi-square tests and independent-samples-t-tests.
Results: After exclusion of individuals with missing values, a total of 257 and 240 respondents were included in the analyses of the use outcomes of feedback read and saved, respectively. The results indicate that among the total population, the print feedback was read more often than the CD-ROM feedback (95% vs 81%; $P = .001$) and saved more often than the CD-ROM feedback (97% vs 77%; $P < .001$). Similar results were found among the gender, age and education subgroups. After exclusion of individuals who did not read the information and those with missing values, a total of 208-233 respondents were included in the analyses of the use outcome of feedback discussed and the appreciation items. The personal relevance of the print feedback was rated higher than for the CD-ROM-delivered feedback (0.97 vs 0.68; $P = .04$), but the effect size was small (0.28). These differences in personal relevance were also seen among women (1.06 vs 0.67; $P= .04$) and respondents aged 35-49 years (1.00 vs 0.58; $P = .03$), with moderate effect sizes (0.38 and 0.44, respectively).
Conclusions: Despite the possible advantages of interactive feedback, the present study indicates that interactive-delivered feedback was used less and perceived as less personally relevant compared to the print-delivered feedback. These differences in use and appreciation of delivery modes should be taken into consideration when selecting a delivery mode for a specific subgroup in order to optimize exposure.
Keywords: computer; Internet; tailoring; process evaluation; demographic differences; diet; nutrition education

INTRODUCTION

Computer-tailored health education

Computer-tailored health education delivers individualized information matched to each individual's characteristics [1, 2] and is a promising health education technique, particularly for (print delivered) nutrition education [3]. The Internet is increasingly being used for the delivery of computer-tailored interventions. There are many features that make the Internet an attractive medium for the delivery of computer-tailored interventions, such as the instant and continuous availability, the possibilities for interactivity, and the possibility to provide immediate feedback [4, 5]. Another potential advantage is that larger numbers of people can be reached for lower costs, as compared with print-delivered interventions [4, 6, 7].

There also may be disadvantages of providing computer-tailored interventions over the Internet: it may be more difficult to read or process information from a computer screen [8, 9], it may require more effort (i.e. starting the computer and the program) to receive the computer-tailored feedback and people may be less likely to save and reread interactive-delivered feedback [8]. Furthermore, it has been suggested that specific groups such as people from lower socioeconomic groups, women, and older people will not be reached with interventions over the Internet, because they may have more difficulty with and less interest in using interactive media [10-14].

On the other hand, some previous studies have shown that persons from lower socioeconomic groups have more interest in computer-tailored feedback compared to generic information [15-17]. In addition, the possibility to incorporate multiple mediums on the Internet to convey the information could reinforce comprehension for less-educated individuals [18]. Even though it has been suggested that there may be differences in use between print and interactive delivery of computer-tailored interventions the evidence to demonstrate this is still limited. The aim of the present study is to examine differences in use and appreciation of an identical-content print-delivered and interactive-delivered computer-tailored intervention.

Knowledge about differences in use and appreciation could help in choosing the appropriate delivery mode for a particular target audience.

Information processing and the delivery mode

Use and appreciation of an intervention are important factors to study, since they are prerequisites for active information processing [19, 20]. Active information processing is necessary for finally achieving changes in determinants and behavior [20]. Information processing starts with attention to the message [19] which can be operationalized as reading the information. The channel through which the information is provided is one of the factors that may determine attention to the message [19]. Attention to the message may be more easily achieved when the information is provided in a readily readable format or when it is provided by a medium that the receiver likes or knows how to use [13, 21].

Active information processing not only involves attention to the message, but also thoughtful consideration of the information content. Reading, saving and discussing the information with others may be indicators of active information processing. Furthermore, information is more likely to be attended to and actively processed, when it is perceived as interesting, personally relevant and individualized [22-26]. In a study by Oenema and colleagues perceived personal relevance and individualization were identified as mediators of the effect of a computer-tailored intervention [26].

Even though, based on theory, indicators of use and perception of personal relevance are important for achieving intervention effects, these factors may be different for print and interactive deliveries: the medium may determine attention and access to the message [19], as well as the ability and willingness to actively process the information [13, 27]. Among other factors, the use of Interactive Computer Technology (ICT) has to do with motivation and skills [13]. So-called information-want-nots, persons not motivated to use ICT, are more often female, older, and less educated [12].

Only two previous studies have compared use of print- and Internet-delivered interventions with identical content [28, 29]. Both studies reported higher recall and use of the print materials as compared to the materials delivered through the Internet. In the current study we will evaluate a broader set of indicators for use and appreciation and perceptions of personal relevance between a print-delivered and an interactive-delivered computer-tailored nutrition education intervention with identical content aimed at the reduction of saturated fat intake. These interventions were found to be equally effective in reducing fat intake at short term, but only the effects of the print-delivered tailored feedback were maintained in the longer term [30].

The current study specifically examines whether there are differences in use (information read, saved, discussed with others) and appreciation (perceived personal relevance, perceived individualization, trustworthiness, user friendliness) between print computer-tailored advice and interactive computer-tailored advice. These differences were examined for a mixed population and for gender, age, and educational subgroups. A CD-ROM was used to deliver the interactive, Web-based intervention, enabling people who did not have Internet access to use the program.

METHODS

Design and Recruitment

This study is part of a larger randomized controlled trial with five study arms. The current study uses data from two study arms for secondary data analysis: computer-tailored dietary fat reduction feedback delivered on CD-ROM (n=151) or delivered in print (n=141). Approval for the research project was obtained from the medical ethics committee of Erasmus University Medical Center, Rotterdam, the Netherlands. All participants gave written informed consent after receiving written information. Volunteers for the larger intervention trial were recruited from among employees of nine large companies and inhabitants of two neighborhoods in the Rotterdam area (2003 – 2004). A total of 798 adults volunteered to participate, none of whom were on a prescribed diet or under treatment for hypercholesterolemia. Participants completed a baseline paper-and- pen screening questionnaire, and were subsequently randomized by computer to the two different intervention conditions (Figure 5.1).

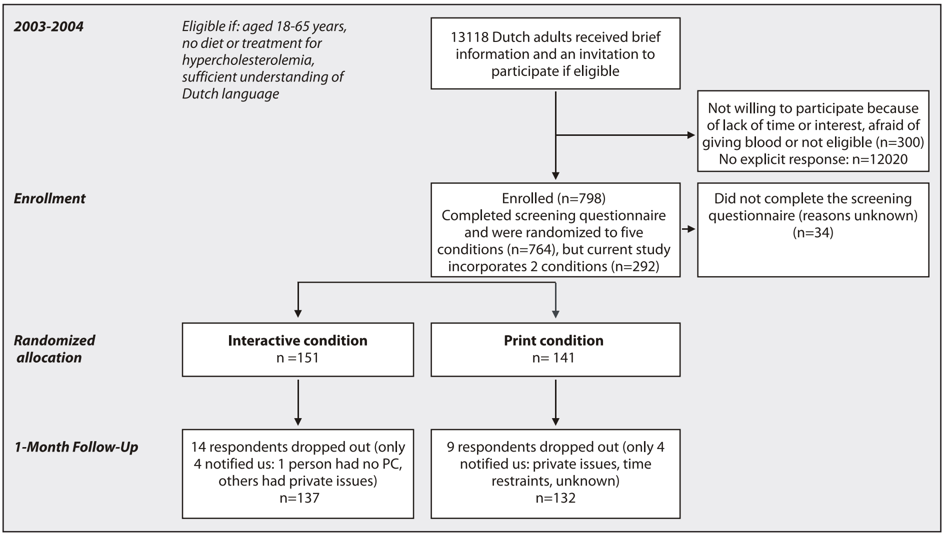


Figure 5.1. Recruitment and retention flow chart

Computer-tailored Interventions

The tailored feedback in the current study incorporated feedback on personal fat intake, social-comparison information, motivational feedback, practical product feedback addressing the most important sources of fat in the person's diet, information on low-fat alternatives, and self-efficacy-enhancing feedback for difficult situations as derived from an individual assessment. The content of the computer-tailored program was identical for the two intervention conditions. Details of the computer-tailored feedback are described elsewhere [30].

CD-ROM condition

In the CD-ROM condition, the computer-tailored feedback was programmed as a series of web pages (questionnaire, feedback messages), then stored on a CD-ROM. The program started with a homepage, explaining the nature and goal of the program and how it should be used. Immediately after completion of the screening questionnaire, the individualized computer-tailored information appeared on-screen (Figure 5.2). Low-fat recipes for appetizers, main courses and desserts could be searched from a recipe page. It was possible to print and save the feedback, but the program did not automatically save the generated advice. Respondents were asked to use the program from a computer with Internet Explorer 5.0 or higher, and to use it in the same week they received the CD-ROM.

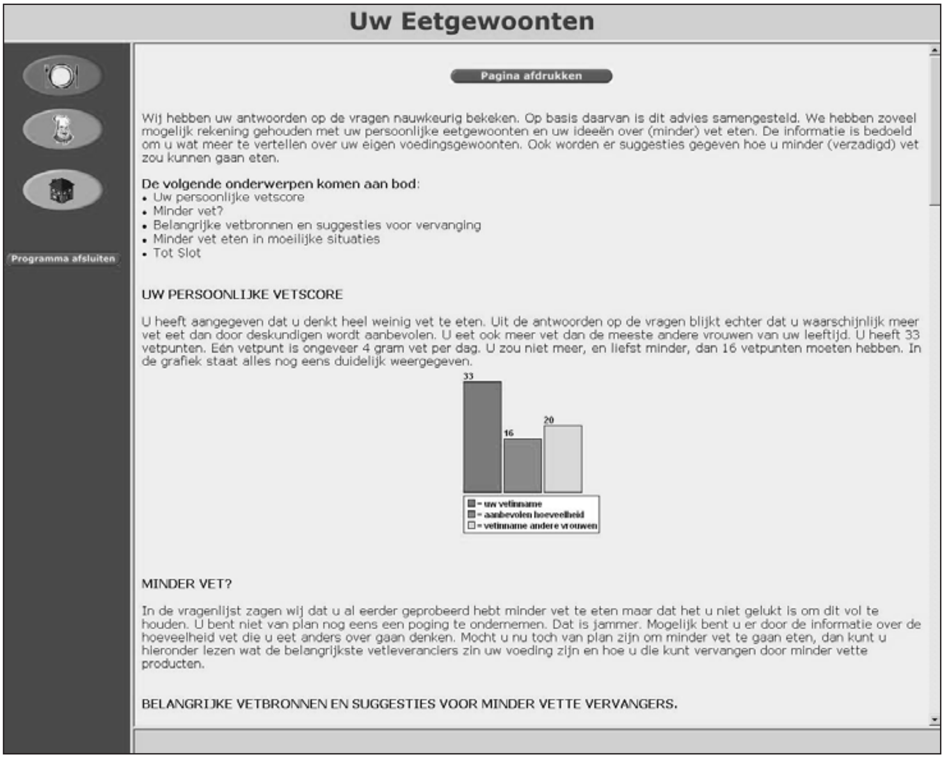


Figure 5.2. Example of part of the feedback delivered on CD-ROM

Print condition

The tailored information in the print condition was generated from the results of a baseline paper-and-pen questionnaire. The questionnaires were scanned and imported into a computer-tailoring program that generated individualized computer-tailored print feedback letters of 1.5 – 4 pages (Figure 5.3). Depending on their preferences, respondents received recipe suggestions for low-fat appetizers, main courses, or desserts. The feedback letters

VOEDINGSADVIES

Rotterdam ,29-4-2004

Geachte heer [redacted],

Deze brief gaat over vet in uw voeding. Eerst wat algemene informatie voordat we ingaan op uw persoonlijke voedingsgewoonten.
In principe heeft ieder mens vet nodig, maar wel met mate. Het lastige hiervan is dat vet 'verstopt' zit in veel producten. Je kunt niet zien dat je vet eet en daardoor eet je al snel te veel vet. Vet in de voeding kan onderverdeeld worden in twee soorten: onverzadigd vet (het goede soort) en verzadigd vet (het slechte soort). Het teveel eten van beide soorten vet vergroot de kans op overgewicht. En overgewicht is weer een belangrijke risicofactor voor het ontstaan van andere gezondheidsproblemen. Onverzadigd vet bevat de vetstoffen die wij nodig hebben om gezond te blijven. Verzadigd vet is het slechte soort vet. Helaas komt deze soort ook het meeste voor in onze voeding. Uit onderzoek is gebleken dat mensen die te veel verzadigd vet eten meer kans hebben op hartklachten en suikerziekte. Dit geldt overigens zowel voor mensen met overgewicht als voor mensen die goed op gewicht zijn! Slanke mensen hebben een vrijwel even grote kans om hart- en vaatziekten te krijgen.

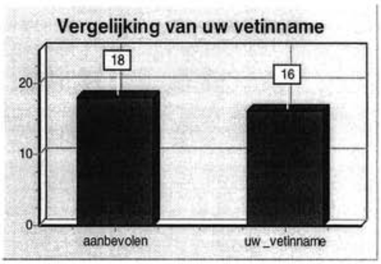
Kort geleden heeft u een vragenlijst ingevuld over uw persoonlijke voeding. Wij hebben uw antwoorden op de vragen nauwkeurig bekeken en op basis daarvan deze brief geschreven. Bij het schrijven van de brief hebben wij zoveel mogelijk rekening gehouden met uw persoonlijke eetgewoonten en uw ideeën over (minder) vet eten. De informatie is bedoeld om u wat meer te vertellen over uw eigen voeding. Ook worden er suggesties gegeven hoe u minder (verzadigd)vet zou kunnen gaan eten, indien van toepassing.

De volgende onderwerpen komen aan bod:
- Uw persoonlijke vetscore
- Minder vet?
- Belangrijke vetbronnen en suggesties voor vervanging
- Minder vet eten in moeilijke situaties
- Tot Slot

Waarom dit advies ook voor u belangrijk is.
U geeft aan dat u zelf niet vaak kookt of de boodschappen doet. U zult zich nu misschien afvragen of u wel iets aan het advies zult hebben. Maar beslist u uiteindelijk niet zelf wat u eet en hoeveel? Bespreek de adviezen ook eens met degene die meestal voor u kookt of de boodschappen doet.

UW PERSOONLIJKE VETSCORE

U heeft aangegeven dat u denkt weinig vet te eten. Wanneer we kijken naar uw antwoorden op de vragen blijkt dat u inderdaad niet te veel vet eet. U eet de hoeveelheid die door deskundigen wordt aanbevolen. U heeft 16 vetpunten. Eén vetpunt is ongeveer 4 gram vet per dag. U zou niet meer, en liefst minder, dan 18 vetpunten moeten hebben. In de grafiek staat dat aangegeven.



Toelichting op de grafiek:
De linker kolom 'aanbevolen' laat zien hoeveel vet mannen van uw leeftijd maximaal zouden moeten eten volgens de richtlijnen voor gezonde voeding. De rechter kolom 'uw_vetinname' laat zien hoeveel vet u eet, op basis van de vragenlijst die u heeft ingevuld.

Figure 5.3. Example of part of the feedback delivered in print

were sent to the home address of the respondents within two weeks of the time the study team received the completed questionnaire.

Measurements

Gender, age, and education level were assessed in the baseline questionnaire. A categorical variable was created from respondent age (≤ 34 years, 35-49 years, 50-65 years) [13]. Highest level of completed formal education of the participants was measured using one question in which seven educational categories were distinguished (from elementary school to university degree) [31]. The categories were then collapsed into a three-level education variable (lower = lower secondary education or less; medium = upper secondary or post-secondary non-tertiary education; higher = college or university training).

At one month post-intervention, the outcome measures (use and appreciation items) were assessed. The questions were introduced by explaining that nutrition advice referred to either the advice delivered by a print letter or by CD-ROM. Use was assessed with the following yes/no items: "I have read the complete nutrition advice"; "I saved the nutrition advice"; and "I discussed the nutrition advice with others". Appreciation was assessed using a 5-point scale (from -2 = strongly disagree to +2 = strongly agree): "I perceived the nutrition advice as trustworthy"; "The nutrition advice addressed my personal dietary habits"; "The nutrition advice was of personal relevance for me"; and "The nutrition advice was user-friendly". Appreciation questions were adapted from the process questionnaire as proposed by Brug and colleagues [23] and have been successfully used in previous studies [25, 26].

Statistical Analysis

Equality of the study groups at baseline was examined with Chi-Square tests (gender, education), and an independent-samples t-test (age). Differences in use and appreciation outcomes between the intervention conditions were analyzed with Chi-square tests (read, saved and discussed) and independent-samples t-tests (trustworthy, perceived individualization, personal relevance, and user-friendliness). The "discussed" variable and the appreciation items were analyzed only for those respondents who confirmed they had read all the information. Finally, in order to compare the size of the difference in appreciation items between the print- and the CD-ROM group, we calculated effect sizes (ESs) as the standardized differences in group means, by dividing the difference between the conditions by the pooled standard deviation. ESs were categorized as small (0-0.32) moderate (0.33-0.55) or large (0.55>) as defined by Lipsey [32]. The analyses were performed for the total group, and based on literature [13] we decided a priori to conduct stratified analyses in specific sub-groups based on gender, age, and education category. All analyses were conducted in SPSS version 11 (SPSS Inc, Chicago, IL, USA).

RESULTS

Population characteristics

Among the respondents (n=292), 46% were male, the mean age was 43.9 years (SD = 10.3), 22% had a lower education level, 34.4% a medium education level and 43.6% a higher education level. There were no significant differences in gender, age, or education level between the two conditions.

Use of the computer-tailored information

As shown in Table 5.1, the print-delivered feedback was read more often than the CD-ROM-delivered feedback according to self-reports among the total population (P = 0.001) and among women (P = 0.003). This was also the case for participants in the 50-65 years age group (P = 0.01; Table 5.2), and for participants in lower and higher education levels (P = 0.04 for both groups; Table 5.3).

The print-delivered feedback was reported to be saved more often than the CD-ROM-delivered feedback among the total population (P < 0.001), men (P = 0.02), women (P < 0.001), the ≤ 34 year and 35-49 year age groups (P = 0.001 for both groups), and medium- and higher-educated respondents (P = 0.001 for both groups).

Less than 50% of those who reported to have read the tailored information discussed it with others.

Appreciation of the computer-tailored information

Trustworthiness, perceived individualization and user-friendliness were not significantly different between the print condition and the CD-ROM condition. However, the CD-ROM was rated as more user-friendly by men and respondents of ≤ 34 years with a moderate, though not statistically significant, effect size (P = 0.10).

Results showed a statistically significant higher perceived personal relevance for the print condition compared to the CD-ROM condition among the total population (P = 0.04), women (P = 0.04) and the group of 35-49 years (P = 0.03), with effect sizes that can be categorized as small (among total population) to moderate (among women and the group of 35-49 years). In addition, the print condition was rated as more personally relevant by the group of <=34 years (P = 0.18) and the less-educated respondents (P = 0.19) with a moderate, though not statistically significant, effect size.

Table 5.1: Use and appreciation of the print- and CD-ROM-delivered, computer-tailored interventions by gender

	TOTAL STUDY GROUP				MEN				WOMEN			
	Print	**CD-ROM**			**Print**	**CD-ROM**			**Print**	**CD-ROM**		
scale yes/no	**n/n (%)**	**n/n (%)**	***P*** c)	X^2_1	**n/n (%)**	**n/n (%)**	***P*** c)	X^2_1	**n/n (%)**	**n/n (%)**	***P*** c)	X^2_1
Read a)	122/129 (94.6%)	103/128 (80.5%)	.001	11.73	53/58 (91%)	45/57 (79%)	.06	3.53	69/71 (97%)	58/71 (82%)	.003	9.02
Saved a)	120/124 (96.8%)	89/116 (76.7%)	<.001	21.42	51/55 (93%)	40/52 (77%)	.02	5.25	69/69 (100%)	49/64 (77%)	<.001	18.23
Discussed b)	50/114 (43.9%)	38/94 (40%)	.62	0.25	25/48 (52%)	16/40 (40%)	.26	1.28	25/66 (38%)	22/54 (41%)	.75	0.10
scale -2/+2	**Mean±SD**	**Mean±SD**	***P*** d)	**ES** e)	**Mean±SD**	**Mean±SD**	***P*** d)	**ES** e)	**Mean±SD**	**Mean±SD**	***P*** d)	**ES** e)
Trustworthy b)	1.28±0.96	1.26±1.02	.89	.02	1.34±0.88	1.33±0.90	.97	.01	1.24±1.03	1.21±1.11	.88	.03
	n=120	*n=102*			*n=53*	*n=45*			*n=67*	*n=57*		
Perceived	1.12±1.01	1.01±1.08	.45	.11	1.04±0.98	1.13±0.97	.63	-.09	1.18±1.04	0.91±1.15	.18	.25
individualisation b)	*n=121*	*n=102*			*n=53*	*n=45*			*n=68*	*n=57*		
Personal	0.97±0.98	0.68±1.11	.04	.28	0.85±1.02	0.69±1.10	.47	.15	1.06±0.95	0.67±1.12	.04	.38
relevance b)	*n=119*	*n=102*			*n=52*	*n=45*			*n=67*	*n=57*		
Userfriendly b)	0.99±1.07	1.09±1.04	.50	-.09	1.00±1.06	1.33±0.88	.10	-.34	0.99±1.09	0.89±1.11	.65	.09
	n=121	*n=102*			*n=53*	*n=45*			*n=68*	*n=57*		

[a] Only cases without missing values are included in analyses, therefore numbers in denominators differ from numbers in Figure 5.1. [b] For the analysis of the variables discussed, trustworthy, perceived individualization, personal relevance, and user-friendly, only respondents who indicated they had read the information and without missing values were included in the analysis. [c] *P*-value derived from Pearson Chi-square. [d] *P*-value derived from Independent samples T-test. [e] Positive ES in favor of print, negative ES in favor of CD-ROM; Effect Size (ES) can be categorized as small (0-0.32), moderate (0.33-0.55) or large (ES>0.55).

Table 5.2: Use and appreciation of the print- and CD-ROM-delivered computer-tailored interventions by age group

	≤ 34 YEARS				35-49 YEARS				50-65 YEARS			
	Print	**CD-ROM**			**Print**	**CD-ROM**			**Print**	**CD-ROM**		
scale yes/no	**n/n (%)**	**n/n (%)**	***P*[c)]**	**X^2_1**	**n/n (%)**	**n/n (%)**	***P*[c)]**	**X^2_1**	**n/n (%)**	**n/n (%)**	***P*[c)]**	**X^2_1**
Read [a)]	22/23 (96%)	26/30 (87%)	.27	1.23	64/69 (93%)	44/54 (82%)	.06	3.60	36/37 (97%)	33/44 (75%)	.01	7.92
Saved [a)]	22/22 (100%)	17/30 (57%)	.001	12.71	65/66 (99%)	40/51 (78%)	.001	12.57	33/36 (92%)	32/35 (91%)	.97	0.00
Discussed [b)]	8/20 (40%)	10/25 (40%)	1.00	0.00	30/61 (49%)	17/40 (43%)	.51	0.43	12/33 (36%)	11/29 (38%)	.90	0.02
scale -2/+2	**Mean±SD**	**Mean±SD**	***P*[d)]**	**ES[e)]**	**Mean±SD**	**Mean±SD**	***P*[d)]**	**ES[e)]**	**Mean±SD**	**Mean±SD**	***P*[d)]**	**ES[e)]**
Trustworthy [b)]	1.18±1.01	1.31±0.97	.66	-.13	1.35±0.90	1.23±1.02	.54	.13	1.23±1.06	1.27±1.10	.87	-.04
	n=22	*n=26*			*n=63*	*n=43*			*n=35*	*n=33*		
Perceived individualization[b)]	1.05±1.13	0.88±1.24	.64	.14	1.22±0.91	1.05±1.00	.35	.18	0.97±1.11	1.06±1.06	.74	-.08
	n=22	*n=26*			*n=63*	*n=43*			*n=36*	*n=33*		
Personal relevance [b)]	0.81±1.03	0.35±1.23	.18	.40	1.00±0.94	0.58±0.96	.03	.44	1.00±1.04	1.06±1.12	.82	-.06
	n=21	*n=26*			*n=62*	*n=43*			*n=36*	*n=33*		
Userfriendly [b)]	0.68±1.21	1.23±1.03	.10	-.49	1.00±1.03	0.98±0.99	.91	.02	1.17±1.03	1.12±1.11	.86	.05
	n=22	*n=26*			*n=63*	*n=43*			*n=36*	*n=33*		

[a.] Only cases without missing values are included in analyses, therefore numbers in denominators differ from numbers in Figure 5.1. [b.] For the analysis of the variables discussed, trustworthy, perceived individualization, personal relevance, and user-friendly, only respondents who indicated they had read the information and without missing values were included in the analysis. [c.] *P*-value derived from Pearson Chi-square. [d.] *P*-value derived from Independent samples T-test. [e.] Positive ES in favor of print, negative ES in favor of CD-ROM; Effect Size (ES) can be categorized as small (0-0.32), moderate (0.33-0.55) or large (ES>0.55).

Table 5.3: Use and appreciation of the print- and CD-ROM-delivered computer-tailored interventions by education level

	LOWER EDUCATION				MEDIUM EDUCATION				HIGHER EDUCATION			
	Print	**CD-ROM**			**Print**	**CD-ROM**			**Print**	**CD-ROM**		
scale yes/no	**n/n (%)**	**n/n (%)**	***P*[c)]**	**X^2_1**	**n/n (%)**	**n/n (%)**	***P*[c)]**	**X^2_1**	**n/n (%)**	**n/n (%)**	***P*[c)]**	**X^2_1**
Read [a)]	29/30 (967%)	22/28 (79%)	.04	4.47	43/46 (94%)	35/43 (81%)	.08	3.00	49/42 (94%)	46/57 (81%)	.04	4.45
Saved [a)]	27/28 (96%)	23/25 (92%)	.49	0.49	46/46 (100%)	31/39 (80%)	.001	10.42	47/50 (94%)	35/52 (67%)	.001	11.52
Discussed [b)]	10/25 (40%)	8/18 (44%)	.77	0.09	20/43 (47%)	13/32 (41%)	.61	0.26	20/46 (44%)	17/44 (39%)	.64	0.22
scale -2/+2	**Mean±SD**	**Mean±SD**	***P*[d)]**	**ES[e)]**	**Mean±SD**	**Mean±SD**	***P*[d)]**	**ES[e)]**	**Mean±SD**	**Mean±SD**	***P*[d)]**	**ES[e)]**
Trustworthy [b)]	1.29±1.01	0.95±1.33	.32	.29	1.37±0.82	1.34±0.68	.87	.04	1.20±1.06	1.36±1.07	.49	-.15
	n=28	*n=22*			*n=43*	*(n=35)*			*n=49*	*n=45*		
Perceived individualization[b)]	1.14±1.06	0.82±1.14	.31	.29	1.23±0.84	1.11±0.90	.55	.14	1.00±1.12	1.02±1.18	.93	-.02
	n=29	*n=22*			*n=43*	*(n=35)*			*n=49*	*n=45*		
Personal relevance [b)]	1.18±1.02	0.77±1.15	.19	.39	1.07±0.70	0.94±0.91	.49	.16	0.76±1.13	0.42±1.20	.17	.29
	n=28	*n=22*			*n=42*	*(n=35)*			*n=49*	*n=45*		
Userfriendly [b)]	1.14±1.03	1.00±1.19	.66	.13	1.07±0.99	1.17±1.01	.66	-.10	0.84±1.16	1.07±0.99	.31	-.21
	n=29	*n=22*			*n=43*	*(n=35)*			*n=49*	*n=45*		

[a.] Only cases without missing values are included in analyses, therefore numbers in denominators differ from numbers in Figure 5.1. [b.] For the analysis of the variables discussed, trustworthy, perceived individualization, personal relevance, and user-friendly, only respondents who indicated they had read the information and without missing values were included in the analysis. [c] *P*-value derived from Pearson Chi-square. [d.] *P*-value derived from Independent samples T-test. [e.] Positive ES in favor of print, negative ES in favor of CD-ROM; Effect Size (ES) can be categorized as small (0-0.32), moderate (0.33-0.55) or large (ES>0.55).

DISCUSSION

Principal results

The results of this study indicate that there are differences in use and appreciation of a print-delivered vs. a CD-ROM-delivered computer-tailored intervention. The differences were mainly in favor of the print-delivered intervention. The print feedback was read and saved more often than the CD-ROM feedback, some specific subgroups excepted, and the print feedback was perceived as more personally relevant in the total study group and in some of the subgroups with small to moderate effect sizes.

Surprisingly, the print-delivered feedback was rated as more personally relevant. Personal relevance is considered to be a core characteristic and a potential working mechanism of computer-tailored interventions [16, 17], and, in the present study both interventions had the same level of personalization and individualization. Apparently it is not only the feedback in itself that is related to perception of personal relevance, but also the delivery mode through which the information is distributed. Perhaps the immediate feedback on screen after completion of the questionnaire versus the time lag between returning the questionnaire to the researchers and receiving feedback influences this perception. The receipt of a personalized mailed letter might also enhance relevance. Another explanation may be that participants had expected more personal relevance from a computer program in which they had to complete questions first.

Comparison with prior work

Our study is unique in evaluating a broader set of indicators for use, appreciation and perception of personal relevance between a print-delivered and an interactive-delivered computer-tailored intervention with identical content.
The finding that the print-delivered feedback is read and saved more often than the CD-ROM delivered feedback is in line with expectations and with findings from previous studies [8, 9, 28, 29].

Information sent through print media may be more easily available and accessible, and easier to read and save [8, 9]. Our results not only indicate that the subgroups suggested in the literature (women, less-educated, and older respondents) use the CD-ROM less than print, but also that this is the case for men and higher-educated and younger respondents. However, we do not know why participants in the CD-ROM group did not read the information. Having to use a computer and start a program may have been a barrier in terms of time, effort or planning that would be needed to use the program and generate the feedback. For another segment of the participants, lack of motivation or skills to use interactive media may have been a reason [13, 21]. This could have been the case for women, older persons and less-educated persons. Vandelanotte et al found that people over 40 years compared to those below 40 years preferred an intervention delivered in print over an interactively delivered intervention [25]. However, it has also been found that even though people had indicated they preferred to receive an intervention over the Internet, they nevertheless did not access this intervention [29].

The findings of this study add to the evidence regarding differences in use of interactive and print-delivered interventions with identical content [28, 29] and provide important new insights in appreciation and perceived relevance of the information. Findings from this and previous studies point in the direction that interactively delivered interventions as used to date may be less successful in attracting attention and may be less suited to facilitate active information processing, as compared to print-delivered computer-tailored information. Efforts are needed to increase use, appreciation and active information processing.

Limitations

The present study provides descriptive data. Further studies should explore if personal relevance and level of reading mediates differential effects between print-delivered and interactive-delivered tailored feedback. Additionally, less-educated people and those older than 65 years were underrepresented or not included in this study. Although the intervention could be provided over the Internet, in this study it was delivered on a CD-ROM.

In this study we conducted a lot of tests without correction for multiple testing, which may increase the risk of false positives in the outcomes of the analyses. However, due to subgroup analyses the number of participants was rather small in some analyses, which may have caused lack of power to detect significant differences, even when there was a moderate effect size. Reducing the p-value to correct for multiple testing would increase the risk of false negatives. Therefore, we reported the uncorrected p-values and the effect sizes of our different outcome measures. We evaluated the significance of differences using a significance level of $P < .05$. Effects can also be evaluated using a more conservative significance level of $P < .01$ to approach correction for multiple testing. In addition, the moderate effect sizes may provide an indication of differences that might become statistically significant when analyzed in larger groups.

Further, this study compared two delivery modes on aspects of use and appreciation that are relevant for both modes (i.e. in both cases, for information processing, the information should be read, saved, and perceived as personally relevant). However, using this approach we may have missed important aspects for use and probably appreciation of the information or the program, that are more sensitive to specific characteristics of interactive media. Future process evaluation studies could use such more extensive and specific instruments.

Conclusions

Interactive computer-tailored feedback appears to be read and saved less than print-delivered feedback and perceived as less personally relevant, especially among certain subgroups. These differences in use and appreciation of the computer-tailored intervention delivered through print or interactive delivery modes can be taken into account when selecting a delivery mode for a specific sub-group in order to optimize exposure. Future studies should explore methods to improve exposure to and use of interactively delivered computer-tailored information.

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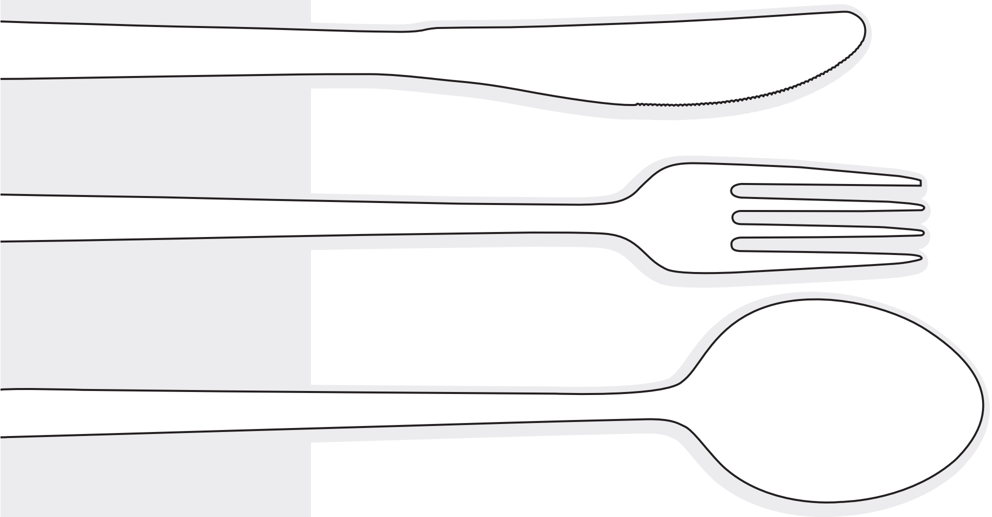
CHAPTER 6

Biomarker evaluation does not confirm earlier evidence on the effectiveness of computer-tailored nutrition education



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ABSTRACT

Background: Reported evidence of the effectiveness of computer-tailored nutrition education interventions is limited to self-reported consumption data. The evidence should be further substantiated with more objective outcome indicators.

Objective: To evaluate the efficacy of a computer-tailored (saturated) fat reduction intervention with blood lipids as objective outcome measures.

Design: A three-group randomized controlled trial (2003-2005) with a pretest and two post-test outcome assessments at one and six months post-intervention among a convenience sample of healthy Dutch adults recruited via worksites and two neighborhoods in the urban area of Rotterdam (n=442). Participants were exposed to one of three intervention conditions: a computer-tailored intervention delivered on CD-ROM, a computer-tailored intervention delivered in print or a generic information condition.

Results: Results from linear regression analyses did not show significant differences between the three intervention groups in total cholesterol, HDL-cholesterol, LDL-cholesterol or triacylglycerol neither among the total population nor among respondents with a higher than recommended fat intake at baseline.

Conclusions: Contrary to results based on self-report data, no effects of a computer-tailored intervention aimed at reduction of saturated fat intake were found based on blood lipids.

Keywords: Health Education*, General population, Computer-Assisted Instruction/methods, Biomarker evaluation, (Saturated) fat consumption, Primary prevention

INTRODUCTION

In promotion of healthful nutrition behaviors computer-tailored nutrition education has been identified as a promising health education strategy especially in promotion of lower fat intake levels [1]. However, to date the reported effects have been primarily based on self-reported consumption data [2].

The use of self-report methods such as food frequency questionnaires (FFQs), recall or diaries to assess nutritional outcome measures of intervention studies, are often criticized for their limitations such as recall bias, underreporting, socially desirable answers and measurement errors. Furthermore, the completion of such self-report measures may in itself induce changes in participants' diets [3-5]. In addition, effects of a computer-tailored intervention should not only be limited to effects on behavior, but these effects should be substantial and sustained enough to impact determinants more proximal to health outcomes [6]. The inclusion of biomarkers of effect has therefore been advocated as an objective indicator of effectiveness [7, 8].

A meta-analysis of controlled feeding studies showed that serum lipids (total, HDL-, LDL-cholesterol and triglycerides) are related to (saturated) fat consumption [9, 10]. Furthermore these serum lipids are associated with mortality and burden of disease [11] due to cardiovascular diseases and diabetes mellitus [12-14].

In the present paper, we report a biomarker evaluation of a computer-tailored fat reduction intervention for which effects have been reported on self-reported dietary fat intake (see Chapter 4) [15, 16]. Two versions of the computer-tailored intervention were tested, a print delivered and a CD-ROM-delivered version that was ready to be distributed through the Internet. The two different delivery modes were chosen to evaluate if an interactive-delivered intervention, for which use and applicability are growing due to increased computer and Internet access, is as effective as an identical-content print-delivered intervention. We hypothesized that a computer-tailored saturated fat reduction intervention will result in a larger reduction in serum cholesterol levels than a generic information condition. We expected no differences in impact between the two versions of the computer-tailored intervention.

METHODS

Design, Participants and Procedure

The study was part of a larger randomized controlled trial with five study arms, investigating different aspects of computer-tailored interventions aimed at dietary fat reduction (Trial registry: ISRCTN01557410). The current study entails the use of blood lipids as an indicator of the efficacy of three conditions: CD-ROM or print-delivered computer-tailored nutrition education and generic nutrition education. The groups in the two study-arms not included in this study received less extensive forms of the print-delivered computer-tailored information and were used for separate analyses to explore how extensive computer-tailored nutrition education should be to be effective [17]. Approval for the research project was obtained from the medical ethics committee of Erasmus MC, University Medical Center Rotterdam.

Recruitment of volunteers was conducted in 2003 and 2004 using two strategies: inviting employees of nine large companies and door-to-door distribution of information leaflets in two neighborhoods in the Rotterdam area. The information leaflets included a response form indicating initial interest in participating in the study. Readers who completed and returned this response form subsequently received further information and an informed consent form. Eligibility criteria to participate in this study were: between 18-65 years of age, sufficient understanding of the Dutch language and receiving no treatment or prescribed diet for hypercholesterolemia. A total of 798 eligible persons volunteered to participate in the larger study (Figure 6.1 - Flow-scheme respondents).

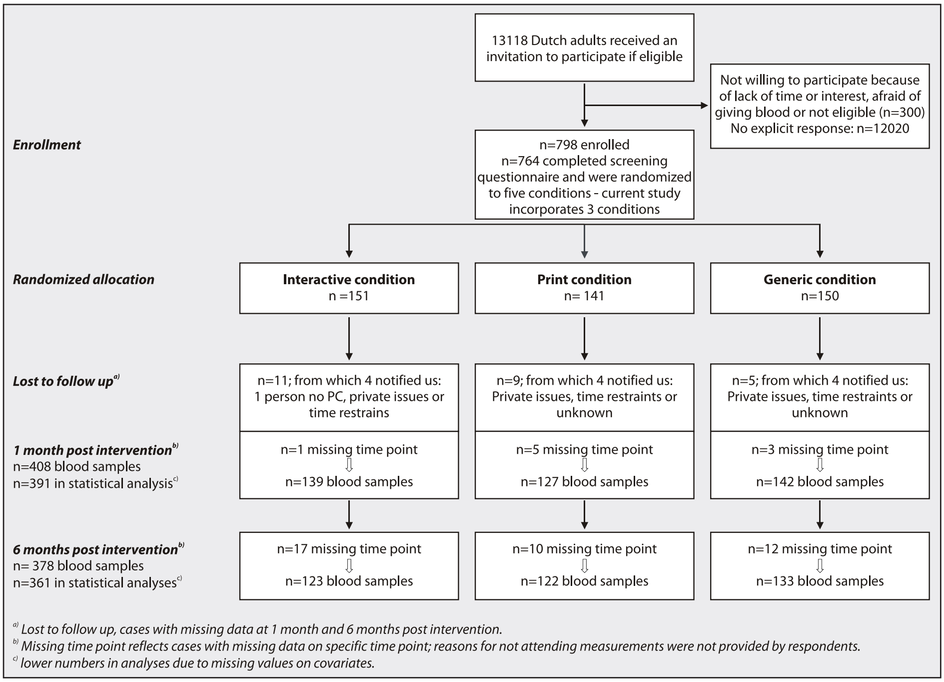

Figure 6.1: Flow scheme respondents

After providing informed consent and completing a baseline paper & pen screening questionnaire, participants were randomized to the five different intervention conditions in a computer-determined sequence, stratified by recruitment source (company/community). The numbers of respondents assigned to the conditions included in this paper are: 151 participants assigned to the CD-ROM condition, 141 to the print-condition and 150 to the generic information condition. The intervention materials were sent to the respondents' home addresses within two weeks after returning the screening questionnaire. Posttests were conducted one month and six months later.

At baseline and at the two posttests blood samples were collected. Sampling and storage of blood samples and determination of the serum lipid levels were carried out by the CCKLS certified laboratory of the STAR (Stichting Trombosedienst en Artsenlaboratorium Rijnmond – i.e. the regional general practitioners laboratory). Respondents were invited to a doctors' office in their company or to one of the locations of the STAR in their home area. Participants who did not show up at their appointment for a blood sample were contacted by e-mail or telephone once in order to schedule a new appointment.

We conducted a post-hoc power-analysis that showed sufficient power to detect statistically significant differences between conditions in total cholesterol (0.93), LDL-cholesterol (0.70) and, triacylglycerol (0.60). The power for detecting differences in HDL-cholesterol was very low (0.19). Moreover, a review of dietary interventions showed that it should be feasible to achieve an average reduction of 0.12 mmol/L in total cholesterol with dietary interventions of low intensity and short duration (3-6 months) among the general public in studies varying in sample sizes from 87-93 per intervention group [18]. Intensity of interventions and sample sizes are comparable to our study. Based on these data, we conclude that the statistical power of our study was sufficient to detect significant differences.

Computer-tailored Interventions

Three components are necessary for generating computer-tailored nutrition education [19, 20]: 1) a screening instrument to assess variables on which the tailored feedback would be based (e.g. fat intake and its determinants: perception of own fat intake, attitude, self-efficacy and readiness to reduce fat intake); 2) a message source file with feedback messages tailored to all possible screening results (e.g. feedback on personal fat intake compared to recommended intake, social-comparison information, motivational feedback, practical product feedback on low-fat alternatives for the most important sources of fat in the personal diet and self-efficacy enhancing feedback for difficult situations); and 3) a computer program that selects the feedback messages that match the individual's responses to the screening questionnaire. The personalized feedback information can be delivered interactively or in print.

The computer-tailored interventions were informed by the Precaution Adoption Process Model and the Theory of Planned Behavior and adapted from previous work [21, 22]. A brief description of the interventions follows below; a detailed description of the interventions is published elsewhere [16].

CD-ROM-condition

In the CD-ROM-condition, the whole computer-tailoring program was developed as a web-based program but stored and delivered on a CD-ROM for the present study to improve exposure. The program started with a homepage, explaining the nature and goal of the program and how to use it. By clicking the button in the menu bar, the screening questionnaire started. Immediately after completion the individualized computer-tailored information appeared on-screen. The information started with a personalized heading, followed by a general introduction to the topic of fat in the diet and it's relation with health. The feedback information consisted of personal feedback, normative feedback and action feedback, i.e. information about personal fat intake and sources of saturated fat, comparison to peer group average and recommended intake levels, and individualized information on how to reduce saturated fat intake. The program also contained a page with low-fat recipes for starters, main courses and desserts. It was possible to save and print the feedback, but the program did not automatically save the generated advice. Respondents were asked to use the program (which was suitable for any computer with Internet Explorer 5.0 or higher) in the same week they received the CD-ROM.

Print-condition

The tailored information for the participants in the print-condition was generated from the results of the baseline paper and pen questionnaire. The questionnaires were scanned and imported into a computer-tailoring program that generated individualized computer-tailored print feedback letters of 1.5 – 4 pages. The content of the program was identical to the CD-ROM program, since the same screening instrument, feedback messages and message selection rules were used. Respondents who had indicated their interest, received recipe suggestions for low-fat starters, main courses, or desserts according to their preference.

Generic condition

Participants in the control condition received non-personalized, non-tailored generic nutrition information about saturated fat (from now on called generic condition). The information explained the importance of a healthy diet and more specific the importance of a limited amount of saturated fat in the diet. In addition it stressed that saturated fat intake of the average Dutch person is generally higher than recommended and higher than most people expect and that this might be the case for the reader as well. Furthermore, practical information on high-saturated fat products and suggestions to reduce saturated fat intake were provided. The generic information was two print pages. The layout of the generic condition and the print-condition letters was the same.

Measurements

Blood lipids

Venous blood samples (2 tubes of 3 ml) were taken after an overnight fast from 10:00 pm the night before. The fasting state was checked before the blood sample was withdrawn by asking participants if they ate or drank anything after 10:00 pm. In case the respondent had not fasted a new appointment was made. Samples were analyzed for total cholesterol, HDL and triacylglycerol. The analyses were carried out on a Vitros 950AT Analyzer (Ortho-Clinical Diagnostics) using colorimetric slides. LDL was calculated based on total cholesterol, HDL-cholesterol and triacylglycerol concentrations [23, 24].

Population characteristics and covariates

Gender, age, physical activity ('How many days of the week are you physically active for at least 30 minutes (e.g. brisk walking, cycling, gardening or sports)' – less than once a week, once a week, 2 to 4 times a week, 5 to 6 times a week, daily); smoking (yes/no), use of functional foods (4 specific products available in the Netherlands – yes/no/I don't know), BMI (by self reported height and weight) and fat score (validated food frequency questionnaire [25]) were measured in a baseline paper & pen questionnaire, which was also the screening instrument for the print-delivered computer-tailored intervention. Based on personal fat score as assessed in the baseline questionnaire and recommended intake, participants were categorized as 'risk consumers' (intake above gender-age specific cut off levels of fat score) or not. From the variable physical activity a three level variable was created (low: ≤1x/week; moderate: 2-4x/week and sufficient: ≥ 5x/week).

Statistical analyses

To explore equality between intervention conditions at baseline one-way ANOVAs for continuous variables (age, BMI and fat score, total, HDL-, and LDL-cholesterol and triacylglycerol) and Chi-Square tests for categorical variables (gender, physical activity, smoking, use of functional foods and percentage 'risk consumers') were conducted.

Chi-Square tests were used to assess if there were differences between intervention conditions for attending the blood sampling at baseline and at one and six months post intervention.

To test the effects of the two tailored interventions compared to the control group, a linear regression analysis was conducted for every blood lipid outcome with the intervention conditions coded as dummy variables (generic condition as reference group). These analyses were adjusted for the following variables at baseline: gender, age (years), concentration of concerned blood lipid (total, HDL-, or LDL-cholesterol or triacylglycerol respectively), physical activity (low/moderate/sufficient), smoking (yes/no) and use of functional foods (yes/no). In a second regression analysis the same variables were used, but the intervention condition variable was dummy coded with the print computer-tailored condition as the reference group to compare both tailoring conditions. Complete case analyses (two-tailed, $p < 0.05$) were performed for the one-month outcomes and the six-month outcomes among the total study population and among the 'risk consumers'. The analyses were also conducted among the subgroup of 'risk consumers', because it is particularly important for them to reduce their fat intake, since their intake at baseline is higher than the recommended fat intake levels.
In addition, intention-to-treat analyses were performed for the one-month outcomes and the six-month outcomes with the last measurement carried forward for subjects without an outcome assessment.
Data were analyzed using SPSS for Windows (release 15.0.0. 2006. Chicago: SPSS Inc.).

RESULTS

Participants

At one-month post intervention, blood samples were collected from 408 respondents (92% response), and at six-months post intervention from 378 respondents (86% response). 54% of the respondents were female, with a mean age of 44 years (SD 10.2 y). There were no group differences on baseline values of gender, age, physical activity, smoking status, use of functional foods, blood lipids, BMI and percentage risk consumers (Table 6.1). Also no differences in attrition were found between the groups. When compared to Dutch consensus reference levels [26], 12.5% of all participants had total cholesterol levels above 6.5 mmol/L and 4.2% had HDL-cholesterol levels below 0.9 mmol/L. Official consensus for LDL-cholesterol and triacylglycerol does not exist in the Netherlands, however compared to American consensus reference levels [27] 14% of the participants had LDL-cholesterol levels above 4.2 mmol/L and 10.5% had triacylglycerol levels above 2.2 mmol/L.

Table 6.1: Baseline population characteristics of the interactive and print computer-tailored conditions and the generic information condition among the respondents assessable at 1 and 6 months of follow-up

	Baseline characteristics of respondents assessable at 1-month				6-months
	Interactive (n= 139)	**Print** (n = 127)	**Generic** (n=142)	**Total group** (n = 408)	**Total group** (n = 378)
Gender (% female)	54.0	54.3	54.9	54.4	56.1
Age (years, mean ± SD)	44.44 (10.56)	43.28 (10.17)	43.97 (9.78)	43.92 (10.19)	44.14 (10.17)
Physical activity ≥ 30 min/d:					
≤ 1x/wk	40.3	37.8	27.5	35.0	34.4
2-4 x/wk	33.1	37.0	40.8	37.0	36.5
≥ 5 x/wk	26.6	25.2	31.7	28.0	29.1
BMI (kg/m^2, mean ± SD)	25.55 (3.85)	25.58 (4.33)	25.32 (3.88)	25.48 (4.01)	25.52 (4.08)
Current smoker (%)	20.9	15.0	14.8	16.9	16.7
Use of functional foods (%)	8.6	3.1	7.0	6.4	6.6
Risk consumers[1]	49.6	50.0	51.4	50.4	51.3
Serum lipids (mmol/L):					
Total cholesterol	5.39 (1.05)	5.37 (0.93)	5.63 (0.94)	5.47 (0.98)	5.48 (0.97)
HDL cholesterol	1.65 (0.54)	1.67 (0.54)	1.60 (0.49)	1.64 (0.52)	1.63 (0.50)
LDL cholesterol	3.13 (0.95)	3.13 (0.88)	3.40 (0.95)	3.23 (0.94)	3.25 (0.92)
Triacylglycerol	1.32 (0.70)	1.27 (0.68)	1.41 (0.68)	1.33 (0.69)	1.33 (0.70)

[1]Percentage with baseline fat score above gender-age specific cut off point.

Differences in blood lipids

No significant differences between the three intervention conditions were found among the total population, nor among the risk consumers, for any of the blood lipids at one- month post intervention (Table 6.2) or at six-months post intervention (results not shown). All effect sizes (regression coefficients) were close to zero and not statistically significant.

For example, among the risk consumers differences in lipids between the CD-ROM-condition and the generic condition varied between -0.11 mmol/L for triacylglycerol (95% CI: -0.39 – 0.16) and 0.12 mmol/L (95% CI: -0.06 – 0.30) for LDL-cholesterol. Differences between the print-condition and the generic condition varied between -0.18 mmol/L (95% CI: -0.47 – 0.101) for triacylglycerol and 0.09 mmol/L (95% CI: -0.10 – 0.27) for LDL-cholesterol. Differences between the CD-ROM-condition and the print-condition varied between 0.03 mmol/L (95% CI: -0.16 – 0.18) for HDL-cholesterol and 0.07 mmol/L (95% CI: -0.13 – 0.27) for total cholesterol (95% CI: -0.13 – 0.27) and for triacylglycerol (95% CI:-0.21 – 0.36). The analyses among the total population, the six months follow-up analyses and the intention-to-treat analyses resulted in similar non-significant outcomes.

Table 6.2: Descriptives of serum lipids (mmol/L) in the computer-tailored and generic conditions, and post-test differences in serum lipids (mmol/L) between the interactive and print computer-tailored conditions and the generic condition, at 1-month follow-up.

	Descriptives (mmol/L)			Intervention effects[1]								
	Interactive	Print	Generic	Interactive vs. Generic			Print vs. Generic			Interactive vs. Print		
	Mean (SD)	Mean (SD)	Mean (SD)	b[2]	95% CI		b[2]	95% CI		b[2]	95% CI	
Total Population												
Total cholesterol	5.39 (0.99)	5.33 (0.96)	5.56 (0.92)	0.10	-0.12	0.14	-0.03	-0.16	0.10	0.04	-0.09	0.17
HDL cholesterol	1.63 (0.52)	1.60 (0.51)	1.60 (0.51)	0.00	-0.05	0.05	-0.04	-0.09	0.01	0.04	-0.01	0.10
LDL cholesterol	3.15 (0.94)	3.13 (0.92)	3.28 (0.92)	0.04	-0.08	0.17	0.03	-0.10	0.15	0.02	-0.11	0.14
Triacylglycerol	1.34 (0.73)	1.32 (0.73)	1.49 (1.29)	-0.10	-0.27	0.06	-0.05	-0.22	0.12	-0.06	-0.22	0.11
Risk Consumers												
Total cholesterol	5.43 (1.00)	5.43 (1.04)	5.43 (0.97)	0.08	-0.11	0.28	0.01	-0.19	0.21	0.07	-0.13	0.27
HDL cholesterol	1.60 (0.47)	1.59 (0.56)	1.53 (0.46)	0.01	-0.07	0.08	-0.03	-0.11	0.05	0.03	-0.05	0.11
LDL cholesterol	3.22 (0.96)	3.21 (0.96)	3.18 (0.92)	0.12	-0.06	0.30	0.09	-0.10	0.27	0.04	-0.15	0.22
Triacylglycerol	1.33 (0.71)	1.42 (0.86)	1.61 (1.63)	-0.11	-0.39	0.16	-0.18	-0.47	0.10	0.07	-0.21	0.36

[1] Values from linear regression analyses, adjusted for gender, age, the concerned lipid at baseline (total, HDL-, or LDL-cholesterol or triacylglycerol respectively), physical activity (3 categories), smoker (yes/no) and use of functional foods (yes/no).

[2] b = unstandardized regression coefficient.

DISCUSSION

In contrast to earlier studies that used self-reports (see chapter 2 and 4), in the present study no evidence for effects of computer tailoring was found for reduced saturated fat intake based on changes in total -, HDL-, or LDL-cholesterol or triacylglycerol as compared with generic, non-tailored nutrition information. This was the case for the total study population, as well as among respondents with high fat intakes at baseline (i.e. the respondents who were more strongly advised to reduce their fat intake levels).

To date only two studies were published that have evaluated the effect of a computer-tailored or targeted nutrition education intervention with objective, non-self report outcome measures. A study of Wylie-Rosett and colleagues [28] assessed the effect of a weight-loss intervention comprising dietary fat reduction and physical activity information. They compared a self-help workbook + computer-tailored intervention with a self-help workbook only condition and found a significant larger weight loss in the group receiving additional computer tailoring based on measured weight (2.2% vs. 0.9% reduction). Similar to the present study, they did not find effects on blood lipids (total, HDL- or LDL-cholesterol or triacylglycerol).
A web-based nutrition counseling intervention for dietary fat reduction among patients from general practices with increased cardiovascular risk [29] did also not result in significant effects on serum cholesterol levels.

Two possible reasons for the lack of effect in the present study should be discussed. First, the use of biomarkers in the present study may have obscured true effects of the intervention. The proportion of people that volunteered for the present study was much lower than we experienced in earlier evaluations of computer-tailored nutrition education interventions [21, 22, 30]. This may have been because the participant burden for the present study was higher because participants had to provide blood samples three times, resulting in a possible selection bias towards people already engaging in low-fat diets. In the present study high saturated fat intake levels were reported by 53% compared to 90% in the general population [31]. In the Dutch population at large 15.5% has a total cholesterol equal or above 6.5 mmol/L; in the present study this was 12.5% [32]. Serum-cholesterol levels of study participants with high levels at baseline are likely to be more sensitive to dietary changes than levels of persons with normal cholesterol concentrations [10, 33, 34].

Moreover, it is well known that there is a large individual variability in the individual response to therapeutic interventions [35, 36]. These differences may be due to the contribution of genes, environment and the interaction between genetic and environmental factors that are ultimately responsible for the actual lipid levels and individual response to interventions [37, 38].

A second likely explanation of the lack of effect is that the intervention was just not strong enough. Blood lipids changes are more likely to be found related to changes in dietary saturated and monounsaturated fatty acids in intervention studies if the diets are tightly controlled for all macronutrients, and if the changes in fatty acid intake are substantial between the diet periods [36, 39]. The changes in fat intake in the present study may have been too small. Although absolute self-reported saturated fat intake was 3.15-6.21 g/d lower in the computer-tailored interventions, we found no difference in percent energy from saturated fat [16], and the latter measure is always used in epidemiological and intervention studies which relate diet to serum lipids [9, 40].

In addition, it may be that the earlier reported effects of computer-tailored fat reduction interventions are due to 'information bias'. Computer-tailored feedback informs participants about what experts believe they should personally change in their own diet to improve the healthfulness of their diet. This individualized feedback could induce social desirable self-reports at post-tests, more so than generic nutrition education information. However, a study of Anderson and colleagues may possibly indicate that information bias does not necessarily occur when evaluating individualized information. They evaluated the effect of a computer-tailored intervention to reduce fat intake and to increase fiber, fruit and vegetable intake [41] with a self-reported FFQ, but at the same time attempted to ascertain a degree of objectivity in measuring dietary fat intake by using shopping receipts of the respondents to evaluate the amount purchased. Results showed that the intervention resulted in dietary fat reduction measured with both the FFQ and the shopping receipts [41].

From two systematic reviews [18, 34] it appeared that dietary advice in population settings (as opposed to tightly controlled clinical settings) can result in favorable changes in serum lipids. Due to the variation in the nature and combination of the messages given across the included studies, the authors were not able to identify 'best advice'. However, from the reviews it appeared that individualized feedback provided by a health care professional and interventions of longer duration and intensity with repeated feedback moments were associated with higher likelihood of effect. It may therefore be that the dose of the intervention may not have been strong enough in the present study, since it included only one feedback moment. There is some evidence that a multiple dose computer-tailored nutrition education intervention [42] is more effective in influencing dietary behavior. Furthermore, our intervention as well as other computer-tailored interventions did not involve interpersonal contact with a health care professional.

We conclude that a computer-tailored intervention with a single dose aimed at reduction of (saturated) fat intake was not sufficient to produce detectable changes in blood lipids in the current study. Methods should be explored to increase the feasibility of objectively assessing the impact of computer-tailored nutrition education interventions with blood lipids or other objective outcome measures. In addition, strategies should be developed to improve the intensity and duration of computer-tailored interventions, and to incorporate social interaction.

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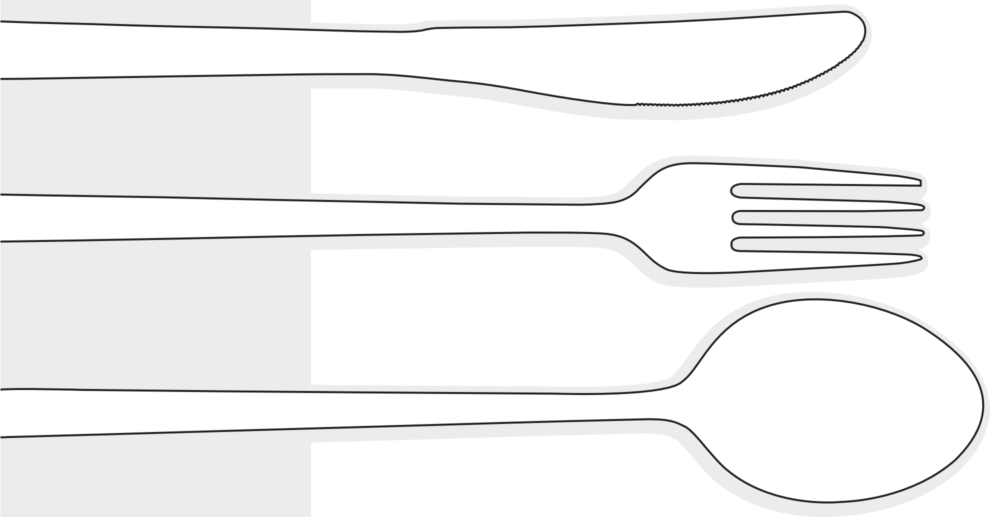
CHAPTER 7

Saturated fat consumption and the Theory of Planned Behavior: Exploring additive and interactive effects of habit strength



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ABSTRACT

The additive and interactive effects of habit strength in the explanation of saturated fat intake were explored within the framework of the Theory of Planned Behavior (TPB). Cross-sectional data were gathered in a Dutch adult sample (n=764) using self-administered questionnaires and analyzed using hierarchical regression analyses and simple slope analyses. Results showed that habit strength was a significant correlate of fat intake (ß = -.11) and significantly increased the amount of explained variance in fat intake ($R^{2\text{-change}}$ = .01). Furthermore, based on a significant interaction effect (ß = .11), simple slope analyses revealed that intention was a significant correlate of fat intake for low levels (ß = -.29) and medium levels (ß = -.19) of habit strength, but a weaker and non-significant correlate for high levels (ß = -.07) of habit strength. Higher habit strength may thus make limiting fat intake a non-intentional behavior. Implications for information and motivation-based interventions are discussed.

Keywords: fat intake, habit strength, Theory of Planned Behavior, interaction.

INTRODUCTION

In most Western countries, intake of saturated fat is higher than recommended [1], posing a threat to public health, especially because of its relation with cardiovascular disease risk [2]. Therefore, there is a need to develop effective behavioral change interventions aimed at decreasing saturated fat intake. Those interventions are likely to be more successful when they target theory-based determinants [3, 4]. The Theory of Planned Behavior (TPB) [5] has been used extensively to identify correlates and determinants of health behavior [6, 7], including fat consumption [8]. According to the TPB, behavior is primarily determined by intention, i.e. a motivational state towards engagement in that behavior. In turn, intention is theorized to be predicted by three social-cognitive variables, namely attitude, subjective norm, and perceived behavioral control. Attitude refers to the degree to which the performance of the behavior is positively or negatively valued, in which both cognitive and affective evaluations are relevant (e.g. [8]). Subjective norm is defined as perceived social pressure from significant others to perform the required behavior, while perceived behavioral control measures the extent to which performance of the behavior is considered to be easy or difficult.

Despite the validity of the theoretical assumptions of the TPB, demonstrated in systematic reviews and meta-analyses [9, 10], and in its usefulness for intervention development [11], calls have been made for the inclusion of additional variables in the TPB [12] to further our understanding of health behavior. One such variable is habit strength [12-14], which relates to behavioral factors such as unawareness of performing the behavior, difficulty in controlling the behavior, as well as mental efficiency in performing the behavior. Initially, habit strength was measured by assessing how often an individual had performed a particular behavior in the past: behaviors that were performed frequently and/or repeatedly were thought to be guided by habits, rather than by intentions [15-17]. Indeed, when included in a regression analyses, a measure of past behavior tends to diminish or nullify the effect of intention on behavior [10, 18, 19]. However, statistical associations between past and future behavior have been described as empty constructs with little explanatory value [20-22]. Because equating habit with past behavior faces several methodological and theoretical problems, a measure of habit strength that has discriminant validity over behavioral frequency is needed [23, 24]. Based on earlier discussions [22, 25, 26], Verplanken and Orbell [27] argued that habit strength is a psychological construct rather than past behavioral frequency and developed a 12-item script-based measure to assess the habitual strength of a particular behavior, the so-called Self-Reported Habit Index (SRHI). This measure is thought to be suitable for the further development of research and theory on habit [27], for instance by combining measures of habit strength with variables from the Theory of Planned Behavior.

Often, researchers rely on hierarchical regression analyses and R^2-change statistics to study the potential usefulness of an additional variable in the TPB (e.g. [28]). Using such analyses, several recent studies have shown that adding a measure of habit strength using the SRHI significantly increased the amount of explained variance in children's' [29] and adult fruit consumption [30] after TPB variables were accounted for. In addition to studying increments in explained variance using hierarchical regression analyses, several authors have proposed that studying the interaction of a new variable within the postulated relations of the TPB are of additional theoretical use [28, 31, 32]. This is particularly relevant for studying the role of habit strength. Because habits originate from repeated behavior in similar contexts, behaviors that are strongly habitual are presumed to be goal-directed behaviors that are automatically triggered by situational cues, rather than by cognitive intentions [16, 33]. A similar notion is acknowledged in Triandis' attitude-behavior theory [17, 34], which postulates that habit strength interacts with intention in the explanation of behavior. More specifically, when habit strength for a particular behavior increases, the association between intention and behavior should diminish. Thus, a strong intention-behavior relationship should be expected when habit is weak, but a weak intention-behavior relationship should be expected when habit strength is strong. In line with this reasoning, De Bruijn and colleagues [13] found that the SRHI indeed moderated the intention-behavior relationship with regard to fruit consumption. In this latter study, it was found that for those with a strong habitual fruit intake, intention was a weak and non-significant predictor of actual fruit intake five weeks later, whereas for those with a non-habitual fruit intake, intention was a stronger and significant predictor.

To date, empirical evidence of the additive effect of habit strength, assessed with the SRHI, in the explanation of saturated fat intake within the framework of the TPB is lacking. Additionally, the proposed moderating role of habit strength in the intention-behavior relationship in the explanation of saturated fat intake has also gone largely unattended. Nevertheless, demonstration of the effects of habit strength may provide further evidence for the usefulness of incorporating a measure of habit strength in theoretical models aiming to explain and predict dietary behaviors. In the present study, we therefore explored the additive effect of habit strength in the explanation of saturated fat intake, and the moderating role of habit strength in the intention-behavior relationship in a cross-sectional sample of Dutch adults. In line with empirical evidence, [13, 29, 30] we hypothesized that 1) habit strength would increase the amount of explained variance in saturated fat intake and that 2) habit strength would moderate the association between intention and saturated fat intake, with a weaker association for those with higher habit strength.

METHODS

Design and procedure

The present study used cross-sectional baseline data from participants in an intervention trial aimed at testing computer-tailored nutrition education to reduce saturated fat intake. Approval for this research project was obtained from the Medical Ethics Committee (MEC) of the Erasmus University Medical Centre Rotterdam. Participants received written information regarding the intervention trial and gave written informed consent. The information packages contained an invitation letter, an application and informed consent form, the declaration of the approval of the study by the MEC, and the bylaw on health insurance for participants. Furthermore, an information leaflet was included in which information on the aim of the study (comparing different types of nutrition information) was provided, as well as eligibility criteria, and a global description of the study procedure like type of measures (e.g. questionnaires), frequency of measures, length of the study and confidentiality. Recruitment was conducted using two strategies: recruiting employees at large companies and door-to-door advertising in two neighborhoods in the Rotterdam area. Rotterdam is the second largest city in the Netherlands, with approximately 600.000 inhabitants. Criteria for eligibility in the study were: between the ages of 18 and 65; sufficient understanding of the Dutch language, currently not on a diet prescribed by a dietician or physician, and currently not being treated for hypercholesterolemia.

Participants

Of the thirty-one companies approached, nine agreed to distribute the information packages among their employees (n=4118). Common reasons for non-participation of the approached companies were 'no answer received' (n=7), 'no time/not interested' (n=6), and reorganization of the company (n=5). Of these 4118 employees, 574 agreed to participate in the present study. Furthermore, some 9.000 information leaflets were distributed door-to-door among inhabitants in the two neighborhoods. Those who expressed their interest (n=224) (by pre-stamped response card, telephone or e-mail) were sent the information package, resulting in a total sample size of 798. Of these 798 participants, 764 completed the baseline questionnaire (mean age = 44.30 (SD = 10.20); 45.3% males (n=346)).

Fat consumption, cognitions and habit strength

Saturated fat intake was assessed with a validated food frequency questionnaire (FFQ) [35]. Pearson correlation with a 7-day diet record for this FFQ was .70 [35]. The FFQ consists of 35 questions covering 19 categories of food items that contribute most to saturated fat intake in the Dutch diet. Respondents were asked how often, how much, and which type of these

19 food items was usually consumed in the reference period of the last four weeks. For each of the 19 categories, a fat score, ranging from zero (lowest fat intake) to a maximum of five points (highest fat intake) was computed. The total fat score of an individual is calculated by adding up the 19 fat scores, which ranges from zero to 80, with a higher fat score indicating a higher fat intake (for a computation of fat scores, see Van Assema et al.[35]). Mean scores of 14 (women) and 17 (men) correspond with the upper levels of recommended dietary saturated fat intake in the Netherlands.

Intention was assessed with the items 'I intend to watch the amount of fat in my diet' (+2 = yes definitely; -2 = no definitely not) and 'How certain are you that you will watch the amount of fat in your diet?' (+2 = very certain -2 = very uncertain) (Cronbach alpha = .85). Instrumental attitude was assessed with the item 'Watching the amount of fat in my diet is' with answering categories healthy (+3) – unhealthy (-3). The same item with answering categories pleasant (+3) – unpleasant (-3) measured affective attitude. The item 'most persons who are important to me believe I should watch the amount of fat in my diet', with answering categories anchored by +3 (yes definitely) and -3 (no, definitely not) was used to assess subjective norm, while perceived behavioral control was assessed with the item 'I find watching the amount of fat in my diet easy (+3) – difficult (-3).

Habit strength towards watching the amount of fat in one's diet was assessed with 12 items derived from the SRHI [27]. Participants were asked to indicate on five-point scales (+2 = totally agree; -2 totally disagree) whether or not they agreed with the following statements regarding the stem 'Watching the amount of fat in my diet, is something' (1) I do regularly, (2) I do automatically, (3) I do without having to consciously remember, (4) that makes me feel strange if I do not do it, (5) I do without thinking, (6), that would require effort not to do it, (7) that belongs to my routine, (8) I start doing before I realize I am doing it, (9) I would find hard not to do, (10) I have no need to think about doing, (11) that is typically me, (12) I have been doing for a long time (Cronbach alpha = .94).

Statistical analyses

Initially, all associations between the study variables were analyzed using Pearson's correlations. In order to test our first hypothesis that habit strength would increase the amount of explained variance in saturated fat intake, hierarchical regression analyses were performed using forced entry with intention and PBC entered in Step 1, subjective norm and instrumental and affective attitude entered in Step 2, and habit strength entered in Step 3. In order to test our second hypothesis that habit strength moderates the association between intention and saturated fat intake, an interaction term intention*habit was computed and entered in the final step of the regression equation. Because interaction terms are likely to be highly correlated with their constituent variables, we followed the recommendation by Aiken and West [36] to centre these constituent variables in order to eliminate potentially problematic multicollinearity. In case of a significant interaction term, simple slope analyses [36] were used to examine the regression coefficient of the intention-behavior relationship across three levels of the moderator (low habit strength: mean – 1 SD; moderate habit strength: mean; high habit strength: mean + 1 SD). Because of the low amount of missing values (< 2%), missing data were mean-imputed. A significance level of $p < .05$ was employed. Furthermore, effect sizes were used as an informational source using Cohen's [37] guidelines for correlational analyses (r) and regression analyses (f^2). Regarding correlational analyses, effect sizes are small when r is equal to or larger than .10, medium when r is between .30 and .50, and large when r equals or exceeds .50. With respect to regression analyses, effect size f^2 was computed by dividing the amount of explained variance (r^2) by the amount of error variance ($1-r^2$): effect sizes were regarded as small when f^2 was between .02 and .15, medium when f^2 was between .15 and .35 and large when f^2 was equal to or larger than .35 [37].

RESULTS

Mean fat score for men was 19.77 (SD=5.74): 65.3% had a fat intake higher than the recommended dietary saturated fat intake of 17 points. Regarding women, mean fat score was 16.03 (SD=5.65), with 58.4% having a fat intake higher than the recommended dietary saturated fat intake of 14 points. Table 7.1 provides descriptives and bivariate correlations for the study variables. Scores for intention and subjective norm were around mid-scale, while mean scores for attitude, perceived behavioral control and habit strength were above mid-scale. Table 7.1 further shows that those with lower fat scores had a more positive intention, a more positive instrumental and affective attitude towards watching the amount of fat in their diet, and found that watching the amount of fat in their diet was easier. Furthermore, those who had a higher habit strength towards watching the amount of fat in their diet had a lower fat intake. Additionally, those who had a more positive intention towards watching the amount of fat in their diet had a more positive instrumental and affective attitude, found watching the amount of fat in their diet easier, and had a higher habit strength towards watching the

Table 7.1: Mean scores, standard deviations, and bivariate correlations between study variables (n=764) with range in parentheses

Study variables	Mean (SD)	1	2	3	4	5	6	7
1. Fat (1.00-36.00)	17.72 (5.99)	1						
2. Intention (-2.00, +2.00)	-0.96 (0.90)	-.25***	1					
3. Instrumental Attitude (-3.00, +3.00)	1.85 (1.17)	-.12**	.42***	1				
4. Affective Attitude (-3.00, +3.00)	0.17 (1.35)	-.19***	.46***	.29***	1			
5. Subjective Norm (-3.00, +3.00)	0.06 (1.86)	.06	.08*	.17***	.07	1		
6. Perceived Behavior Control (-3.00, +3.00)	0.46 (1.64)	-.27***	.49***	.24***	.55***	-.10**	1	
7. Habit strength (-2.00, +2.00)	-0.11 (0.99)	-.26***	.63***	.33***	.48***	.06	.61***	1

* p<.05 ** p<.01 ***p<.001

small effect size: r ≥ .10; medium effect size: .30 < r < .50; large effect size r ≥ .50

amount of fat in their diet. Effect sizes for the associations between saturated fat intake and study variables were small, while associations between TPB variables and intention were medium. A large effect size was found for the association between habit strength and intention, between habit strength and PBC, and between PBC and affective attitude.

Regression analyses

Table 7.2 shows the standardized regression coefficients resulting from the hierarchical regression analyses. In the first step, intention and PBC were significant negative predictors of fat intake: those who had a more positive intention and perceived more behavioral control towards watching the amount of fat in their diet had a lower fat intake. This model explained eight percent of the variance in saturated fat intake. Adding subjective norm and instrumental and affective attitude in the second step did not significantly increase the amount of explained variance, $R^{2\text{-change}} = .00$, $F^{\text{Change}} [3, 758] = .956$, $p = .413$. Furthermore, subjective norm and instrumental and affective attitude were non-significant predictors of fat intake in this step. Adding habit strength in the third step significantly increased the amount of explained variance, $R^{2\text{-change}} = .01$, $F^{\text{Change}} [1, 757] = 4.552$, $p = .036$. Habit strength was a significant positive predictor of fat intake, while PBC and intention remained significant predictors of fat intake: subjective norm, and affective and instrumental attitude were non-significant predictors of fat intake. The final model explained nine percent of the variance in fat intake, indicating a small effect size ($f^2 = .10$)

To test the theorized interaction, the habit * intention term was entered in the final step, which significantly increased the amount of explained variance, $R^{2\text{-change}} = .01$, $F^{\text{Change}} [1, 756] = 7.239$, $p = .007$ and revealed a significant interaction term (ß = .10, p = .007). Decomposing this interaction term by using simple slope analyses showed that intention to watch the amount of fat in one's diet was a significant predictor of fat intake for those with low habit

Table 7.2: Standardized regression coefficients, R^2, and $R^{2\text{-change}}$ statistics from hierarchical regression analyses (n=764) with fat scores as the dependent variable and intention and perceived behavioral control (Model 1), instrumental attitude, affective attitude, and subjective norm (Model 2), habit strength (Model 3) and the intention*habit interaction (Model 4) as the independent variables

	Model 1		Model 2			Model 3			Model 4		
	β	R^2	β	R^2	F^{change}	β	R^2	F^{change}	β	R^2	F^{change}
Intention	-.15***	.08	-.14**	.08	.957	-.10*	.09	4.552*	-.15**	.10	7.239**
PBC	-.20***		-.18***			-.14**			-.12**		
Instrumental attitude			-.02			-.01			-.01		
Affective attitude			-.03			-.02			-.02		
Subjective norm			-.06			.06			.07		
Habit strength						-.11*			-.09		
Interaction									-.10**		

*p<.05;**p<.01;***p<.001

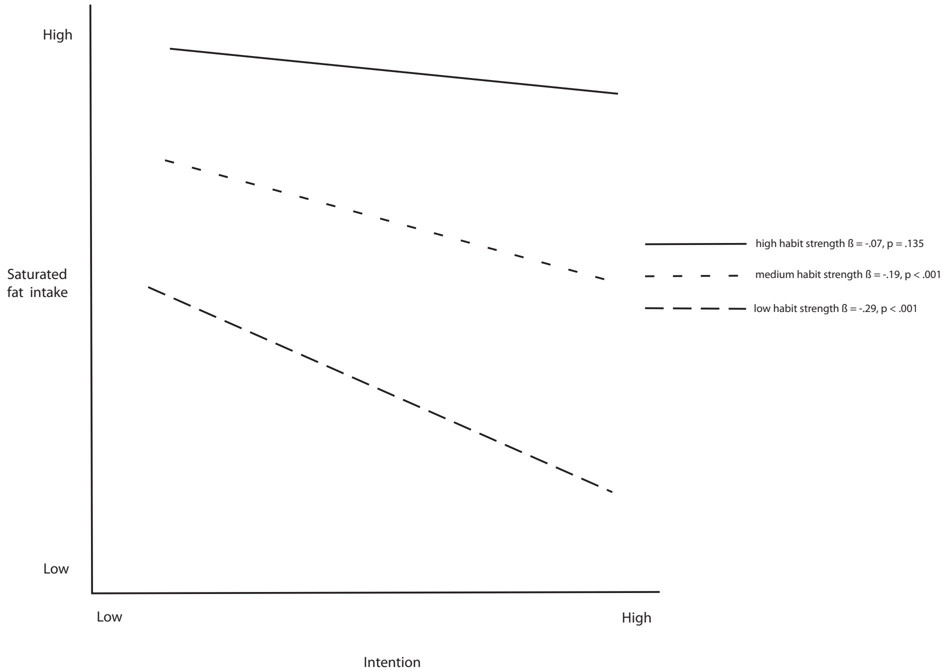

Figure 7.1: Association between intention to watch the amount of fat in one's diet and saturated fat intake across three levels of habit strength

strength (ß = -.29, p < .001) and moderate habit strength (ß = -.19, p < .001), but a weaker and non-significant predictor of fat intake for those with high habit strength (ß = -.07, p = .135) (see Figure 7.1)

DISCUSSION

In the present study, we used cross-sectional data to explore the additive effect of habit strength, as well as the hypothesized [17, 34] interaction between intention and habit strength, in the explanation of saturated fat intake amongst Dutch adults. Findings supported both our hypotheses. Habit strength significantly increased the amount of explained variance in fat intake scores, while habit strength also moderated the intention-behavior relationship.

The additive effect of habit strength in the explanation of dietary-related behaviors has been shown in other recent studies, most often with regard to the explanation of fruit consumption [29, 30]. Our results add to those studies by showing that habit strength also significantly increases the amount of explained variance in saturated fat intake. Furthermore, habit strength was, after PBC, the strongest correlate of saturated fat intake and, albeit marginally, a stronger correlate than intention, suggesting that saturated fat intake can become (at least partially) habitual behavior.

In line with the theoretical relations outlined in the TPB, intention was a significant correlate of saturated fat intake, with those with a stronger intention towards watching the amount of fat in their diet consuming less fat. However, simple slope analyses distinguishing three levels of habit strength showed that intention was only significantly associated with fat intake for those with low and medium levels of habit strength. For those with a high habit strength, intention was a weaker and non-significant correlate of fat intake. Our study adds to a substantial body of evidence [13, 15, 16, 38-41] that indicates that the relation between intention and behavior may be dependent upon habit strength, with intentions becoming less relevant when behavior is more habitual.

These latter results may also provide some insight into the limited effectiveness of traditional persuasive mass media campaigns aimed at decreasing saturated fat intake [1]. There are two reasons for this proposition. First, persuasive messages often transfer information about positive consequences of adopting the recommended health behavior and/or negative consequences of maintaining an unhealthy behavior [42, 43], targeted at the most salient beliefs regarding the behavior of interest in order to change attitudinal and control beliefs in a more healthy direction (e.g. [44]). These changed beliefs are then thought to increase one's motivation towards enactment of the desired behavior. However, even if these messages succeed in changing underlying beliefs and intentions, the weak and non-significant association between intention and behavior amongst those with strong habits suggests that behavioral change may not occur [13, 39]. Second, persuasive messages generally necessitate the recipient to pay attention to, and actively process the new information, if their effect on health behavior change is to be maximized [21, 45]. However, empirical evidence also suggests that those who are guided by strong habits use limited and selective information processing regarding alternative options [46]. Consequently, information commonly transferred in health interventions (such as benefits from a diet low in saturated fat) may go unnoticed and/or unprocessed by those with a strong habitual fat intake because their increased focus on the habitually chosen option may override attentional mechanisms needed to process such information [46, 47].

Because habits are triggered by situational or environmental cues, health behavioral change interventions for those guided by strong habits may therefore need to focus on strategies incorporating environmental cues, such as implementation intentions [48]. Whereas the TPB specifies intention in the form of 'I intend to do X', implementation intentions have the structure of 'I intend to do X when situation Y arrives'. Implementation intentions may thus automatically induce behavior when a suitable selected situation is encountered. An additional strategy is to make environmental changes, such as making unhealthy dietary choices less accessible [49]. Indeed, both strategies have found to successfully induce behavioral change regarding saturated fat intake [49, 50].

A few limitations regarding the present study need to be addressed. First, cross-sectional data were used in which behavior, cognitions and habit strength were measured contemporaneously. Although cross-sectional data are often used in studies on the TPB (e.g. [9, 10]), such data present conceptual problems since the causal ordering in the TPB is violated and associations between TPB variables may become artificially inflated [51]. Second, we used a self-selected sample of respondents who volunteered to take part in a nutrition education intervention study. Although our sample did not substantially differ from the general Dutch population regarding age and gender distributions, there was an over-representation of highly educated in our sample, so caution is needed in generalizing our findings.

Despite these limitations, our exploratory study is one of the first to show that habit strength is a potentially important determinant of saturated fat intake among adults. Additionally, our study also showed that the association between intention and saturated fat intake may be dependent upon habit strength, with higher habit strength making saturated fat intake a less intentional behavior. Future research efforts on saturated fat intake, habit strength and TPB should use longitudinal data in order to delineate the causal ordering between habit strength and saturated fat intake more precisely.

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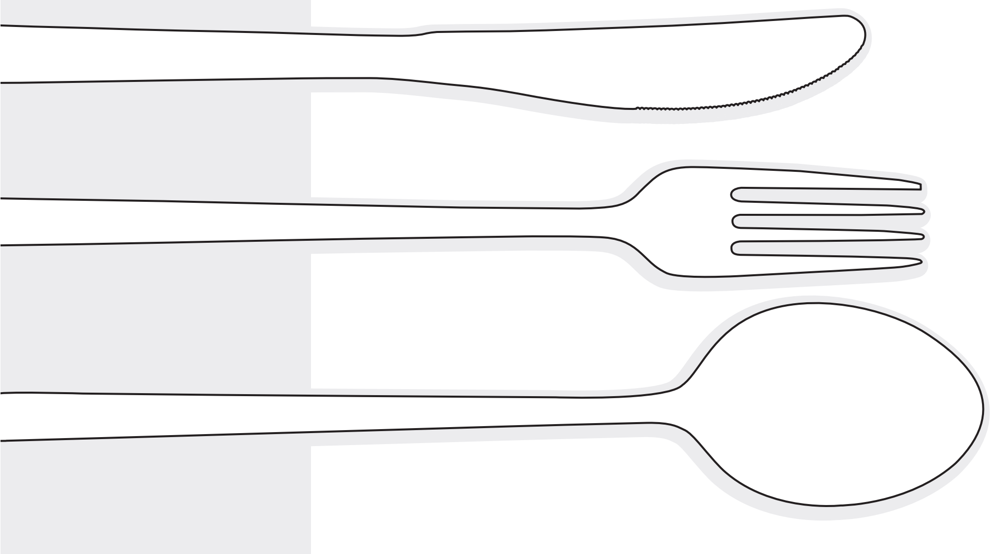
CHAPTER 8

General Discussion



Previous research recognized computer-tailored nutrition education as a very promising health education strategy. However, the evidence was mostly based on self-report measures, and more specific knowledge on why and how computer tailoring works and for whom was largely lacking (Chapter 2). There is limited evidence regarding which feedback elements that are commonly included in computer-tailored nutrition education are essential for effectiveness. Furthermore, we also do not know what delivery modes are most promising, for example if computer-tailored intervention can better be delivered in interactive electronic form, or if more traditional print-delivered versions are more effective and better appreciated. In addition, there is a need to test the impact of computer-tailored nutrition education with more objective outcome measures. In this thesis these knowledge-gaps were addressed in a large randomized controlled trial with five study arms and with post-tests at one and six months after the intervention. Respondents (aged 18-65 years) were randomly allocated to one of four computer-tailored feedback conditions or the control condition, receiving: 1) Personal-feedback in print format, 2) Personal-Normative feedback in print format, 3) Personal-Normative-Action feedback in print format, 4) Personal-Normative-Action feedback in interactive format, or 5) generic information in print format. Outcome measurements were cognitions (intention, awareness), self-reported dietary intake, and blood lipids. Statistical analyses were conducted among the total population and when relevant among the sub group of risk consumers (respondents with higher than recommended fat intakes at baseline) and the sub group of under estimators (respondents who underestimated their fat intake at baseline). This final chapter provides a summary of the main findings reported in chapters 3-7. Next, these results will be integrated and interpreted in light of the literature on these topics. Furthermore, methodological issues and possible limitations will be discussed followed by practical implications and recommendations for future research.

MAIN FINDINGS

Essential feedback elements

In Chapter 3 we compared three different computer-tailored interventions that varied in the amount/type of feedback that was given, with a 'control' group that received generic 'one size fits all' nutrition education. The first group received personal feedback on their own fat intake compared to the recommended amount of fat (P-feedback condition); The second group received additional normative feedback on own fat intake compared to the consumption of peers on top of the personal feedback (PN-feedback condition); the third group received further additional action feedback: practical suggestions on how to reduce fat intake and low-fat products (PNA-feedback condition). Differences between the intervention conditions were evaluated among all study participants randomly allocated to the different groups, and among two specific subgroups: 'risk consumers' and 'under estimators'.

We found evidence that risk consumers and under estimators benefit more from interventions with a combination of personal, normative and action feedback in inducing self-reported changes in fat intake and improving awareness of personal risk behavior. The briefer conditions had an effect on the intermediate determinants, but these types of feedback were not sufficient to change behavior. Therefore, future interventions should continue to incorporate these different individualized personal, normative and action feedback elements.

Comparison of interactive-delivered and print-delivered feedback

In Chapter 4 we compared the efficacy of two computer-tailored interventions with identical content (personal, normative and action feedback) provided through different delivery modes. One computer-tailored intervention was delivered in interactive form (CD-ROM) the other computer-tailored intervention was delivered in print. Both interventions were also compared to a condition receiving generic information. The intervention conditions were compared among the total study population and among 'risk consumers'. Since the overlap between the subgroups of 'risk consumers' and 'under estimators' appeared to be rather large and we did not evaluate the effects on cognitions in these papers, we did not conduct analyses among the subgroup of 'under estimators'. The results of this study indicated that interactive and print-delivered computer-tailored interventions could have similar short-term beneficial effects on total fat and energy intake. Differences between the feedback and generic condition could still be demonstrated for the print-delivered intervention after six months, but not for the interactively delivered intervention. There were no differences between the two feedback conditions.

In addition to efficacy evaluation we also conducted a process evaluation to explore possible differences in use and appreciation of the identical-content computer-tailored interventions, delivered in print or on CD-ROM in Chapter 5. The results of that study indicated that the print-feedback was read and saved more often than the CD-ROM-feedback in the total population and among men, women various age groups and educational levels. And, although the interventions had the same level of personalization and individualization, personal relevance of the print feedback was rated higher than for CD-ROM delivered feedback, which was especially the case for women and respondents aged 35-49 years.

Biomarkers as outcome measures of computer-tailored nutrition education

In Chapter 6 we explored the efficacy of the computer-tailored interventions aimed at the reduction of dietary fat intake using blood lipids as objective outcome measures. We compared the same three intervention conditions as in Chapter 4: the extensive computer-tailored interventions delivered in print or on CD-ROM and the generic information condition.

No significant differences between the three intervention conditions on total cholesterol, HDL-cholesterol, LDL-cholesterol or triacylglycerol neither among the total population nor among the risk consumers were found. We concluded that a computer-tailored intervention with a single dose aimed at reduction of (saturated) fat intake was not sufficient to lead to detectable changes in blood lipids.

Habit and the intention-behavior relationship

From the previous chapters we learned that the effect sizes of computer-tailored interventions are rather small. The content of the computer-tailored intervention was informed by the Precaution Adoption Process model and the Theory of Planned Behavior, i.e. mostly by theories that recognize determinants of nutrition behavior change that presume rather rationale decision making and personal control. However, in recent years the habitual nature of dietary behaviors received more attention. In Chapter 7 we therefore explored the possible role of habit strength in the prediction of saturated fat intake and the potential interaction effect of habit strength with intention. This study was explorative, since it made use of the cross-sectional data set obtained as the baseline measurement for the intervention studies. We concluded that habit strength is a significant correlate of fat intake behavior and higher habit strength may make limiting fat intake a non-intentional behavior.

INTERPRETATION OF THE MAIN FINDINGS

Are computer-tailored interventions really effective in reducing fat intake?

What can we conclude about the efficacy of computer-tailored interventions aimed at the reduction of fat intake? The systematic review presented in chapter 2 of this thesis pointed out that computer-tailored diet interventions and particularly the interventions aimed at reducing fat intake were effective. This was the case for both print-delivered and interactive-delivered interventions. However, the outcomes were based mostly on self-report measures. In the current project these effects on self-reported behavior were confirmed, especially among participants who were most in need of change, the risk-consumers. In contrast the effects of the computer-tailored intervention could not be confirmed in analyses with blood lipids as objective outcome measures.

Even though based on one study we cannot conclude that computer-tailored interventions may not be that promising for improving health outcomes, the findings should at least give rise to serious considerations about when to decide when computer-tailored interventions are effective. Are effects on self-reported behavior acceptable, or are effects on biomedical outcome measures at least required? If effects are indeed restricted to self-reports only, computer tailoring will not lead to changes substantial enough to promote health. However, a single study is not enough to conclude that computer-tailored nutrition interventions are not effective enough, and that results from earlier studies were due to the biases caused by self-reported measures. There are many difficulties with using blood lipids as outcome measures in field studies where respondents are supposed to change their own diet based on the information received. Firstly, it is costly and logistically complex to take samples from large populations, needed to detect small effects. Secondly, earlier studies suggest that dietary intake should be highly controlled to get detectable changes in blood lipids [1, 2]. Furthermore, eating less fat can also have beneficial health effects independent on changes in blood lipids, for example because lower fat intake is associated with lower likelihood of weight gain and overweight [3].

However, the lack of effect on blood lipids and the low effect sizes for self-report behavior certainly indicate that there is much room for improvement of computer-tailored interventions. Based on the findings of the studies in the present thesis, we can conclude that computer-tailored interventions aimed at saturated fat intake are effective in modifying determinants and self-reported behavior. We do not have evidence for effects on biomedical outcome measures.

How elaborate should a computer-tailored intervention be?

Based on the review it was not clear how elaborate a computer-tailored intervention should be to have either of the aforementioned effects. Interventions were usually not described in enough detail to make meaningful comparisons on dose-response relations possible. Our study was one of the first that made an attempt to get more insight in which feedback elements are essential for a computer-tailored intervention to be effective.
We concluded that the combination of personal, normative and action feedback was most effective in inducing changes in fat intake and improving awareness of personal risk behavior. Shorter feedback that only includes elements of comparison with guidelines and peers can only influence determinants, but does not lead to self-reported behavior change. Noar et al. also suggested that studies that tailored on behavior only had the weakest effects compared to studies that also tailored on theoretical concepts [4].

These findings correspond with the insights from theories that consider the behavior change process as consisting of a motivational and a volitional phase; both motivation and abilities are required for behavior change. The Social Comparison Theory posits that people are likely to evaluate performances preferably to that of others, especially when an objective standard is not readily available [5]. Giving feedback on personal consumption in relation to the dietary guidelines and in relation to the consumption of peers serves this desire and will influence awareness and motivation [6]. However, wanting to change is not sufficient for inducing behavior change. Abilities, skills and self-efficacy are also required [6, 7]. Feedback on how to change may improve these cognitions [6]. The most extensive type of feedback included feedback to increase the knowledge of behavioral options and to improve skills and self-efficacy.

It was often speculated that a possible problem with more elaborated tailoring is that the amount of information may become too extensive for people to process, remember, and put into use. In our study we found some evidence that more information is needed and that it is apparently not a problem to receive more information, as long as it contains meaningful elements that are tailored to the individual and make them aware of their risk behavior. People are still willing to read this information, especially when it is provided in print format. Speculating, it seems like if people do not want to make efforts to find more information on how to change, but want to receive it in an easy way.

In this study we dismantled behavioral feedback in various components. We did not study the additive effects of feedback on attitude or self-efficacy beliefs, or feedback on the environment. These elements may improve the efficacy and effectiveness of the intervention.

How can we improve the impact of computer-tailored nutrition education?

Primary prevention is important to reduce the burden of disease of many chronic conditions and the Dutch government emphasizes the individual responsibility of the public to adopt lifestyles conducive to health [8]. Computer tailoring is an individual directed intervention type, able to reach many people, that can support in improving health. Till now the effects of computer-tailored dietary change interventions, like many other dietary change interventions, are small and probably limited to self-reported behavior. Although we did find effects on self-reported fat intake in favor of our computer-tailored interventions and previous versions were also effective, there is room for improvement.

The impact of a nutrition education intervention depends on both the efficacy of the intervention as well as the exposure to the intervention [9, 10]. To evaluate those aspects both efficacy evaluation and process evaluation of the intervention should be integrated, as is emphasized by the RE-AIM framework [9]. According to this framework for an intervention to have an impact on public health, a substantial reach (i.e. a high proportion of people that participate in an intervention and are exposed to the intervention content) is needed. Furthermore, an intervention needs to be efficacious and the effects need to be maintained over time (maintenance). Improving the reach and the efficacy can help in improving the impact of computer-tailored interventions. In the next paragraphs we will reflect on two aspects of reach (improving the reach by choosing the optimal delivery mode of computer-tailored interventions and the optimal selection of target populations), and on improving the efficacy by modifying/extending the contents of the interventions.

Selecting delivery modes for computer-tailored interventions

Previous studies have examined the effects of both print-delivered and web-based or Internet delivered interventions. We included twenty studies addressing the reduction of fat consumption in the review; eight of these studies used an interactive delivery mode. From these studies eleven out of fourteen reported significant short-term effects in favor of computer-tailored interventions, among those were five interactive interventions. In addition, five out of seven reported significant medium-term effects of which three used an interactive delivery mode.

However, few have studied whether one delivery mode results in better effects than the other. Differences in effects could be caused by differences in attention to the intervention and cognitive processing of the information. We found that print-delivered and interactive delivered interventions can have similar effects, even though the effects of a print delivered intervention may persist longer. Based on these findings print-delivered and CD-ROM delivered interventions may be equally useful in terms of efficacy. There may, however be differences in use, that may as well be an important consideration for the choice of delivery mode. The results from our process evaluation suggest that the print-feedback was read and saved more often than the CD-ROM-feedback and personal relevance of the print feedback was rated higher than for CD-ROM delivered feedback, especially among women and respondents aged 35-49. This disadvantage of lower use and recall rates of interactive-media was also reported in two other studies that compared identical content print-delivered and Internet-delivered interventions [11, 12].

These findings may demonstrate that even though delivery through interactive media, in particular the Internet, has many advantages and is highly appreciated [13], print-delivered computer-tailored interventions would still be a good choice particularly for specific groups. The findings may also demonstrate that even though the Internet has many advantages and is used by many people, much more effort is needed to improve use of health education interventions [13]. Attention to the message as well as reading it and perceiving it as personal relevant is likely to contribute to the effectiveness of health education interventions [14-16].

Many studies have reported on the advantages (high potential reach, low costs, interactivity) of using the Internet as a channel for delivery of computer-tailored interventions, but also many difficulties and challenges have been encountered. In a Dutch report on promotion of healthy behaviors via the Internet [17] it was concluded that Internet-delivered interventions are potentially effective, but lack of exposure is a major threat to the effectiveness of those interventions. In addition, another Dutch study also concluded that web-based behavioral intervention programs might reach those who need them the least [18]. Furthermore, lack of exposure is not only caused by not having access to the Internet, there is also evidence that there is a digital divide in skills and in the actual use of Internet [19, 20]. Our data also illustrate this, since even among volunteers who participate in an intervention study about 20% did not read the information delivered on CD-ROM compared to only 5% who did not read the print-delivered information. In choosing the right delivery mode also the preference should be taken into account. Despite the high accessibility of Internet, many Dutch adults do not prefer it as an information source (ranked 15th out of 20) and ranked the Internet lower than health professionals, and written education[21].

Both print and interactive delivery modes can have their own advantages. Therefore it is advisable to carefully select the delivery mode based on the target population you want to reach. Combinations of computer and print could also be considered as delivery mode. The assessment of a risk behavior and its determinants can be done on for instance the Internet, a computer-kiosk in a doctor's office or computerized telephone. That way the risk of missing values on the screening instrument is none and the data can be easily processed. Feedback can be printed in a personalized letter or report and sent to the respondents by electronic or regular mail.

Selecting target populations for computer-tailored interventions

Still, using delivery modes that reach the audience and having effective interventions, does not guarantee the effectiveness. It may very well be the case that a proportion of the population is just not interested in information on healthy eating, let alone willing to read that information and make dietary changes. This lack of interest may for instance be caused by the fact that persons are not aware of their own risk behavior and/or the relation of that risk behavior with certain health risks.

Information needs are very diverse and are changing over time; certain life events or societal changes can trigger new information needs [21]. Interests may become different at a 'teachable moment', a time in someone's life when motivation to change one's lifestyle is especially high [22-24]. A teachable moment can, for example, be a diagnosis for a serious disease [25] or health risk factors, such as having obesity. This may have to do with perceived susceptibility for and severity of certain health conditions. A study among 603 Dutch adults [21] showed that lowering cholesterol and losing weight were only perceived as relevant by 23% and 21% of the study population respectively. Especially persons of 51 years and older attached more importance to lowering cholesterol and eating less fat and they were also interested in more information about lowering cholesterol. In addition overweight people found losing weight, lowering cholesterol and eating less fat more important while people of low socioeconomic status perceived eating less fat as more important.

A systematic review [26] on interventions to increase adult fruit and vegetable intake concluded that larger effects were generally observed in individuals with preexisting health disorders. Future computer-tailored intervention studies may consider using a high-risk strategy because those people may profit more from health promotion interventions [27]. The Third Joint Task Force on cardiovascular diseases recommends this high-risk approach[28].

To reach the high-risk groups with dietary change interventions it may be more effective to approach persons pro-actively [10, 22, 29, 30]. For example general practitioners can send out targeted mailings to their patients to stress the need for a healthy diet and refer them to good programs on the Internet, but also health insurance companies may do that. Recent developments show that health insurance companies are becoming more interested in primary prevention and promoting healthy lifestyles. Results on the reach of a computer-tailored nutrition education program in the Dutch heart health community intervention 'Hartslag Limburg' indicate that incorporating such interventions in a community approach may help to reach more lower-educated people [31].

Improving the content of computer-tailored nutrition education interventions

Although computer-tailored nutrition education interventions incorporating personal, normative and action feedback elements seem to be more effective than generic information, the reported effect sizes were usually small and long-term effects were not convincing, leaving room for improvement of the intervention. Issues on the diagnostic instrument and on the feedback messages used in the interventions evaluated in the studies described in this thesis will be discussed.

Firstly, our diagnostic instrument for fat intake may not be as adequate as it was in the past. The fat-list used was developed in 1992 [32] and updated in 2001 [33]. We see that the mean baseline fat score in previous studies that used an intervention from which the interventions in the current studies were derived, was higher than in our study (17.4), but decreased over the years: 28.5 in 1996 [34], 27.0 in 1999 [35] and 20.0 in 2005 [36]. An adaptation of the scoring system of the fat list [32, 33] may explain part of the difference in fat scores between the studies conducted before and after the year 2000, but it is not likely that the downward trend is totally due to that change in scoring system. In the Dutch population at large a downward trend in fat consumption was also detected in the last decade [37], although consumption of saturated fat is still too high. The fat-list especially measures those products that contribute to the saturated fat intake. The fact that the mean fat score of study populations decreased over the years may either reflect the possibility that volunteers eat healthier or that consumption patterns have changed, which are missed by our instrument. Our diagnostic instrument could be improved by incorporating 'new' product categories like 'ready-to-eat-meals' and 'take-home-meals' that usually contain lots of hidden fat and are consumed more and more often [38], and a wider range of snack-foods.

In addition the basis of the psychosocial determinants included in the diagnostic instrument is based on determinant studies conducted more than a decade ago. There may have been a change in determinants over the years. Besides, the range of determinants addressed was limited and were measured with single items only. We found some indication in the review (Chapter 2) that a more detailed diagnostic tool, leading to more detailed feedback may result in larger effect sizes. Findings of a recent meta-analysis on computer tailoring also suggest that tailoring on at least four theoretical concepts is more effective than tailoring at 0-3 concepts [4]. However, it may be so that respondents will perceive the questionnaire as too long and are therefore not willing to finish it, leaving them without a proper tailored advice. This topic is currently under study at the department of Public Health of Erasmus Medical Center.

The feedback messages may be improved with respect to the content of the feedback as well as the strategies used in the feedback.
The feedback on consumption mainly addressed the reduction of fat intake, by substituting high fat products with low fat products. But, to enable a shift in nutrient intake it is also important to replace saturated fat by unsaturated fat [39]. This replacement is more likely to result in changes in saturated fat intake measured in percentage of daily energy intake. To achieve changes in diet composition it may be even better to address the daily diet instead of a certain group of products. The aim of the present study was to evaluate the effects of a single behavior intervention: reduction of saturated fat intake. By doing so other aspects of a healthy diet have not been addressed. An emphasis on fat, may neglect products containing a lot of sugar that may contribute to a positive energy balance [3]. Furthermore, promotion of healthy products like fruit and vegetables may also have a positive influence on reduction of fat and calorie intake [40]. In the review (Chapter 2) we also, provisionally, noticed that combining fat reduction with other dietary goals might improve the chances of success.

Interpersonal counseling is still regarded as potentially the most effective method in health education. Such personalized feedback can be mimicked by computer-tailored interventions, but a social interaction component is lacking. Adding a social interaction component to computer-tailored interventions may improve the efficacy. The Internet offers many possibilities for including a social component such as chat boxes, message boards etc. Adding a social component in print-delivered interventions is difficult. Woolf et al [41] suggest that web sites are more likely to be effective as part of a suite of tools that incorporates personal

assistance. Social support may be just one important part of a supportive environment that is a key to the maintenance of behaviors [42].
An example of a computer-tailored intervention incorporating social components is a study of Winett and colleagues [43] in which they describe the usefulness of the Guided Mastery Process from Bandura in computer-tailored interventions. A mastery-counselor is a competent and successful model who provides guidance in goal setting, planning, and self-monitoring at each phase of behavior change (e.g. initiating behavior change, establishing new behaviors in one's repertoire, and behavioral maintenance) as well as serving as an exemplar of those behaviors. Their results indicate that those interventions extended with personal coaching, (virtual) counseling or embedded in social networks were more effective than programs without such a social component.

The emphasis of the interventions evaluated in this thesis was on improving fat consumption, by improving the intention to change and increasing awareness of own fat consumption. But, when someone has high habit strength for a certain behavior, the association between intention and behavior may become very small. It may, however, be argued that feedback about behavior is intended to make people aware of their behavior as a means to break their habit. Further, being motivated is also not a guarantee for acting as was identified by researchers who call this the 'intention-behavior-gap'. Gollwitzer argued that effective goal pursuit consists of two phases, a motivational and a volitional phase [44]. The motivational phase is concerned with thinking about and deciding to achieve a particular goal. The volitional phase consists of planning actions in order to achieve that goal. Action feedback was used to provide behavioral options and to improve skills. Stronger methods could have been used for action initiation such as goal setting [45, 46] and implementation intentions [47].

Our individual-level intervention acknowledges the importance of motivation and to a lesser extent abilities. However, opportunities are also identified as important determinants of behavior [7]. Behavior is not only caused by personal factors, the interaction with the environment may play an important role [48-50]. The physical availability, the economical accessibility, and the social-cultural acceptability of eating and buying lower fat foods may all be important opportunity-related factors that were not addressed in the present intervention. For instance, our intervention did not address barriers for eating less fat in an extensive way. Assessing why certain situations are perceived as barriers, could refine the feedback to overcome these barriers. This feedback may also be important in the maintenance of a behavior. A combination of strategies aimed at both the individual and the environmental level, may lead to more and longer lasting behavioral change [48-50].

Finally, the dose of our intervention may not have been enough to achieve sustainable changes in the long-term. Noar and colleagues suggest that studies that utilized more intervention contact points, many of which included ipsative feedback, were more effective in stimulating health behavior change than those that did not [4]. A one-dose intervention does not allow providing feedback on progress in performance and teaching skills in dealing with lapses and to maintain the behavior initiated. A greater understanding is required of the factors determining maintenance of health behavior; it is likely that they will be different from the factors important in the initiation of behavior [42]. Including these methods in an intervention is likely to improve the effects [42].

METHODOLOGICAL ISSUES

A randomized controlled trial was chosen as the design to study the various research questions. This design was appropriate for answering the research question in this phase of intervention evaluation; establishing efficacy, in which the internal validity is of major concern. This design is the strongest to evaluate the impact of an intervention [51, 52]. The randomization procedure is used to create equal study groups [53], and rules out several threats to internal validity. Hence, the observed differences in study groups can be ascribed to the intervention strategies with great certainty. Despite our strong design, there may be some methodological issues that limit the findings of our study. We will discuss the selectivity of our study sample, the lack of exposure to the interventions, and potential problems with the measurements of fat intake and blood lipids as potential limitations with respect to participants and procedure as well as to the outcome measures.

Participants and Procedure

The target group for our project was Dutch adults aged 18-65 years, without a treatment (diet or medication) due to hypercholesterolemia and with a sufficient understanding of the Dutch language. We recruited volunteers through large companies and distribution of door-to-door leaflets in Ommoord, a neighborhood of Rotterdam and in Spijkenisse. Our recruitment activities resulted in a sample of volunteers from mostly white-collar companies and middle-class communities, who were relatively highly educated, compared to the Dutch population at large and had a lower fat score at baseline. This selection hampers the generalizability of our findings to other population groups, such as lower educated groups and those with high fat intakes. However, our sample included about 50% of participants with higher than recommended fat intake levels and we found that among those so-called 'risk consumers' the efficacy of the computer-tailored interventions was most pronounced. In contrast to our expectations, the dropout rate of our participants was lower than expected. We started the trial with a total of 764 respondents and ended with 667 respondents, a dropout of 12.7%. Dropout did not depend on study condition; only age appeared to play a minor role. Apparently our respondents were highly motivated to participate. It may, however, be that some of the volunteers participated because they would receive the outcomes of their blood cholesterol test at the end of the study and not because of the nutrition education intervention. These participants may not have meaningfully processed the information in their assigned intervention program, which may have diluted the intervention effects.

Furthermore, the actual exposure to the different intervention conditions was beyond our control due to the real-life setting, this might have influenced the internal validity of our study. Respondents may have decided not to read the information. Furthermore, we cannot rule out the possibility that respondents from companies lend their CD-ROM to colleagues who were assigned to other conditions, despite the instructions that the program was strictly personal and only suitable for them. However, due to this real-life setting the results say more about the effectiveness and can be better generalized to the general public, than results derived from intervention studies evaluated in full-controlled behavioral laboratory circumstances.

Measurements

To assess the outcome measures of fat and nutrient intake we decided to use the extensive food frequency questionnaire developed by Wageningen University. This questionnaire was validated and enabled assessment of the nutrient intake measured in percentage of daily energy intake [54]. Measuring fat intake in such detail was important, because diet measured in those units is usually linked to health and biological outcomes like blood lipids. However, completing the FFQ is very time consuming and rather complex. We used the instrument as a self-administered questionnaire, even though it was developed for researcher-assisted administration. To improve the quality of our collected data, it may have been better to phone or visit every single respondent to check if they filled-out the questionnaire in the right way. However, this would not have been feasible for this large-scale study.
In addition, self-reported data may be subject to socially desirable answers and inaccurate responses. In case of fat-intake, this may results in under-reporting of fat consumption since many people know that too much fat is not healthy, especially after receiving (computer-tailored) nutrition education information on this topic. Bias due to socially desirable answering may, however, be limited, because of the extensive questionnaire that calculates intakes from many variables.

Using ‘objective’ or ‘hard’ outcome measures may have advantages over self-reports and is not prone to response biases. However, assessing blood lipids and using them as outcome measures of a nutrition education intervention aimed at primary prevention comes with its own drawbacks.

Firstly, it is logistically complex and very costly to collect and analyze the blood samples among a large study group. Although we requested the participants not to eat or drink (except water, coffee, tea without any condiments) from 10 pm the night before blood sampling had to take place, there may have been some participants who did not comply with this request. Furthermore, because blood lipids are not very sensitive, the number of participants needed to detect meaningful changes in blood lipids was very high and it is questionable if effects can be expected when blood lipid levels are not elevated.
However, two systematic reviews [55, 56] did indicate that dietary advice in population settings (as opposed to tightly controlled clinical settings) can improve diet (fat intake in percentage of daily energy intake) and serum lipids in free-living healthy persons. Brunner and colleagues [55] reported statistically significant reductions in total serum cholesterol (-0.13 mmol/L) and LDL-cholesterol (-0.13 mmol/L) 3-12 months after interventions aimed at reduction of cardiovascular risk. Thompson and colleagues [56] reported reductions in total cholesterol after six months or less among 'dietitian-groups' (-0.34 mmol/L) and among the 'self-help resources group' (-0.07 mmol/L), with a significantly larger reduction for the dietitian groups.

Because we considered behavior (fat consumption) and blood lipids as most important outcome measures, and we tried to reduce the burden for participants in our study as much as possible, we were not able to assess possible mediators and moderators of intervention effects (psychosocial determinants, process evaluation, exposure etc.) more thoroughly. To get a good picture of the impact of interventions more information on those mediators and moderators is essential.

RECOMMENDATIONS FOR PRACTICE

Computer-tailored nutrition education including extensive feedback, is effective in changing self-reported dietary fat intake. Efforts should be made to develop and incorporate new strategies to improve the effect size of computer-tailored interventions as well as the long-term effects.

It is important to always inform people on why, what and how to change. Telling someone that he or she does not comply with dietary standards by personalized feedback seems to be important to make him or her aware of their risk behavior. In addition a clear link between the risk behavior and health problems should be given. Awareness and motivation are crucial to behavior change as is practical behavior change information. Practical feedback information should be given about how to make the required changes in a relatively easy way and about how to cope with situations in which it might be difficult to eat less fat.

Nutrition education by an interactive delivery mode such as a CD-ROM (or Internet) is an effective tool to potentially reach large audiences. However, it is important to realize that many people lack skills to use computers properly, still do not have access to the Internet, or simply prefer other methods like written information. Therefore, it may be good to offer different delivery modes for interventions to optimize exposure to the interventions.

It also is of vital importance to develop computer-tailored interventions that are especially suitable for high-risk populations like those with a lower socioeconomic status. The interventions should also especially be evaluated among those groups. Also strategies to maximize exposure to the interventions among these groups have to be studied. Given the increase in number of ethnic majorities, it is worthwhile to develop proper diagnostic tools for such target groups and interventions that are culturally tailored to their specific determinants and behaviors.

RECOMMENDATIONS FOR FUTURE RESEARCH

We recommend that future research projects should be aimed at evaluation of (Internet-based) computer-tailored interventions in real-life settings.

Drawing a firm conclusion on the efficacy of computer-tailored nutrition education is difficult, since the reported effects may be limited to self-reported behavior. We recommend that more research is necessary to evaluate the efficacy of computer-tailored nutrition-education interventions with objective biological outcome measures. To evaluate the efficacy of computer-tailored interventions, aimed at saturated fat reduction, on objective outcome measures, it may be more cost-effective to recruit participants with elevated blood lipid levels. Sensitivity to changes will increase, making the required sample sizes lower thereby reducing the costs for blood sampling and analyses.

In addition, we still do not know how detailed the screening instrument and how elaborate the feedback should be for an optimal effect. More research is necessary on how we can achieve long-term (life long) behavioral change effects and how we can improve the effect sizes of the interventions. Continuous efforts to open up the 'black box' of tailoring, will provide us with more insight that will enable us to improve health behavior change interventions and in the long run public health.

The diagnostic instrument is a crucial factor for the efficacy of computer-tailored interventions. We recommend a regular monitoring system to assess determinants of health behavior preferably longitudinal; this system can be used as an up-to-date database to extract relevant determinants (goals) for new targeted or tailored interventions. It is important that funding agencies acknowledge the importance of such 'basic' research and make resources available for those projects. Reliable and valid measurements are not only crucial for effective computer-tailored interventions, but also for outcome measurements. We recommend striving for reliable, validated, uniform, national, up-to-date questionnaires for health behaviors and determinants and making these easily findable and available for scientific research.

Finally, more research is necessary to improve the content of and exposure to interactive interventions. Research on how behavior change strategies can be used in an optimal way in interactive interventions and how interactive interventions can make better use of the possibilities of the Internet. But also exposure to/use of interactive interventions should be investigated to improve these aspects. Some initiatives in this field are already started.

GENERAL CONCLUSION

It can be concluded that computer-tailored nutrition education incorporating personal, normative and action feedback is more effective in reducing dietary fat intake than generic information. There were no differences in effects between two identical-content interventions delivered through different modes (interactive on CD-ROM and print). Both interventions had an impact on self-reported fat and energy intake on short term. The effect was still measurable in the print condition six months after the intervention. However, these effects of both interventions could not be confirmed with biomarkers and effect sizes were generally small, leaving much room for improvement. The print-delivered feedback was read and saved more often and perceived as more personally relevant. When changing saturated fat intake is the aim, an intervention including personal-normative-action feedback can be provided in either interactive or print format. For specific sub-groups print information is read more and therefore the effects may persist longer. More research is needed to improve efficacy and exposure rates of interactively delivered computer-tailored interventions.

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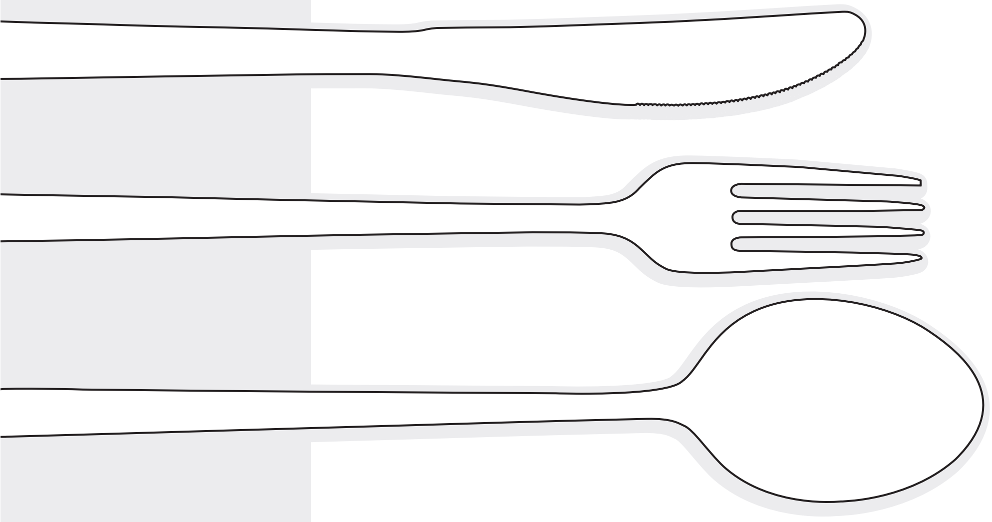
SUMMARY & SAMENVATTING



Summary

High saturated fat intake is highly prevalent among the general populations of Western countries. Saturated fat intake is an important risk factor for cardiovascular diseases, one of the main burdens of disease worldwide. Therefore it is important to use population-wide health promotion efforts to target this risk behavior. Computer-tailored nutrition education has been found to be a very promising health education strategy that can be applied in population health promotion. A review study presented in **Chapter 2** of this thesis showed that three out of eleven of the physical activity studies and twenty out of twenty-six of the nutrition studies found significant effects in favor of the tailored interventions, especially for fat consumption. However, several questions remained unanswered on why, where and for whom computer-tailored (nutrition) education is effective. First, it is not yet clear why tailored materials are more successful in influencing behavior than non-tailored materials. The question remains which elements and features of computer-tailored interventions are responsible for the effect. Second, we do not know if the second generation of computer tailoring, delivered by interactive media such as a CD-ROM or the Internet is as effective as the first generation print-delivered computer tailoring. Third, the evidence for computer-tailored interventions is based on self-reported outcome measures with all its disadvantages. What is the efficacy of computer-tailored nutrition education measured by means of more objective outcome measures? And fourth, there is lack of evidence on how the relatively small effects of computer-tailored interventions can be explained or improved. Answering these questions can help in improving the efficacy and applicability of computer-tailored (nutrition) interventions.

This thesis presents a series of studies (**Chapter 3-7**) in which these questions are addressed. The separate studies were conducted in one large randomized controlled trial aimed at the reduction of saturated fat intake, with five study arms and two post-tests at one and six months after the intervention. Respondents were recruited from among employees of nine companies in Rotterdam and two neighborhoods in the urban-area of Rotterdam (Ommoord and Spijkenisse). Respondents (n=764) who completed the screening questionnaire were randomly allocated to one of four computer-tailored feedback conditions or the control condition receiving: 1) Personal feedback (i.e. feedback about personal intake levels

compared to recommended intake) in print format, 2) Personal-Normative feedback (normative feedback is feedback on own fat intake compared to the consumption of peers) in print format, 3) Personal-Normative-Action feedback (action feedback is practical suggestions on how to reduce fat intake and on low fat products) in print format, 4) Personal-Normative-Action feedback in interactive format (on CD-ROM) or 5) Generic information in print format. Outcome measurements were cognitions (intention to reduce fat intake and awareness of ones own fat intake), self-reported dietary intake (fat intake in grams/day and percentage of daily energy intake) and blood lipids. The intervention effects were evaluated among the total population and among relevant sub groups of 'risk consumers' (respondents with high fat intakes at baseline) and 'under estimators' (respondents who underestimated their fat intake at baseline).

Chapter 3 addresses the first question mentioned above and describes a study in which the efficacy of three types of feedback was evaluated. The conditions 1) Personal feedback, 2) Personal-Normative feedback, 3) Personal-Normative-Action feedback and 5) Generic information were compared, in order to identify the essential feedback elements for a computer-tailored intervention to be effective in changing (saturated) fat intake, intention to reduce (saturated) fat intake and awareness of one's own (saturated) fat intake. Our results indicate that the combination of personal, normative and action feedback is necessary to achieve significant changes in awareness of one's own fat intake (one month post-intervention) and in intention to reduce fat intake and (saturated) fat intake levels (most apparent at six months post-intervention). Personal feedback only had some effects on awareness and intention to reduce fat intake, while the combination of personal and normative feedback had some effect on intention. Effects were only found among the risk consumers and under estimators, i.e. the respondents who should profit most.

Chapters 4 and 5 address the second question and describe studies on the comparison of an identical-content computer-tailored intervention delivered in print and in interactive format. The studies address the effect and process evaluation of the Personal-Normative-Action-feedback condition delivered in interactive format on a CD-ROM in comparison with the identical-content condition delivered in print and generic information. **Chapter 4** showed that, in the short-term, interactive and print-delivered computer-tailored fat reduction education have similar effects on total fat (g/d), saturated fat (g/d) and energy intakes compared to generic information. In both tailoring conditions, the effects were most pronounced in the subgroup 'risk consumers'. Even though these effects on the fat outcome measures were maintained at longer term in the print-delivered condition only, there were no significant differences between the interactive-tailored and the print-tailored condition at any point in time. Differences in (saturated) fat intake measured in percentage of daily energy intake were not significant. **Chapter 5** describes differences in use and appreciation of the interactive-delivered and print-delivered computer-tailored feedback (groups 3 and 4). Analyses were conducted among various specific target groups who may be less motivated to use, or have fewer skills in using a computer and/or Internet (i.e. gender, age and educational level). The results of this study show that print-delivered feedback was read more often than the interactive-delivered feedback among the total population, women, participants aged 50-65 years, and lowest- and highest-educated respondents. The print-delivered feedback was reported to be saved more often among the total population, men, women, the groups of <= 34 years and 35-49 years, and medium- and highest-educated respondents. In addition, the print-delivered feedback was perceived as more personally relevant in the total study group and in the subgroups of women and the group of 35-49 years of age.

The study presented in **Chapter 6** addresses the third question and explored the efficacy of the computer-tailored interventions aimed at the reduction of dietary fat intake using blood lipids as objective outcome measures. In this study the same three intervention conditions were included as in Chapter 4: the extensive computer-tailored interventions delivered in print (group 3) or interactively (group 4) and the generic information condition (group 5). No significant differences between the three intervention conditions on total cholesterol, HDL-cholesterol, LDL-cholesterol or triacylglycerol among the total population or among the risk consumers were found.

From the previous chapters we learned that the effect sizes of the computer-tailored interventions tested in this thesis were rather small. Therefore, we explored possible theoretical explanations for that lack of effect in **Chapter 7**, based on cross-sectional baseline data of the overall trial. We explored the additive effect of habit strength for limiting fat intake in the explanation of saturated fat intake within the framework of the Theory of Planned Behavior and the potential interaction effect of habit strength in the intention-saturated fat intake relationship. Results showed that male gender, perceived behavior control and habit strength were positively associated with saturated fat intake. There was a significant habit-intention interaction; intention was a significant correlate of fat intake among respondents with low habit strength, but a non-significant correlate for those with medium and high habit strength.

The **conclusions** of this thesis are as follows: It was concluded that computer-tailored nutrition education incorporating personal, normative and action feedback is more effective in reducing self-reported dietary fat intake than generic information. There were no differences in effects between two identical-content interventions delivered through different modes (interactive on CD-ROM and print). Both interventions had an impact on self-reported fat and energy intake on short term. The effect was still measurable in the print condition six months after the intervention. However, these effects of both interventions could not be

confirmed with biomarkers and effect sizes were generally small, leaving much room for improvement. The print-delivered feedback was read and saved more often and perceived as more personally relevant compared to the interactive-delivered feedback. When changing saturated fat intake is the aim, an intervention including personal, normative and action feedback can be provided in either interactive or print format. However, some target groups read the print information more and therefore the effects may persist longer. More research is needed to improve efficacy and exposure rates of interactively delivered computer-tailored interventions.

Samenvatting

Een hoge verzadigd vet consumptie komt veel voor onder de algemene bevolking van Westerse landen. Verzadigd vet consumptie is een van de belangrijkste risicofactoren die bijdragen aan de wereldwijde ziektelast (de zogenaamde 'global burden of disease'), vanwege de sterke samenhang met hart- en vaatziekten. Het is daarom van belang dat de gezondheidsbevorderende strategieën die ingezet worden om dit risico gedrag aan te pakken, gericht zijn op de gehele bevolking. In de afgelopen 15 jaar is onderzoek verricht naar de effectiviteit van advies-op-maat interventies in de (voedings)voorlichting. Hieruit is gebleken dat advies-op-maat een veelbelovende gezondheidsvoorlichtingmethode is voor verschillende gezondheidsgedragingen. De resultaten van de systematische review die in **hoofdstuk 2** van dit proefschrift worden gepresenteerd, lieten zien dat drie van de elf studies gericht op lichamelijke beweging en twintig van de zesentwintig studies gericht op voeding significant betere effecten vonden voor advies-op-maat methoden vergeleken met een controle groep die algemene informatie of geen informatie ontving. Die gunstige effecten werden voornamelijk gevonden bij studies die zich richtten op het verminderen van de (verzadigd) vet consumptie. Desondanks bleven de vragen naar waarom advies-op-maat beter werkt, hoe het werkt en voor wie dit het beste werkt nagenoeg onbeantwoord. Ten eerste is het niet volledig duidelijk waarom advies-op-maat meer succes heeft in het beïnvloeden van gedrag dan algemene informatie. Welke elementen en eigenschappen van advies-op-maat interventies zijn eigenlijk verantwoordelijk voor het effect? Ten tweede is het niet duidelijk of de zogenaamde tweede generatie van advies-op-maat die verstrekt wordt via interactieve media zoals een CD-ROM of Internet, net zo effectief is als de eerste generatie advies-op-maat die schriftelijk wordt verstrekt. Ten derde is het bewijs voor advies-op-maat gebaseerd op zelfgerapporteerde uitkomstmaten met al hun tekortkomingen. Maar wat is het effect van voedingsadvies-op-maat gemeten met meer objectieve uitkomstmaten? Ten vierde is nog niet duidelijk waarom de grootte van het effect van advies-op-maat relatief klein is en hoe de effecten verbeterd kunnen worden.

In dit proefschrift worden studies gepresenteerd (**hoofdstuk 3-7**) die op deze vragen ingaan. De afzonderlijke studies zijn uitgevoerd in één grote gerandomiseerde gecontroleerde trial met vijf studie armen en twee nametingen op één maand en op zes maanden na de interventie. De trial richtte zich op de vermindering van de consumptie van verzadigd vet. Deelnemers werden geworven onder de werknemers van negen bedrijven in Rotterdam en onder de bevolking van twee wijken in de regio Rotterdam (Ommoord en Spijkenisse). Deelnemers die de vragenlijst op de voormeting hadden ingevuld (n=764) werden door het lot toegewezen aan één van de vier advies-op-maat groepen of aan de controle groep. De groepen ontvingen: 1) schriftelijke 'Personal feedback' (dit is feedback op de hoeveelheid vet die gegeten wordt, in vergelijking met de richtlijnen), 2) schriftelijke 'Personal-Normative feedback' (normative feedback, is feedback op de hoeveelheid vet die gegeten wordt, in vergelijking met wat anderen van hetzelfde geslacht en dezelfde leeftijd eten), 3) schriftelijke 'Personal-Normative-Action feedback' (action feedback is praktische (product) informatie voor het verminderen van vet in de voeding), 4) interactieve 'Personal-Normative-Action feedback' (op CD-ROM) of 5) algemene schriftelijke informatie. De uitkomstmaten van de studies waren cognities (intentie om minder vet te gaan eten en bewustzijn van eigen vet inname), zelf gerapporteerde voedingsinname ((verzadigd) vet gemeten in gram/dag en in het percentage van de dagelijkse energie-inname) en bloed lipiden (totaal cholesterol, HDL- en LDL-cholesterol en triacylglycerol). De effecten van de interventie werden geëvalueerd bij de totale studiegroep en bij de belangrijke subgroepen 'risicoconsumenten' (deelnemers met een hoge vet inname op de voormeting) en 'onderschatters' (deelnemers die hun eigen vetinname onderschatten op de voormeting).

In **hoofdstuk 3** wordt ingegaan op de eerste vraag die hierboven werd genoemd; welke feedback elementen zijn noodzakelijk voor een advies-op-maat om effect te kunnen hebben op het bewustzijn van de eigen vetinname, de intentie om minder vet te gaan eten en de (verzadigd) vetinname? De interventiegroepen 1) Personal feedback, 2) Personal-Normative feedback, 3) Personal-Normative-Action feedback en 5) algemene informatie, werden met elkaar vergeleken om zo de noodzakelijke feedback elementen voor een effectief advies-op-maat te identificeren. De resultaten lieten zien dat de combinatie van Personal-Normative-Action-feedback noodzakelijk is om veranderingen in bewustzijn, intentie en (verzadigd) vet consumptie te bewerkstelligen. Personal-feedback afzonderlijk had enig effect op het bewustzijn van eigen vetinname en de intentie om vetinname te verminderen, terwijl de combinatie van Personal en Normative feedback enig effect op intentie had. Er werden alleen effecten gevonden bij de deelnemers die er het meeste baat bij zouden moeten hebben: de risicoconsumenten en de onderschatters.

De studies in **hoofdstuk 4 en 5** gaan over de tweede vraag en vergeleken de groepen 3 en 4 die gelijk van inhoud zijn (Personal-Normative-Action feedback), maar schriftelijk (brief) of interactief (CD-ROM) verstrekt werden. De studies behandelen respectievelijk de effect- en de procesevaluatie van deze interventies.

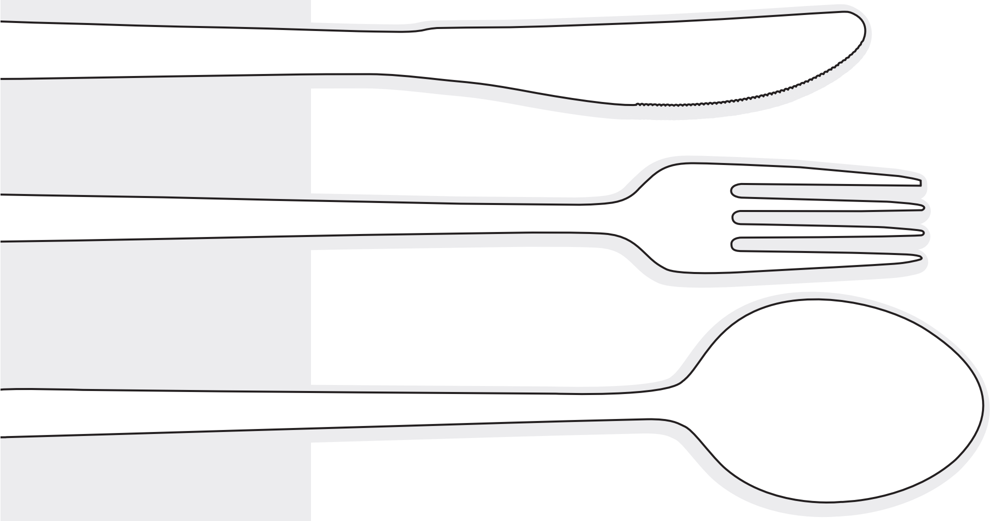
Uit **hoofdstuk 4** blijkt dat de korte termijn effecten op de totale vet inname (g/d), de verzadigd vet inname (g/d) en de energie-inname van het schriftelijke advies-op-maat en het interactieve advies-op-maat aan elkaar gelijk zijn in vergelijking met de groep die algemene informatie kreeg. In beide advies-op-maat groepen werden deze effecten vooral gezien bij de subgroep 'risicoconsumenten'. Hoewel deze verschillen met algemene informatie op lange termijn alleen zichtbaar bleven bij de schriftelijke advies-op-maat groep, waren er geen significante verschillen tussen de schriftelijke en de interactieve advies-op-maat groep op beide meetmomenten. Er werden geen significante verschillen tussen de drie groepen gevonden op de uitkomstmaat (verzadigd) vet consumptie gemeten als percentage van de dagelijkse energie-inname.
Hoofdstuk 5 beschrijft de verschillen in gebruik en waardering tussen de schriftelijke en de interactieve advies-op-maat interventie (de groepen 3 en 4). De analyses werden uitgevoerd bij verschillende doelgroepen (gebaseerd op geslacht, leeftijd en opleidingsniveau) die mogelijk minder gemotiveerd zijn en/of minder vaardigheden hebben om een computer en/of Internet te gebruiken. De resultaten van deze studie laten zien dat de hele studiegroep, vrouwen, deelnemers tussen 50-65 jaar en de lager en de hoger opgeleiden het schriftelijke advies-op-maat vaker lezen dan het interactieve advies-op-maat. Het schriftelijke advies-op-maat werd ook vaker bewaard dan het interactieve advies-op-maat; dit was het geval voor de hele studiegroep, mannen, vrouwen, deelnemers van 34 jaar of jonger, deelnemers tussen 35-49 jaar en de gemiddeld en de hoger opgeleiden. Daarnaast werd het schriftelijke advies-op-maat als persoonlijk relevanter ervaren door de hele studiegroep en door vrouwen en deelnemers van 35-49 jaar.

De studie uit **hoofdstuk 6** gaat in op de derde vraag en testte de effectiviteit van de advies-op-maat interventies met behulp van objectieve uitkomsten, lipiden in het bloed. In deze studie werden dezelfde drie groepen vergeleken als in hoofdstuk 4: 3) de uitgebreide schriftelijke advies-op-maat groep, 4) de uitgebreide interactieve advies-op-maat groep en 5) de algemene informatie groep. Zowel bij de hele studiegroep als bij de risicoconsumenten werden geen verschillen tussen de drie groepen gevonden in de bloed lipiden (totaal cholesterol, HDL- en LDL-cholesterol en triacylglycerol).

Uit voorgaande hoofdstukken bleek dat de grootte van het effect van een advies-op-maat interventie over het algemeen tamelijk klein is. Mogelijke theoretische verklaringen voor dit gebrek aan effect werden bestudeerd op basis van de gegevens verzameld op de voormeting (**hoofdstuk 7**). Binnen het framewerk van de Theorie van Gepland Gedrag, werd gekeken wat de mogelijke toegevoegde waarde van het concept 'gewoonte om op vet in de voeding te letten' ('gewoonte') was in de verklaring van het gedrag (verzadigd vet inname). Daarnaast werd het mogelijke interactie effect van 'gewoonte' op de relatie tussen intentie en de verzadigd vet inname getest. De resultaten lieten zien dat het mannelijke geslacht, waargenomen gedragscontrole en 'gewoonte' positief samen hangen met de verzadigd vet inname. Daarnaast was de interactieterm gewoonte-intentie significant; bij mensen met een zwakke tot gemiddeld sterke gewoonte hangt intentie significant samen met vet inname, bij mensen met een sterke gewoonte juist niet.

De **conclusies** van het proefschrift zijn als volgt: voedingsadvies-op-maat bestaande uit Personal, Normative en Action feedback is het meest effectief in het verminderen van de verzadigd vet consumptie in vergelijking met algemene informatie. Het verstrekken van een dergelijk advies-op-maat in schriftelijke of interactieve vorm maakt geen verschil voor de effectiviteit. Beide interventies hadden een korte termijn effect op de zelfgerapporteerde vet en energie-inname; op langere termijn was dit effect alleen nog zichtbaar voor de schriftelijke advies-op-maat groep. De gevonden effecten op inname konden echter niet bevestigd worden met behulp van de biomarkers en de grootte van de effecten was klein. Wat gebruik en waardering betreft, blijkt dat het schriftelijke advies-op-maat over het algemeen vaker werd gelezen en bewaard en als persoonlijk relevanter werd ervaren dan het interactieve advies-op-maat. Voor het veranderen van de verzadigd vet inname is een voedingsadvies-op-maat bestaande uit Personal, Normative en Action feedback het meest geschikt, zowel in schriftelijke als in interactieve vorm. Sommige groepen lezen het schriftelijk advies-op-maat echter beter, waardoor de effecten langer behouden zouden kunnen worden. Het is belangrijk om meer onderzoek te doen naar verbetering van zowel de effectiviteit als de blootstelling aan (interactieve) advies-op-maat interventies.

P E R S O O N L I J K



Dankwoord

Daar ligt ie dan, mijn proefschrift! Om eerlijk te zijn, kijk ik er nog steeds met enige verbazing tegen aan. Toen ik ooit aan dit onderzoek begon, had ik niet persé gepland dat het ook met een proefschrift zou eindigen. Ik vond onderzoek doen gewoon erg leuk, het ontwikkelen van een advies-op-maat interventie zag ik helemaal zitten, maar het schrijven van een proefschrift vond ik op dat moment nog erg ver weg… Ik ben me er goed van bewust, dat het behalen van zo'n prestatie toch meer is dan moed houden, geduld en stevig doorwerken. Om doelen te halen heb je ook een positieve, faciliterende en steunende omgeving nodig, met af en toe de broodnodige afleiding. Hierbij, wil ik mijn omgeving dan ook graag bedanken.

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Willemieke

Over de auteur

Willemieke Kroeze (21 januari 1976) is geboren en getogen in Amersfoort als tweede dochter van Henk-Jan Kroeze en Coby Kroeze-Speksnijder en zus(je) van Martine en Jan. Dit liefdevolle thuisfront was een goede basis voor haar ontwikkeling.

Nadat zij in 1994 haar VWO diploma behaalde op het Van Lodenstein College te Amersfoort, begon zij aan haar opleiding Voeding & Diëtetiek aan de Hogeschool van Amsterdam. Na haar afstuderen in 1998 verhuisde Willemieke naar Maastricht om de studie Gezondheidsvoorlichting (afstudeerrichting van Gezondheidswetenschappen) te gaan volgen aan de Universiteit van Maastricht en nog wat van het studentenleven mee te pikken op de christelijke studentenvereniging Ichthus Maastricht. Daarnaast volgde zij het epidemiologietracé en de cursus medische basiskennis. Dit leidde in 2001 tot haar bul, een registratie als epidemioloog-A en een baan bij de capaciteitsgroep Gezondheidsvoorlichting van de Universiteit Maastricht.

Vanaf September 2002 zette zij haar promotieonderzoek voort bij de afdeling Maatschappelijke Gezondheidszorg van het Erasmus MC in Rotterdam alwaar zij ook een Master of Public Health van het NIHES voltooide (2005). Naast het afronden van haar proefschrift heeft zij meegewerkt aan verschillende andere projecten op het gebied van het bevorderen van een gezonde leefstijl. Verder was zij als projectmanager enige tijd betrokken bij twee Europese projecten HOPE en TEENAGE.

Sinds 3 oktober 2007 is Willemieke bovendien getrouwd met Jan Versluis.