Examining the minimal required elements of a computer-tailored intervention aimed at dietary fat reduction: results of a randomized controlled dismantling study

Willemieke Kroeze1*, Anke Oenema1, Pieter C. Dagnelie2 and Johannes Brug1,3

Abstract

This study investigated the minimally required feedback elements of a computer-tailored dietary fat reduction intervention to be effective in improving fat intake. In all 588 Healthy Dutch adults were randomly allocated to one of four conditions in an randomized controlled trial: (i) feedback on dietary fat intake [personal feedback (P feedback)], (ii) P feedback and feedback on one’s own behavior relative to that of peers [personal—normative feedback (PN feedback)], (iii) PN feedback and practical suggestions on how to change fat intake [personal—normative—action feedback (PNA feedback)] and (iv) generic information. Data on fat intake, awareness of one’s own fat intake and intention to change were collected 1 and 6 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 (underestimators), differences in awareness and (saturated) fat intake were found between the generic and PNA feedback conditions. Compared with generic information P feedback was more effective in changing awareness and intention among the underestimators, and PN feedback was more effective in changing intention among both risk consumers and underestimators. 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 [4].

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 Strecher [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 et al. [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 et al. [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 personal feedback (P feedback), normative feedback and action feedback elements [6, 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 precautionary 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 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 (P feedback, normative feedback, action feedback) were necessary for a computer-tailored fat reduction intervention to be effective in improving awareness of one’s 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 measures for the larger trial in a sophisticated manner [mean daily (saturated) fat intake measured in g/day 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 and 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 2 weeks after returning the screening questionnaire. One and 6 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 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 (dropout 4.3%) filled out the screening questionnaire, 611 respondents were assigned to the conditions presented in this paper: a condition receiving computer-tailored P feedback (n = 155), personal + normative feedback (n = 160), personal + normative + action feedback (n = 142) or a control condition receiving generic information (n = 154). With 82 participants in each condition at post-test, a relative difference of 8.7 g/day in saturated fat intake (with an assumed saturated fat intake in the generic information group of 43.5 g/day) 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. [6] and Oenema et al. [9] and adjusted for the present study. The intervention was informed by the PAPM and the theory of planned behavior, as described in more detail elsewhere [6, 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 4 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 cutoff 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 [18, 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 sociodemographic and background characteristics included questions on gender, age and education level.

Condition 1: 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. The feedback section in the condition of personal and normative feedback (PN feedback) included the P 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. The personal, normative and action feedback (PNA feedback) condition included the provision of P 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 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, body mass index (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 cutoff levels of fat score) or ‘underestimators’ (respondents who think their fat intake is very low/low/not low, not high, while their fat score is above recommended cutoff levels) [22].

Post-test questionnaires
Both the 1- and 6-month post-test questionnaires 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/day) were assessed using an extensive paper and pen FFQ 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 underestimators) and one-way analyses of variance (ANOVARs) for continuous variables (age, BMI and fat score) were conducted. Logistic regression analyses with dropout (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 dropout at 1 and 6 months post-intervention.

ANOVA and analysis of covariance (ANCOVA) with post hoc Bonferroni corrections (two tailed, α = 0.05) 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/day) (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 post-test the independent variables. The analyses were run separately for the outcomes at 1 and 6 months.

The analyses were performed among the total study population and among the risk consumers and underestimators. 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 <0.05 and at least one post hoc comparison had a P value <0.05. Complete case analyses were performed using SPSS11.

Finally, in order to compare the effect sizes (ESs) of the different feedback conditions relative to the generic condition, we calculated ESs as the standardized differences in group means at 1 and 6 months post-intervention by dividing the difference between a feedback condition and the generic condition by the pooled standard deviation. ESs 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 I). About half of the respondents were female (55%), the majority was of native Dutch origin (85%), mean age was 44.4 years [standard deviation (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% underestimated their own fat intake.

A total of 571 respondents (response rate 94%) completed and returned the 1-month post-test questionnaire and 537 (response rate 88%) the 6-month post-test questionnaire. Older respondents were somewhat more likely to dropout at 1 month [OR 1-year increase = 1.04; 95% confidence interval (CI) = 1.00–1.08] and at 6 months (OR 1-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 1 month (Table II) or at 6 months post-intervention (Table III). However, significant effects were found among those who needed to change: the risk consumers and underestimators.

At 1 month post-intervention (Table II), significant group effects were found for awareness of own fat intake among the group of risk consumers ($F(3,264) = 4.57; P = 0.004$) and among the underestimators ($F(3,221) = 5.05; P = 0.002$). *Post hoc* analyses showed that risk consumers and underestimators who received either P feedback or PNA feedback had a significantly more realistic perception of their own fat intake compared with the generic condition.

Furthermore, a significant group effect was found for fat intake ($F(3,288) = 3.64; P = 0.013$) and saturated fat intake ($F(3,288) = 3.14; P = 0.026$) 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 with the generic condition.

Among the risk consumers and among the underestimators, the ESs for awareness of own fat intake, intention to reduce fat intake and total and saturated fat intake in all feedback conditions at 1 month post-test were small, except for fat intake among risk consumers receiving PNA feedback where the ES was moderate.

At 6 months post-intervention (Table III), significant group effects were found for intention to reduce fat intake among the group of risk consumers ($F(3,264) = 3.94; P = 0.009$) and among the underestimators ($F(3,218) = 4.31; P = 0.006$). *Post hoc*

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**Table I. Baseline characteristics of the computer-tailored feedback conditions and the generic information group**

<table>
<thead>
<tr>
<th></th>
<th>P feedback ($n = 155$)</th>
<th>PN feedback ($n = 160$)</th>
<th>PNA feedback ($n = 142$)</th>
<th>Generic information ($n = 150$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (% female)</td>
<td>53.5</td>
<td>55.0</td>
<td>55.3</td>
<td>56.0</td>
</tr>
<tr>
<td>Age (years, mean ± SD)</td>
<td>45.2 ± 10.22</td>
<td>45.0 ± 10.37</td>
<td>43.4 ± 10.07</td>
<td>44.1 ± 9.75</td>
</tr>
<tr>
<td>Ethnicity (% native Dutch origin)</td>
<td>83.9</td>
<td>83.1</td>
<td>86.5</td>
<td>87.2</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elementary</td>
<td>2.7</td>
<td>1.9</td>
<td>3.6</td>
<td>2.0</td>
</tr>
<tr>
<td>Lower secondary</td>
<td>19.3</td>
<td>16.6</td>
<td>18.6</td>
<td>18.4</td>
</tr>
<tr>
<td>Higher secondary</td>
<td>40.7</td>
<td>37.6</td>
<td>35.0</td>
<td>37.4</td>
</tr>
<tr>
<td>Tertiary (bachelor degree or higher)</td>
<td>37.3</td>
<td>43.9</td>
<td>42.9</td>
<td>42.2</td>
</tr>
<tr>
<td>BMI (kg/m², mean ± SD)</td>
<td>25.8 ± 4.36</td>
<td>25.8 ± 4.58</td>
<td>25.5 ± 4.29</td>
<td>25.3 ± 3.81</td>
</tr>
<tr>
<td>Fat score (mean ± SD)</td>
<td>18.3 ± 6.33</td>
<td>18.0 ± 5.76</td>
<td>16.9 ± 5.51</td>
<td>17.9 ± 6.55</td>
</tr>
<tr>
<td>Risk consumption (% above gender–age-specific cutoff point)</td>
<td>53.9</td>
<td>48.1</td>
<td>50.0</td>
<td>50.7</td>
</tr>
<tr>
<td>Underestimators (% that underestimates own fat intake)</td>
<td>44.1</td>
<td>41.8</td>
<td>40.0</td>
<td>43.2</td>
</tr>
<tr>
<td>Perception of own fat intake</td>
<td>-0.34 ± 0.86</td>
<td>-0.33 ± 0.76</td>
<td>-0.34 ± 0.86</td>
<td>-0.37 ± 0.78</td>
</tr>
<tr>
<td>Intention to reduce fat intake</td>
<td>0.05 ± 1.04</td>
<td>0.11 ± 1.09</td>
<td>0.02 ± 1.12</td>
<td>0.05 ± 1.09</td>
</tr>
</tbody>
</table>

There were no statistically significant differences between study conditions at baseline.
Table II. 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 underestimators

<table>
<thead>
<tr>
<th></th>
<th>Mean (SD)</th>
<th>ANCOVA&lt;sup&gt;a&lt;/sup&gt;</th>
<th>ES&lt;sup&gt;b&lt;/sup&gt; feedback versus generic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P feedback</td>
<td>PN feedback</td>
<td>PNA feedback</td>
</tr>
<tr>
<td></td>
<td>n = 147</td>
<td>n = 151</td>
<td>n = 132</td>
</tr>
<tr>
<td>Total population</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Awareness of own intake&lt;sup&gt;c&lt;/sup&gt;</td>
<td>−0.12 (0.90)</td>
<td>−0.14 (0.81)</td>
<td>−0.11 (0.93)</td>
</tr>
<tr>
<td>Intention to reduce fat</td>
<td>−0.10 (1.26)</td>
<td>0.03 (1.15)</td>
<td>0.07 (1.21)</td>
</tr>
<tr>
<td>Fat intake (g/day)</td>
<td>80.1 (31.30)</td>
<td>82.4 (27.92)</td>
<td>80.0 (25.23)</td>
</tr>
<tr>
<td>Saturated fat intake (g/day)</td>
<td>28.3 (11.13)</td>
<td>30.2 (11.02)</td>
<td>28.7 (9.48)</td>
</tr>
<tr>
<td>Risk consumers</td>
<td>n = 78</td>
<td>n = 73</td>
<td>n = 66</td>
</tr>
<tr>
<td>Awareness of own intake&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.21 (0.80)</td>
<td>0.09 (0.76)</td>
<td>0.31 (0.80)</td>
</tr>
<tr>
<td>Intention to reduce fat</td>
<td>0.39 (1.17)</td>
<td>0.35 (1.03)</td>
<td>0.44 (1.18)</td>
</tr>
<tr>
<td>Fat intake (g/day)</td>
<td>88.8 (32.01)</td>
<td>92.8 (28.96)</td>
<td>85.8 (21.97)</td>
</tr>
<tr>
<td>Saturated fat intake (g/day)</td>
<td>31.3 (10.60)</td>
<td>33.5 (11.71)</td>
<td>30.9 (8.74)</td>
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<tr>
<td>Underestimators</td>
<td>n = 64</td>
<td>n = 64</td>
<td>n = 52</td>
</tr>
<tr>
<td>Awareness of own intake&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.10 (0.69)</td>
<td>0.03 (0.67)</td>
<td>0.10 (0.75)</td>
</tr>
<tr>
<td>Intention to reduce fat</td>
<td>0.41 (1.16)</td>
<td>0.34 (1.01)</td>
<td>0.38 (1.23)</td>
</tr>
<tr>
<td>Fat intake (g/day)</td>
<td>88.8 (31.64)</td>
<td>90.9 (29.00)</td>
<td>84.3 (22.68)</td>
</tr>
<tr>
<td>Saturated fat intake (g/day)</td>
<td>31.4 (10.78)</td>
<td>32.7 (11.86)</td>
<td>30.5 (8.75)</td>
</tr>
</tbody>
</table>

<sup>a</sup>Significant outcomes (overall test P < 0.05 and post hoc test P < 0.05) are printed in bold font.

<sup>b</sup>Standardized differences between feedback and generic conditions at 1 month; standardized ESs can be categorized as small (ES = 0.2–0.5), moderate (ES = 0.5–0.8) or large (ES > 0.8).

<sup>c</sup>Corrected for total fat intake at 1-month post-test.
Table III. Six-month post-test differences between the computer-tailored feedback conditions and the generic information group among the total population and among risk consumers and underestimators

<table>
<thead>
<tr>
<th>Mean (SD)</th>
<th>ANCOVA&lt;sup&gt;a&lt;/sup&gt;</th>
<th>ES&lt;sup&gt;b&lt;/sup&gt; feedback versus generic</th>
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<tr>
<td></td>
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<tr>
<td></td>
<td>P</td>
<td>PN</td>
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<tr>
<td>Total population</td>
<td>n = 140</td>
<td>n = 140</td>
</tr>
<tr>
<td>Awareness of own intake&lt;sup&gt;c&lt;/sup&gt;</td>
<td>-0.24 (0.85)</td>
<td>-0.15 (0.82)</td>
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<tr>
<td>Intention to reduce fat</td>
<td>-0.29 (1.15)</td>
<td>-0.14 (1.25)</td>
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<tr>
<td>Fat intake (g/day)</td>
<td>81.7 (30.76)</td>
<td>78.7 (27.73)</td>
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<tr>
<td>Saturated fat intake (g/day)</td>
<td>28.5 (10.68)</td>
<td>28.3 (10.42)</td>
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<tr>
<td>Risk consumers</td>
<td>n = 74</td>
<td>n = 67</td>
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<tr>
<td>Awareness of own intake&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.06 (0.80)</td>
<td>-0.05 (0.87)</td>
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<tr>
<td>Intention to reduce fat</td>
<td>0.07 (1.13)</td>
<td>0.13 (1.05)</td>
</tr>
<tr>
<td>Fat intake (g/day)</td>
<td>90.3 (32.52)</td>
<td>87.4 (27.60)</td>
</tr>
<tr>
<td>Saturated fat intake (g/day)</td>
<td>30.8 (10.89)</td>
<td>31.4 (10.74)</td>
</tr>
<tr>
<td>Underestimators</td>
<td>n = 60</td>
<td>n = 58</td>
</tr>
<tr>
<td>Awareness of own intake&lt;sup&gt;c&lt;/sup&gt;</td>
<td>-0.09 (0.77)</td>
<td>-0.20 (0.78)</td>
</tr>
<tr>
<td>Intention to reduce fat</td>
<td>0.02 (1.17)</td>
<td>0.13 (1.11)</td>
</tr>
<tr>
<td>Fat intake (g/day)</td>
<td>89.8 (32.27)</td>
<td>86.5 (28.09)</td>
</tr>
<tr>
<td>Saturated fat intake (g/day)</td>
<td>30.4 (10.83)</td>
<td>30.8 (10.98)</td>
</tr>
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</table>

<sup>a</sup>Significant outcomes (overall test P < 0.05 and post hoc test P < 0.05) are printed in bold font.

<sup>b</sup>Standardized differences between feedback and generic conditions at 6 months; standardized ESs can be categorized as small (ES = 0.2–0.5), moderate (ES = 0.5–0.8) or large (ES > 0.8).

<sup>c</sup>Corrected for total fat intake at 6 months post-test.
analyses showed that risk consumers who received PN feedback or PNA feedback had a significantly higher intention to change compared with the generic condition. In the group of underestimators, participants in the P feedback, the PN feedback and the PNA feedback conditions had a significantly higher intention to change compared with the generic condition. Among the risk consumers and the underestimators, the ESs of the feedback conditions compared with the generic condition were small for awareness and moderate for intention, except for P feedback among risk consumers which was small.

Furthermore, significant group effects were found for fat intake \(F(3,272) = 3.38; P = 0.019\) and saturated fat intake \(F(3,272) = 3.77; P = 0.011\) among the risk consumers and for fat intake \(F(3,226) = 4.47; P = 0.005\) and saturated fat intake \(F(3,226) = 4.91; P = 0.003\) among the underestimators. Post hoc analyses showed that among the risk consumers and among the underestimators, total fat and saturated fat intake were significantly lower in the PNA feedback condition compared with the generic condition.

Among the risk consumers and underestimators, the ESs of total fat and saturated fat intake of the feedback conditions compared with the generic condition were small (P- and PN feedback) to moderate (PNA feedback).

### Discussion

In this study, we investigated which combination of feedback elements (P feedback, PN feedback or PNA 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 1 and 6 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 (1-month post-intervention) and in intention to reduce fat intake and (saturated) fat intake levels (most apparent at 6 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 [4]. 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 P feedback (daily dietary fiber intake) and P 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 PAPM, behavioral feedback (PN 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 P 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 P 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, 19]. 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 et al. [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 6 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 [4]. We provided only one dose of the intervention, and based on this, probably no larger ESs can be expected. Two studies have shown that multiple doses of a tailored dietary intervention produced greater behavioral effects compared with 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 conditions 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 pre-test with the extensive FFQ used at the two post-tests. 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 PNA 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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Conflict of interest statement

None declared.

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