Towards Healthy Diets for Parents

Effectiveness of a counselling intervention

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ABSTRACT

Introduction and Objective: As parents' modelling of dietary behaviour is one of the factors influencing children's diets, improving parents' diets is expected to result in improved dietary intake of their children. This thesis describes research that was conducted to develop and evaluate a counselling intervention to improve parental adherence to the Dutch dietary guidelines.

Methods: A counselling intervention was developed, which was underpinned with the theory of planned behaviour and the transtheoretical model. In 20 weeks, five face-to-face counselling sessions were provided by a registered dietician who used motivational interviewing to improve parental adherence to the Dutch dietary guidelines. In addition, parents received three individually tailored email messages. During the counselling, the dietary guidelines and additional eating behaviours, that were hypothesized to affect diet quality, were addressed. The intervention was evaluated in a randomised controlled trial with 92 parents receiving the counselling and 94 parents as controls. Effects on dietary intake, biomarkers, intermediate markers of health and children's dietary intake were evaluated. With mediation analyses, it was investigated if changes in dietary intake were established via changes in behavioural determinants. Thereby, it was also examined if spot urine samples could be used to replace 24 h urine samples for evaluating changes in sodium and potassium intake.

Results: The intervention group increased their adherence to the dietary guidelines, as assessed with the Dutch Healthy Diet-index (ranging from 0 to 100 points), by 6.7 points more than the control group did. This improvement was achieved by small increases in the scores of seven out of ten index components. The most substantial changes were shown in fruit and fish intakes of which increases in fish intake were reflected in changes in fatty acid profiles derived from blood plasma. Also a small decrease in waist circumference was observed. Based on parental reports, the children in the intervention group increased their intakes of fruit, vegetables and fish more than the children in the control group. Improvements in parental fruit intake were mediated by changes in the behavioural determinants attitude and habit strength. Decreases in snack intake were mediated by changes in self-identity as a healthy eater. Although the results of a study in young Caucasian women showed that spot urine can be used to rank individuals for their ratios of sodium to potassium, no intervention effects on these ratios were observed.

Conclusion: This thesis provides empirical knowledge on potential effective elements for counselling interventions aiming at improving the dietary pattern as a whole of parents and provides knowledge on methods to evaluate changes in dietary intake.

CONTENTS

CHAPTER 1

Introduction

BACKGROUND

To reduce the risk of chronic diseases such as cardiovascular disease, hypertension and diabetes, the health council of the Netherlands has formulated ten guidelines for a healthy diet (Text box 1.1).[1] In short, the health council advises individuals to have a diet rich in fruits, vegetables and whole-grain cereal products and to consume fish regularly. Thereby, individuals are recommended to have a diet low in energy-dense foods and to moderate consumption of foods that are high in saturated fatty acids and trans fatty acids. It is also advised to limit sodium intake, alcohol consumption and the number of consumption occasions with easily fermentable carbohydrates and alimentary acids. In addition, the council advises a physically active lifestyle. These guidelines apply to the apparently healthy Dutch population and are translated into a food circle guide, "schijf-van-vijf", to educate people.[1, 2]

Text box 1.1 Dutch guidelines for a healthy diet of 2006.[1]

1. Perform on at least 5 days a week 30 min. moderate or intensive physical activity.
2. Eat 150 to 200 grams of vegetables a day.
3. Eat at least 200 grams of fruit a day.
4. Consume about 30 - 40 grams of fibre from fruit, vegetables and whole-grain cereal products a day.
5. Eat two portions of fish a week of which one should contain oily fish.
6. Limit saturated fatty acid consumption to less than 10 per cent of energy intake.
7. Limit mono trans-fatty acid consumption to less than 1 per cent of energy intake.
8. Limit the consumption of foods and beverages that contain easily fermentable sugars and beverages that are high in food acids, to seven occasions a day.
9. Limit consumption of salt to 6 grams a day.
10. If alcohol is consumed at all, men should limited intake to two units and women to one unit a day.

Although the majority of the people are aware of the guidelines for a healthy diet, only a minority complies with them.[3, 4] For example, in the Netherlands more than 85% of the children and adults until 50 years of age do not consume the recommended amounts of fruits and vegetables. Besides, the saturated fatty acid consumption in the Dutch population is far too high. The unhealthy dietary intakes in children are particularly alarming because unhealthy dietary behaviours learned in childhood may track into adulthood.[5, 6]

The family food environment is an important factor for child dietary intake when children live at home.[7-11] This environment includes multiple factors such as parenting styles, parental feeding practices, food availability and accessibility, perceptions of adequacy of the child's diet, mealtime interruptions and modelling of eating. Parental modelling of eating may be

important for children's dietary intake because parental fruit, vegetable and snack intakes have shown positive associations with children's fruit, vegetable and snack intakes.[12-14] These findings indicate that improving parents' diets will result in improved dietary intake of their children. Parents' influence on children's dietary intake is perceived to be strongest in early childhood.[15] Nevertheless, a review has shown that parents are also important in improving the dietary intake of primary school aged children.[16]

The purpose of the research described in this thesis was to improve adherence to the Dutch dietary guidelines in parents of primary school aged children. This introductory chapter describes the rationale behind the development of an intervention to improve parental dietary intake and it describes the selection of methods to evaluate intervention effectiveness. The chapter ends with the aim, hypothesis and outline of the thesis.

INTERVENTION DEVELOPMENT

To improve parental adherence to the Dutch dietary guidelines a counselling intervention was developed. In this section we outline the literature and theory behind the intervention and the decisions that were made while composing a protocol for the intervention program.

Overall dietary intake and eating behaviours

The intervention was aimed at improving adherence to the dietary guidelines as a whole, rather than focusing on single foods or food groups, because foods are consumed in combinations and not as single items. In addition, the whole dietary pattern has shown considerable associations with the occurrence of chronic diseases.[17, 18] Focussing on diets as a whole has also been receiving increased interest in epidemiology and public health. However, as far as to our knowledge, no studies have attempted to improve parents' adherence to the Dutch dietary guidelines and evaluate intervention effectiveness on the dietary pattern as a whole.

Overall dietary patterns are potentially affected by certain eating behaviours. Studies have shown that eating behaviours including 'breakfast skipping', 'having dinner away-from-home', 'soft drink consumption' and 'snacking' are associated with a more unfavourable overall dietary pattern in both adults and children.[19-26] These associations may indicate that eating behaviours negatively affect the quality of the food intake during the day. To increase the probability of intervention success, it was considered important to aim intervention elements not only at the Dutch dietary guidelines but also at these specific eating behaviours.

Determinants of dietary behaviour and behaviour change

It is generally acknowledged that interventions to improve dietary intake should not only focus on the dietary behaviours but also on the behavioural determinants.[27-29] Thus for intervention

development, we started with investigating determinants that are potentially important for dietary behaviour change.

Literature provides a large number of theories and models that attempt to explain behaviour or behaviour change. A number of theories and models explain behaviour, e.g. the theory of planned behaviour and the health belief model; others evaluate the processes of behaviour change e.g. the cognitive behavioural theory and the transtheoretical model of behaviour change.[30] No standardised protocol exists for selecting the applicable theories and models for intervention development. Selection is often based on effectiveness of previous theory-based interventions, the intervention setting and on the researchers' preferences. In this way we selected the theory of planned behaviour and the transtheoretical model.[31]

It was decided to work with the theory of planned behaviour, not only because it is one of the most influential theories, but also because studies have shown that its determinants were relevant predictors of dietary intake.[32, 33] The theory of planned behaviour is also known as the reasoned action approach and it assumes that the most important predictor of behaviour is intention to perform the behaviour (Fig. 1.1).[34] Intention, in turn, is a function of attitude, subjective norm and perceived behavioural control. Attitude includes the personal beliefs towards the behaviour, which can be positive and enhancing performance of behaviour or negative and resulting in not performing the behaviour. Subjective norm is the perceived social pressure to perform the behaviour. Subjective norm is built on two aspects: the expectation that others expect him or her to perform the behaviour and the inclination to act towards others' expectations. Perceived behavioural control is the individual's perception of control over performing the behaviour. These determinants belong to the simplified version of the theory. The developers acknowledge that other factors, referred to as background factors in the elaborated theory, affect the attitude, subjective norms and perceived behavioural control. Besides, another group of factors might affect the relationship between intention and behaviour.[34] Examples of these complementing determinants are: habit, self-identity, food availability and barriers.[34-37]

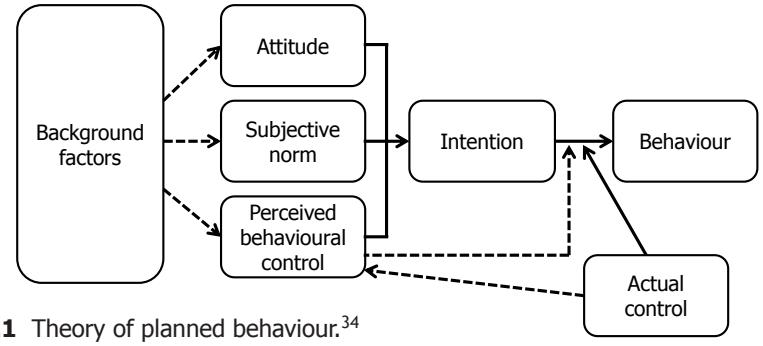

Figure 1.1 Theory of planned behaviour.[34]

The transtheoretical model was selected because it appears to be helpful to build interventions for changing dietary intake.[38] The transtheoretical model,[31] is frequently used as a model to underpin research on behaviour change. It assumes that behaviour change is a multi-step cyclical process and covers five stages of readiness to change behaviour (Fig. 1.2); therefore the model is also known as the stages of change model. The first stage is the precontemplation stage, in this stage individuals do not have the intention to change behaviour. The second stage is the contemplation stage, indicating that individuals are aware of the need for behaviour change, but they have not yet made the commitment to actually start changing. The third stage is the preparation stage, in which individuals have formed a plan of action, but are not yet performing the desired behaviour. In the fourth stage, the action stage, individuals have changed their lifestyle in order to conduct the desired behaviour. The fifth stage, the maintenance stage, is a stage in which individuals try to prevent relapse to former behaviour.

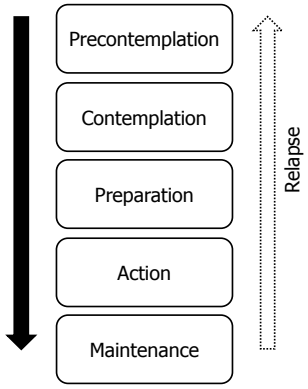

Figure 1.2 Transtheoretical model of behaviour change.[31]

Counselling to change dietary behaviour

People often perceive general nutrition information not relevant for their own health.[39] To increase the relevance of the nutrition information, the information could be tailored to for example a person's characteristics and dietary intake.[39-41] With tailored messages individuals with similar characteristics can be reached. However, changing diets is complex as they exist of a series of behaviours and to change overall dietary intake potentially the most individualised form of communication is needed.[42] We perceive counselling to be the most individually tailored form of communication. Nutrition counselling is a supportive process in which the counsellor helps individuals to set priorities and to establish goals with corresponding plans of action.[29] Setting specific and achievable goals is one of the elements of counselling that potentially results in dietary behaviour change.[43] Thus by providing nutrition counselling to parents we expect to increase the likelihood of dietary behaviour change.

Research has shown that motivational interviewing can be an effective method for improving dietary behaviours and was therefore selected as the method for nutrition counselling.[42,44,45] Motivational interviewing is a person-centred communication style for enhancing intrinsic motivation to change by exploring and resolving a person's ambivalence.[46, 47] It encourages the individual to express thoughts and feelings and the counsellor responds with reflective listening. Accordingly, the individual hears himself talk about motivations to change. Based on these motivations, the individual decides to change and develop plans with specific goals. The counsellor helps to explore the feelings and only provides direct advice if the individual asks for it. Thus, in a counselling session with motivational interviewing, the client should talk more than the counsellor.[48]

Motivational interviewing is not based on a single theoretical framework, but it is based on research knowledge and concepts from social psychology.[49] One of these concepts includes the transition through different stages of change and therefore counselling has specific tasks for each stage of behaviour change. This concept is similar to the stages of changes in the transtheoretical model.[47] Consequently, motivational interviewing can be an effective conversation style to enhance transition through the stages of change.[49] Another concept behind motivational interviewing is that people modify their behaviour as result of their interaction with others.[49] This concept makes the counsellor critical for facilitating behaviour change.

Motivational interviewing includes four basic principles to enhance motivation to change: expressing empathy, developing discrepancy between one's long-term goals and one's behaviour, rolling with resistance and support self-efficacy.[47] Expressing empathy helps to make the individual feel respected and heard. Developing discrepancy is creating a gap between an individual's current behaviour and his or her values and future goals. Rolling with resistance includes that the individual's resistance to change behaviour is channelled instead of confronted and helps the individual to consider new perspectives. The concept of self-efficacy is quite similar to perceived behavioural control and reflects an individual's belief in his or her control over the behaviour and ability to change. Because these basic principles show similarities to the determinants of behaviour as described by the theory of planned behaviour,[34] motivational interviewing can be a good method to increase the intention to perform behaviour. Thereby, by enhancing intrinsic motivation to change behaviour and by supporting perceived behavioural control, motivational interviewing may help to close the intention-behaviour gap that is presented in the theory of planned behaviour.[34] Thus motivational interviewing is a promising method to help individuals to perform healthy dietary behaviours.

Intervention protocol

With motivational interviewing as selected method to provide nutrition counselling and with the transtheoretical model to guide to the processes of change, we established a well-defined method to change dietary behaviour of the parents. These principles were combined with the selected determinants of behaviour and formed the basis for the development of a protocol for the dietary counselling.[50, 51]

Because the selected method of behaviour change is quite extensive, it was decided to work with practising dieticians to provide the dietary counselling. Dieticians are trained and experienced in providing nutrition counselling and adapting nutrition advice to the individual's stage of readiness to change.[29] Six registered dieticians working for dietetic practices in Wageningen and surroundings participated in our research. These dieticians were trained in motivational interviewing[47] and used this way of counselling in their practices.

After discussions with the dieticians and a representative of the Dutch dietetic association, it was decided that the intervention would include five face-to-face counselling sessions. This number was expected to be necessary in order to make substantial changes in dietary behaviour and to discuss the whole range of dietary guidelines, related eating behaviours and specific topics that are important for parents. Two examples of these topics are 'being a role model' and 'eating healthily with the family'.

The use of the theory of planned behaviour, transtheoretical model and motivational interviewing with the specific topics for parents resulted in an intervention protocol with detailed information on how to change dietary intake and eating behaviours. Counselling sessions differed in topics that were discussed but had a similar outline. Before the sessions, the dieticians reviewed the dietary intake of the parents that was obtained via web-based questionnaires. Every session started with an assessment of the parent's stage of readiness to change dietary behaviours. Thereafter, specific topics and determinants were discussed. The sessions ended with setting specific goals with plans of action. To remind parents of what has been discussed and to provide additional practical information to improve dietary intake, the parents received leaflets about the discussed dietary behaviours. For example, parents in the first two stages of behaviour change received information on the risk of their dietary intake for developing chronic diseases. The motivational tasks for dieticians were to increase discrepancy between the performed behaviour and future goals. If the parents reached the preparation or action stage, potential behaviour change goals were discussed. If these goals included improving fruit or vegetable intake, the parents received a leaflet with practical tips and recipes to help increasing fruit and vegetable intake.

To motivate parents to improve dietary intake and to reach their goals it was decided to include three additional individualised email messages. These were tailored to the parents' current dietary intake based on a short web-based questionnaire on adherence to the dietary guidelines. Because we wanted the emails to be an extension of the intervention, the dietary intake was discussed in light of the goals set during the previous face-to-face meeting. The input for the messages and the format of the emails were compiled in such a way that they could easily be incorporated in web-based tools.[52] To keep the parents motivated between the sessions and tailored emails, it was decided to send weekly email messages with generic tips about nutrition and meal preparation.

EVALUATION OF INTERVENTION EFFECTIVENESS

To evaluate intervention effectiveness a number of primary and secondary measures of outcome were selected. Besides, we also selected outcomes to evaluate if the intervention was implemented as intended. In the following paragraphs, the measures of evaluation are described.

Study population

The study centre was based at Wageningen University, and therefore, it was decided to recruit parents in Wageningen and surrounded areas. It was estimated, based on sample size calculations, that we would need at least 91 parents in the intervention group and 91 parents in the control group. The estimates for this sample size calculation were derived from two comparable nutrition interventions aiming at improving adherence to a healthy diet in adults.[53, 54]

Study design

Parents who were willing to participate in our study and who were generally healthy were included in the study population. After inclusion, participants were randomly assigned to intervention or control group by an external researcher. The participants were block-randomized on sex and BMI derived from self-reported weight and height (under 25, 25-30 and over 30 kg/m^2). Both sex and BMI are associated with adherence to the Dutch dietary guidelines[55] and by performing block-randomisation we wanted to prevent differences in baseline dietary intake between intervention and control group.

After two weeks of baseline measurements, the 20-week counselling intervention started. Session one and two were both planned within the first three weeks to tackle possible barriers for behaviour change in an early phase of the intervention. The other three sessions took place in weeks eight, thirteen and nineteen, to give the parents time to implement their plans

of action. The three individually tailored emails were sent in weeks five, ten and fifteen. The control group did not receive any of the intervention elements. After 20 weeks, participants completed the end measurements.

Measures of outcome

The primary outcome measure was parental adherence to the Dutch dietary guidelines. This was assessed with the Dutch Healthy Diet-index (DHD-index), which is a measure for adherence to the Dutch dietary guidelines, i.e. a measure of diet quality.[55, 56] The DHD-index that consists of ten components representing the ten Dutch dietary guidelines,[1] can be calculated from 24 h dietary recalls. We used recalls that were self-administrated via the web-based program Compl-eat™. In addition to the nine components reflecting dietary intake, the DHD-index includes a physical activity component. This physical activity component is estimated from the short questionnaire to assess health enhancing physical activity, also known as the SQUASH.[57]

The DHD-index is based on self-reports of dietary intake and to support expected self-reported changes in dietary intake objective markers of dietary intake were collected.[58] It was attempted to use the best available biomarkers, which were carotenoid concentrations for intakes of fruit and vegetables[59] and fish fatty acid plasma concentrations for fish intake.[60] The best available biomarker for sodium intake is urinary sodium excretion measured from 24 h urine collections.[61] However, these collections are burdensome and often result in incomplete urine samples.[62] Therefore, it was decided to collect urine samples of one voiding, also called spot urine samples. We checked if these samples could be used to rank individuals according to their sodium and potassium excretions in a similar way as 24 h urine samples.

Because dietary intake is associated with chronic diseases, we also wanted to evaluate if the expected changes in dietary intake would be reflected in changes in intermediate markers of health. Overweight and obesity are such markers as they have been associated with several chronic diseases.[63] The most used measure for overweight and obesity is BMI; thereby we included waist circumference as measure for fat distribution.[64] We also measured cholesterol levels and blood pressure as a risk factor for coronary heart disease.[65] Quality of life also provides an indication of health, and for that reason a questionnaire to assess quality of life (SF-36) was included as measure of outcome.[66]

We expected that the changes in dietary intake in the parents would reflect in changes in the dietary intake of the children. Therefore, we included a measure of food intake of the children. Parents were asked to complete a food frequency questionnaire which included specific foods that were of importance for evaluating adherence to the Dutch dietary guidelines.[1]

Process evaluation

Besides information on the effectiveness of the intervention on dietary intake and health outcomes, we also wanted to evaluate which mechanisms and processes are important for changing dietary intake.[67] To evaluate how dietary behaviour change was established, it was decided to ask the participants to complete a questionnaire inquiring about the previously described determinants of behaviour. Thereby, we were interested in how well the intervention was implemented and whether it is feasible to implement the intervention in practice. To evaluate this, we interviewed the dieticians who provided the counselling. The interview was semi-structured and was aimed to obtain information on both the counselling sessions and individually tailored emails. In addition, the participants were asked to rate and comment on the different intervention elements via a web-based questionnaire.

AIM AND OUTLINE OF THE THESIS

This thesis describes research that was conducted to develop and evaluate a nutrition counselling intervention to improve adherence to the Dutch guidelines for a healthy diet in parents with primary school aged children. It was hypothesized that with standardised nutrition counselling by dieticians and individually tailored emails, the dietary intake of parents could be improved.

In Chapter 2 we describe a study in which was assessed whether eating behaviours that have shown associations with the quality of dietary patterns in the USA and Europe, were also associated with diet quality in Dutch adults. This information was used for intervention development. The intervention itself was evaluated in a randomised controlled trial and the results are presented in two chapters. Chapter 3 reports on the primary measure of outcome, parental adherence to the Dutch dietary guidelines. It also reports on the secondary outcome measures such as markers of dietary intake, intermediate health outcomes and food intake of the children. Since change in dietary intake does not provide information on how behaviour change was established, the intervention effects on determinants of behaviour were investigated and the results are described in Chapter 4. We were not only interested how behaviour change is established, but also in simple methods to objectively assess changes in dietary intake, therefore Chapter 5 includes an evaluation of a simple method to estimate 24 h urinary sodium and potassium excretions. In Chapter 6, the final chapter of this thesis, the main findings of the studies are summarised and discussed. We also reflect on the implications for practice and provide suggestions for future research.

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CHAPTER 2

Associations of breakfast skipping, dinner away-from-home, soft drink consumption and snacking with diet quality in a Dutch population

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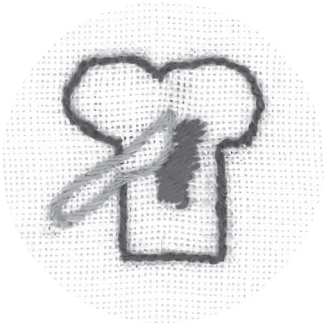

ABSTRACT

Background and Objective: Eating behaviours such as 'breakfast skipping', 'having dinner away-from-home', 'soft drink consumption' and 'snacking' are suggested to contribute to low diet quality. To investigate this, we evaluated the associations between these eating behaviours and adherence to the Dutch dietary guidelines.

Subjects and Methods: One out of two 24 h recalls from the Dutch national food consumption survey 2007-2010 was randomly selected per adult (*n* 2055). With this data, the eating behaviours were determined and the Dutch Healthy Diet-index (DHD-index), to assess adherence to the dietary guidelines, was calculated. The index consists of ten components with an overall score ranging from zero to 100. Linear regression analyses were performed to determine associations between eating behaviours and DHD-index adjusting for energy, smoking, age, BMI, educational level, week or weekend day and following a diet.

Results: Breakfast skipping was associated with lower total DHD-index scores in women (-5.0 points; P <0.001), but not in men. Having dinner away-from-home was associated with 2.8 and 2.3 points lower DHD-index scores in men and women respectively (P <0.001). Unexpectedly, men who consumed soft drinks had 1.5 points higher DHD-index scores than non-consumers (P = 0.049), but for women no difference was observed. Snacking was not associated with the DHD-index score. The four eating behaviours explained 5% of the variance in the overall DHD-index.

Conclusions: This cross-sectional study among a representative sample of the Dutch adult population showed that breakfast skipping and having dinner away-from-home were considerably associated with lower diet quality scores and these associations differed between men and women.

BACKGROUND

Certain eating behaviours, including 'breakfast skipping', 'having dinner away-from-home', 'soft drink consumption' and 'snacking', have been associated with obesity and have also been suggested to be associated with low diet quality.[1, 2] Therefore, these eating behaviours may not only result in higher energy intakes but may also affect the quality of the food choices during the day. Since the frequency of these unhealthy eating behaviours is increasing,[3] knowledge on the relationship between eating behaviours and diet quality is important for public health.

To study the quality of dietary patterns, indices have been developed. The Healthy Eating Index-2005 (HEI-2005)[4] is an example of such a measure for evaluating adherence to the 2005 American dietary recommendations and the Mediterranean Diet Score (MDS)[5] for complying with the Mediterranean diet. Research on eating behaviours and adherence to dietary recommendations has shown that breakfast skipping and having dinner away-from-home were associated with lower HEI-2005 scores.[6-8] Unexpectedly, frequency of snacking in-between meals has shown associations with higher HEI-2005 scores.[9] A study on soft drink consumption showed that this behaviour was associated with lower adherence to the MDS.[2] Thus studies showed that there are associations between these specific eating behaviours and diet quality, but the studies are limited in numbers and were merely performed in American populations.

Recently, the Dutch Healthy Diet-index (DHD-index), a measure to assess adherence to the Dutch dietary guidelines, was developed.[10, 11] This index made it possible to evaluate eating behaviours with diet quality in a Dutch population. Therefore, the objective of this study was to investigate the associations of breakfast skipping, dinner away-from-home, soft drink consumption and snacking with the DHD-index in a national representative sample of Dutch adults. It was hypothesized that individuals who performed one or more of these behaviours were more likely to have lower adherence to the dietary guidelines than individuals who did not perform these behaviours. Because the strengths of the investigated associations are potentially affected by participant characteristics, we explored if the associations differed for gender, educational level, BMI and age.

PARTICIPANTS AND METHODS

Study population

Data were used of the Dutch national food consumption survey 2007-2010.[12] Participants of this survey were drawn from a consumer panel of a marketing research institute which is

described in detail elsewhere.[12] People could not participate if they were pregnant, lactating, living institutionalised or participated in the previous national food consumption survey. For the present study, data of adults aged 19-69 years were analysed (*n* 2106). The food consumption survey was conducted according to the guidelines laid down in the declaration of Helsinki.[13]

Data collection

Dieticians assessed dietary intake by two non-consecutive 24 h recalls using the computer-based program EPIC-soft. This program follows standardised steps for assessment of dietary intake of the previous day.[14] The recall method was also used to obtain information about the meal occasion (i.e. breakfast, lunch, dinner and snack) and time and location of food intake. To calculate energy and nutrient intakes and assign foods to food groups, the Dutch food composition database of 2011 was used.[15]

Information on smoking, following a diet and use of dietary supplements was provided via a questionnaire. To assess physical activity, the short questionnaire to assess health-enhancing physical activity (SQUASH) was administered.[16] Information on gender, educational level and place of residence was provided by the marketing research agency. Height and weight were asked at start of the 24 h recall interviews from which BMI in kg/m^2 was calculated.

Definition of eating behaviours

Information on the eating behaviours breakfast skipping, dinner away-from-home, soft drink consumption and snacking was obtained from the 24 h recalls. When no foods, drinks or only consumption of water were reported for the consumption occasion 'breakfast', a recall was coded as 'breakfast skipping'. If the reported place of dinner was other than 'home' a recall was coded as 'dinner away-from-home'. Furthermore, a recall was coded as 'soft drink consumption' if it included one or more non-alcoholic beverages containing 20 KJ or more energy per 100 grams, thus excluding water, coffee, thee and diet beverages. Also, fruit juices consisting of 100% fruit and milk-based drinks were not considered being soft drinks. Finally, a recall was coded as 'snacking' if consumption of unhealthy foods between the three main meals (breakfast, lunch and dinner) was reported. Foods were defined unhealthy if they were part of the following food groups: pastry, cookies, chips, nuts, candy and ice cream. Sugar-free chewing gum was not considered being a snack.

Dutch Healthy Diet-index

Diet quality was assessed with the Dutch Healthy Diet-index (DHD-index).[10, 11] The index consists of ten components representing the 2006 Dutch guidelines for a healthy diet. The index includes one physical activity component, as physical activity is important for

maintaining energy balance and is therefore part of the guidelines. The other nine components are fruit, vegetable, dietary fibre, fish, saturated fatty acids, trans fatty acids, consumption occasions with acidic drinks and foods (ADF), sodium and alcohol. Adherence to the individual components was scored zero to 10, leading to a total score ranging from zero to 100, with a score of 100 representing complete adherence to the dietary guidelines. The DHD-index has shown to be a good measure of nutrient density and has shown acceptable correlations with biomarkers of dietary intake.[10, 11]

Data analyses

Per participant only one of the two 24 h recalls was randomly selected to calculate the DHD-index and determine the eating behaviours. Data of participants who reported being ill (*n* 51) on the day of dietary recall were excluded, consequently 2055 recalls were analysed. Thereby, data on place of dinner was missing in 37 recalls and these recalls were removed from data-analyses of dinner away-from-home.

All analyses were weighted for socio-demographic characteristics and for day and season of data collection. The weighing factors were derived from a reference population and created in an iterative process.[12] In addition, the data were analysed for men and women separately, because after evaluation of interaction terms for gender, educational level, BMI and age, gender was observed to modify the associations between eating behaviours and DHD-index (P <0.05).

Differences in participant characteristics, recall characteristics and eating behaviours according to dietary quality score were evaluated with sex-specific quartiles of the DHD-index score, using *P* for trend derived from linear regression analyses. Thereby, multiple regression analyses were used to estimate the association between each behaviour and the DHD-index score. To control for ceiling and floor effects, which were the result of scoring adherence to the individual guidelines, Tobit regression models were used to evaluate the DHD-index components.[9, 17] The Tobit regression coefficients were interpreted in the same way as linear regression coefficients. The components ADF and trans fatty acids were analysed with logistic regression models because these were dichotomous variables with a score of zero or 10. All regression models were adjusted for age, energy intake, BMI, smoking, educational level, 24 h recall assessed on a week or weekend day and for following a diet regimen. To investigate how much of the variance in the DHD-index was explained by breakfast skipping, dinner away-from-home, soft drink consumption and snacking, all four behaviours were included in unadjusted and covariate-adjusted regression analyses.

All statistical analyses were carried out by using SAS (version 9.3, SAS Institute, Cary, NC) and statistical significance was set on P <0.05.

RESULTS

The mean DHD-index score of women was 64.0 (SD 16.3), which was 4 points higher than the score of 59.9 (SD 15.0) in men (Table 2.1). Moreover, the participants with higher DHD-index scores were generally older, leaner, non-smokers and had higher educational levels than those with lower DHD-index scores (Table 2.2). They were also more likely to follow diet regimen. The DHD-index showed an inverse association with energy intake (P <0.001). Furthermore, recalls derived from weekend days showed lower DHD-index scores. The frequency of the eating behaviours breakfast skipping, having dinner away-from-home and soft drink consumption was inversely associated with the DHD-index scores. Although snacking was more frequent in the lowest quartile of the DHD-index, no significant trend across quartiles was observed.

Table 2.1 Weighted[a] mean (SD) DHD-index and component scores for the 1031 men and 1024 women (19-69 years) from the Dutch national food consumption survey 2007-2010.

	Total	Men	Women
	(*n* 2055)	(*n* 1031)	(*n* 1024)
DHD-index score	61.2 (15.8)	59.9 (15.0)	64.0 (16.3)
Physical activity	8.4 (3.3)	8.0 (3.6)	8.7 (3.0)
Vegetable	5.6 (4.6)	5.6 (4.7)	5.6 (4.5)
Fruit	4.5 (5.1)	4.2 (5.1)	4.8 (5.1)
Dietary fibre	6.7 (2.7)	6.4 (2.7)	6.9 (2.7)
Fish (EPA+DHA)	1.9 (3.8)	2.0 (3.9)	1.8 (3.8)
Saturated fatty acids	5.0 (5.0)	5.1 (4.9)	4.9 (4.0)
Trans-fatty acids	9.0 (2.7)	9.1 (3.5)	8.8 (4.0)
ADF	9.5 (2.7)	9.3 (3.1)	9.6 (2.4)
Sodium	3.2 (5.1)	2.1 (4.3)	4.3 (5.3)
Alcohol	8.4 (3.8)	8.1 (4.1)	8.6 (3.6)

Abbreviations: DHD-index, Dutch Healthy Diet-index; ADF, consumption occasions with acidic drinks and foods.

[a] Weighted for socio-demographic characteristics and for day and season of data collection.

Table 2.2 Weighted[a] distribution of participant and recall characteristics (mean (SD)) across sex-specific quartiles of the DHD-index in 1031 men and 1024 women (19-69 years) from the Dutch national food consumption survey 2007-2010.

	Sex-specific quartiles of the Dutch Healthy Diet-index[b]				
	1 (*n* 513)	2 (*n* 513)	3 (*n* 516)	4 (*n* 512)	*P* for trend
DHD-index	45.4 (7.6)	57.9 (3.9)	66.2 (3.9)	78.2 (7.9)	
Energy (MJ/day)	11.1 (4.6)	9.7 (4.2)	9.2 (4.0)	8.4 (3.6)	<0.001
BMI (kg/m^2)	26.8 (6.5)	26.3 (6.1)	25.7 (5.5)	25.7 (5.6)	<0.001
Age (year)	42.5 (16.7)	43.7 (16.6)	44.6 (17.4)	45.8 (16.8)	<0.001
Weekend day (%)	43	30	24	20	<0.001
Current Smoking (%)	33	24	24	16	<0.001
Following a diet (%)	10	9	15	19	<0.001
Education (%)					<0.001
Low	36	34	29	29	
Intermediate	44	41	47	42	
High	20	25	24	29	
Breakfast skipping (%)	13	8	8	7	<0.001
Dinner away-from-home (%)	24	19	14	13	<0.001
Soft drink consumption (%)	47	48	43	42	0.028
Snacking (%)	79	75	73	75	0.106

Abbreviations: DHD-index, Dutch Healthy Diet-index.

[a] Weighted for socio-demographic characteristics and for day and season of data collection.

[b] Cut-off values for men: 52.3, 60.4, and 68.6. Cut-off values for women: 54.1, 64.4 and 73.4.

Associations of eating behaviours with the DHD-index

The regression analyses showed that women who skipped breakfast generally had 5.0 points lower DHD-index scores than those who consumed breakfast (*P* <0.001; Table 2.3). For men no association between DHD-index and breakfast consumption was observed. Both men and women who skipped breakfast were more likely to have lower scores for fruit and dietary fibre than those who consumed breakfast. Women who skipped breakfast had lower scores for saturated fat and alcohol, but had higher scores for trans fatty acid than women consuming breakfast. Men who skipped breakfast had generally better scores for fish and sodium than breakfast consumers.

Table 2.3 Weighted[a] and adjusted[b] regression coefficients (SE) for the association between the eating behaviours and DHD-index score and its components based on 1031 men and 1024 women (19-69 year) from the Dutch national food consumption survey 2007-2010.

	Breakfast skipping vs. consumption		Dinner away-from-home[c] vs. at home		Soft drinks vs. no soft drinks		Snacking vs. no snacking	
	Men (*n* 120)	Women (*n* 79)	Men (*n* 179)	Women (*n* 179)	Men (*n* 521)	Women (*n* 456)	Men (*n* 734)	Women (*n* 809)
DHD-index	-0.1 (1.2)	-5.0 (1.5)*	-2.8 (0.9)*	-2.3 (1.0)*	1.5 (0.7)*	-1.0 (0.8)	0.4 (0.8)	1.3 (1.0)
Physical activity	-0.8 (0.8)	-1.0 (1.1)	-0.4 (0.7)	-0.6 (0.8)	-0.5 (0.5)	-0.7 (0.6)	0.1 (0.6)	2.0 (0.8)*
Vegetable	0.7 (0.6)	-0.3 (0.7)	-1.4 (0.5)*	-0.3 (0.4)	-0.1 (0.4)	-0.7 (0.4)	-0.2 (0.4)	-0.5 (0.5)
Fruit	-2.7 (1.1)*	-2.5 (1.1)*	-0.3 (0.8)	-0.9 (0.7)	-0.3 (0.7)	-1.3 (0.6)*	0.5 (0.7)	1.1 (0.7)
Dietary fibre	-0.6 (0.2)*	-1.0 (0.3)*	-0.4 (0.2)*	-0.6 (0.2)*	-0.4 (0.1)*	-0.5 (0.2)*	-0.0 (0.2)	-0.5 (0.2)*
Fish	0.9 (0.3)*	-0.1 (0.4)	0.6 (0.3)	0.7 (0.3)*	0.3 (0.2)	-0.5 (0.2)*	-0.1 (0.3)	-0.5 (0.3)
Saturated fatty acids	-0.8 (0.8)	-2.6 (1.0)*	-0.3 (0.6)	-1.2 (0.7)	0.7 (0.5)	0.9 (0.6)	-0.1 (0.5)	-0.2 (0.7)
Trans fatty acids	0.0 (0.1)	0.4 (0.1)*	0.2 (0.1)	0.1 (0.1)	-0.3 (0.1)	0.0 (0.1)	0.4 (0.1)*	-0.3 (0.1)*
ADF	0.1 (0.2)	-0.0 (0.3)	0.1 (0.1)	-0.3 (0.2)	-0.0 (0.1)	0.1 (0.1)	-0.1 (0.1)	-0.1 (0.2)
Sodium	3.5 (1.2)*	0.3 (1.3)	-1.6 (1.1)	-0.6 (0.9)	-0.1 (0.8)	1.0 (0.7)	1.3 (0.9)	0.8 (0.9)
Alcohol	0.5 (1.3)	-3.0 (1.3)*	-3.1 (1.0)*	-2.2 (0.9)	5.1 (0.8)*	3.6 (0.8)*	3.0 (0.9)*	2.4 (0.9)*

Abbreviations: DHD-index, Dutch Healthy Diet-index; ADF, consumption occasions with acidic drinks and foods.

[a] Weighted for socio-demographic characteristics and for day and season of data collection.

[b] The model is adjusted for energy, smoking, age, BMI, education level, weekend day and following a diet regimen.

[c] In 37 24 h recalls place of dinner was not reported and these recalls were removed from data-analyses of dinner.

* *P* value < 0.05.

Having dinner away-from-home was associated with 2.8 and 2.3 points lower diet scores for men and women respectively (P <0.001) as compared to having dinner at home. Both men and women having dinner away-from-home were more likely to have lower scores for dietary fibre than those consuming dinner at home. Men who had dinner away-from-home also had lower scores for vegetable and alcohol. Remarkably, women who consumed dinner away-from-home had higher scores for fish than those consuming dinner at home.

Unexpectedly, men who consumed soft drinks had on average a 1.5 points higher DHD-index score than non-consumers (P = 0.049). For women, no association between soft drink consumption and the DHD-index was observed. Higher DHD-index scores related to soft drink consumption in men were merely explained by higher mean scores for alcohol. Nevertheless, men who consumed soft drinks had lower mean scores for dietary fibre than non-consumers. In women, soft drink consumption was associated with lower scores for fruit, dietary fibre and fish than non-consumers and higher scores for alcohol.

With regard to snack intake, for both men and women no differences between consumers and non-consumers in overall DHD-index scores were observed, even though the sub-scores differed between consumers and non-consumers. Men who consumed snacks were more likely to have better scores for alcohol and trans fatty acids than those who did not consume snacks. For women who consumed snacks, also better scores for alcohol were shown, as well as better scores for physical activity than non-consumers. Thereby, women who consumed snacks had generally lower dietary fibre and trans fatty scores than women who did not consume snacks.

Unadjusted analysis of the four eating behaviours together explained 5% of the variance in the overall DHD-index and covariate-adjusted analysis of the four behaviours explained 20% of this variance. The regression coefficients with concurring standard errors of the regression analyses with the four eating behaviours together were only slightly different from those of the individual eating behaviours.

DISCUSSION

It was investigated whether four eating behaviours were associated with diet quality in a representative sample of the Dutch population. The results showed that, in women but not in men, breakfast skipping was associated with lower adherence to the dietary guidelines. Having dinner away-from-home was associated with lower diet quality than having dinner at home, which was observed in both sexes. Unexpectedly, men who consumed soft drinks adhered better to the guidelines than non-consumers; for women we did not observe such an association. Also no association was observed between consuming snacks and diet quality.

Although considerable associations were observed, the four eating behaviours together explained only 5% of the variance in the DHD-index.

This study confirms previous findings that participants who skip breakfast have a lower diet quality on that day than those who use breakfast,[6] but this was only seen for women. An explanation for the association of skipping breakfast with a lower diet quality is that skipping breakfast may result in lower appetite control and therefore increases intake of unhealthy foods.[18] The observed higher saturated fatty acid intakes of women who skipped breakfast may confirm this explanation. Another explanation is that skipping breakfast is part of an unhealthier lifestyle[19] and for this reason is associated with lower scores for fruit, saturated fatty acids and alcohol. To our knowledge, we are the first that did not find a relationship between breakfast skipping and diet quality in men. Nevertheless, men who skipped breakfast had lower intakes of fruit and dietary fibre, but they compensated this by a higher score for sodium indicating a lower sodium intake. Breakfast skipping might lead to lower salt consumption because of lower intakes of bread, processed meat and cheese, which are all three elements of a Dutch breakfast and important sources of sodium intake in the Netherlands.[12] Thus, breakfast skipping appears to be associated with lower diet quality, although this association may depend on the type of breakfast.

The present study confirms previous findings that participants who consumed dinner away-from-home had lower diet quality on that day than those who consumed dinner at home.[7,8,20] The lower overall DHD-index score was merely explained by lower scores for vegetable, dietary fibre and alcohol. The lower vegetable and fibre intakes, might be caused by the low availability of vegetables at restaurants, bars and canteens.[21] The higher alcohol intakes might be explained by the social context in which having dinner away-from-home often takes place.[22] Interestingly, women who had dinner away-from-home were more likely to have higher intakes of fish, than women having dinner at home. An explanation may be the perceived difficulty to prepare fish,[23] so when fish is prepared by someone else, people are more likely to consume it. Thus, having dinner-away-from home was associated with a lower overall diet quality in both sexes, but also with higher fish consumption in women.

The results do not confirm previous findings that soft drink consumption is associated with lower diet quality.[2, 24] Yet, we observed that soft drink consumption by men was associated with better adherence to the dietary guidelines compared with no consumption of soft drinks. Their higher overall score was the result of higher scores for alcohol, indicating a lower consumption of alcoholic beverages. This suggests that a group of men consume soft drinks instead of alcoholic beverages. Since the Dutch dietary guidelines do not include a component for scoring sugars or sugar-sweetened beverages,[10] consuming soft drinks will not directly result in a lower score for adherence to the guidelines. Nevertheless, consumption of multiple

soft drinks adds to the number of consumption occasions with acidic drinks and foods and may result in low scores on the ADF component. We observed lower dietary fibre intakes and higher energy intakes (data not shown) in both men and women who consumed soft drinks as compared to the non-consumers. These results are in line with the existing literature[2, 24] and therefore, we still identify consumption of soft drinks as a behaviour that is potentially associated with lower overall diet quality.

This study does not confirm previous findings that snack consumption is associated with low diet quality.[25] The results showed no difference between snack consumers and non-consumers in overall diet quality. This finding contradicts the findings of Zizza and colleagues, who observed that increased daily snacking frequency was associated with better diet quality scores.[9] The dissimilarity in outcome might be explained by a difference in definition of snacking. First, in the present study it was decided to only include unhealthy snacks, whereas Zizza and colleagues also included healthy snacks such as fruit and vegetables. Second, we did not include portion size or frequency in our definition, which may have resulted in only small differences in daily dietary intake between the snack consumers and non-consumers. For example, recalls in which consumption of only one biscuit was reported, were labelled as "snacking". To conclude on the association between snacking and diet quality it may be needed to include portion size and snack frequency in data analyses.[26] Another explanation for the lack of association might be under-reporting of unhealthy foods.[27] Individuals who reported no snack consumption in-between meals had generally higher body weight, but reported lower overall energy intake (data not shown). It is known that individuals with a higher body weight are more likely to report to perceived norms.[28] Therefore, a potential selective under-reporting of snacks in participants with higher body weight might have resulted in a lack of associations between snacking and diet quality.

The four eating behaviours together explained only 5% of the variance in the DHD-index; a greater part of the variance was explained by the covariates. Thus, eating behaviours seem only to play a small role in adherence to the dietary guidelines whereas participant characteristics, lifestyle factors and day of the week may be more important for dietary intake. Furthermore, the regression analyses including one behaviour at a time and the analyses with all four behaviours combined resulted in similar regression coefficients, suggesting that the eating behaviours are independently associated with diet quality. Therefore, skipping breakfast and having dinner away-from-home on the same day is potentially associated with even lower diet quality scores than the four to seven per cent that we observed for the individual behaviours. Thus, although eating behaviours only explain a small part of adherence to the dietary guidelines, breakfast skipping and having dinner away-from-home were considerably associated with diet quality.

This study is one of the few evaluating the association between eating behaviours with adherence to the dietary recommendations. These results provide insight into behaviours that are potentially important for the development of nutrition interventions. Important strengths of this research are the representativeness of the study sample for the general Dutch population and the large number of recalls that were investigated. Nevertheless, the study has a few limitations as well. First, the study is based on cross-sectional data, thus we cannot determine causality. Second, the use of 24 h recalls to assess dietary intake is a potential limitation of this study. Although 24 h recalls were the best available methodology, they may be inaccurate and biased due to misreporting caused by social desirability of answers or memory lapses.[29] Last, because we only included one dietary recall, we could not evaluate habitual eating behaviours.

CONCLUSION

Breakfast skipping and having dinner away-from-home showed considerable associations with lower diet quality scores in a representative sample of the Dutch adult population and these associations differed between men and women. Further studies should be performed to confirm the observed associations and to evaluate whether a causal relationship between eating behaviours and diet quality exists.

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CHAPTER 3

Effects of a counselling intervention to improve diet quality: a randomised controlled trial in parents of 4 to 12 year old children

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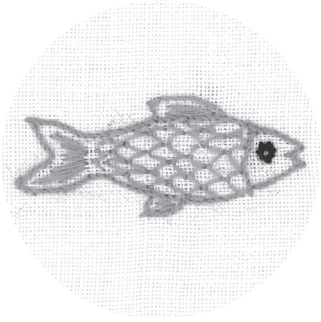

ABSTRACT

Objective: To determine whether a counselling intervention for parents improved their overall diet quality.

Methods: Between September 2011 and March 2013, a randomised controlled trial was conducted to evaluate a 20-week intervention. Participants in the intervention group (*n* 92) received dietary counselling and individually tailored email messages from a dietician. The control group (*n* 94) received no treatment. The primary outcome was change in Dutch Healthy Diet-index (DHD-index) scores (ranging from 0 to 100). The DHD-index scores were calculated from two 24 h dietary recalls and the SQUASH to assess physical activity. Secondary outcome measures included biomarkers of dietary intake, intermediate health outcomes and parental reports of children's dietary intake.

Results: The differential change in DHD-index between groups was significant (difference 6.7; 95% CI 3.27, 10.07). This change was explained by significant differential changes in fruit and fish intakes, with changes in fish intake confirmed by its biomarker ($P = 0.016$). The study also showed a 1.16 cm differential decrease in waist circumference ($P = 0.027$) and improvements in children's dietary intake of vegetables, fruit and fish ($P = 0.012$, $P < 0.001$ and $P < 0.001$, respectively).

Conclusion: A nutrition counselling intervention improved the diet quality of highly educated parents and seemed effective in improving dietary intake of their children.

BACKGROUND

The dietary intake of most adults and children in the Netherlands does not comply with the national dietary guidelines.[1, 2] This is alarming, because unhealthy dietary behaviours lead to higher risks for chronic diseases.

It is especially important that parents have good dietary patterns, as they are important role models of dietary behaviours for their children.[3, 4] Thereby, studies have shown that it is important to include parents in interventions to improve dietary intake of children.[5, 6]

To improve dietary intake of adults, a range of interventions have shown to be effective. However, these interventions merely focus on improving specific dietary behaviours such as fruit or vegetable intake and not on improving the whole dietary pattern. Because, the whole dietary pattern is associated with occurrence of diseases,[7-10] improving overall diet quality will potentially have a larger effect on health than focussing on selected behaviours.

In order to facilitate change in dietary behaviours, it is important to underpin nutrition interventions by theory of behaviour change.[11, 12] The transtheoretical model[13] is frequently used as a framework to tailor dietary advice to persons' stage of change and it appears helpful in building interventions for changing dietary intake.[14] In addition, interventions using motivational interviewing,[15] a communication style for motivating people to change behaviour and that complies well with the transtheoretical model, were generally effective in improving dietary intake.[16]

We developed an intervention based on the transtheoretical model to improve parental adherence to the Dutch dietary guidelines.[2] The intervention included five face-to-face sessions during which a dietician used motivational interviewing to guide the parents towards a healthy diet. The parents also received three emails with individualised feedback. The primary objective was to investigate if the intervention improved diet quality of the parents as was expected. Secondary outcome measures were changes in biomarkers of dietary intake, intermediate markers of health and dietary intake of the children.

METHODS

Participants and recruitment

Between September 2011 and October 2012, participants were invited to take part in the randomised controlled trial through participant email databases and primary schools in Wageningen and surrounded areas. All parents of a child aged four to twelve years who showed interest (*n* 218) were screened for eligibility criteria via a questionnaire. Exclusion

criteria were: (a) known high blood pressure, (b) known high cholesterol levels, (c) recent considerable changes in diet, (d) being pregnant or willing to become pregnant, (e) weight changes greater than 5 kg within the past six months, (f) taking part in another study, (g) having a nutrition related profession, (i) having a partner that was included in the study. After screening, 209 parents were invited to join the study and 186 parents decided to participate (Fig. 3.1). It was estimated that each arm should include 91 participants to detect a 5 point difference (SD 11.5) in healthy diet score representing 90% power (alpha = 0.05).[17, 18] Ethical approval for the study protocol was obtained by the Wageningen University institutional review board and all participants provided written informed consent.

Study design

Participants were randomised to intervention (*n* 92) or control (*n* 94) group. An independent researcher block-randomised participants based on sex and BMI derived from self-reported weight and height (under 25, 25-30 and over 30 kg/m^2) using a computer-generated table of random numbers.

At baseline, participants came twice to the study centre at Wageningen University for body measurements, withdrawal of blood and urine collections. All measurements were done by research assistants who were blinded to treatment. Participants were asked to complete a series of web-based questionnaires on dietary intake and related behaviours. After baseline measures, the intervention group received a 20-week counselling intervention to improve adherence to the Dutch dietary guidelines.[2] The control group did not receive any of the intervention elements. At the end of the 20 weeks, participants completed the same procedures as at the start of the study.

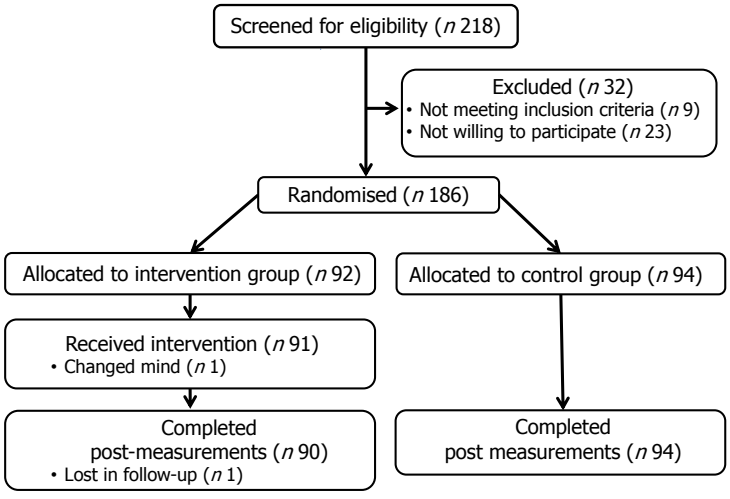

Figure 3.1 Study design and follow up of participants in the intervention and control group, Wageningen, The Netherlands, 2011-2013.

Dietary intervention

Two weeks after the baseline measurements, participants in the intervention group visited one of six registered dieticians for a first individual session of 45 minutes. The other four sessions of 20 minutes each, were planned in week three, eight, thirteen and nineteen. The dieticians were trained to work via a protocol that was developed to standardise the counselling sessions among dieticians. The dieticians' counselling took the participants current dietary intake into account and was tailored according to readiness to change dietary.[13] The counselling was also focused on the determinants of dietary behaviour as described by theory of planned behaviour.[19] The dieticians used motivational interviewing to facilitate and engage participant's intrinsic motivation to change behaviour.[15]

In the first four counselling sessions a theme was discussed. These were; "healthy diet for the parent", "healthy diet in a family-setting", "energy-related behaviour" and "set the example for your child". The fifth session did not have a theme; it was included to make sustainable and long-term goals. In short, each session had the following outline; (1) discussion of dietary intake of the previous period with reinforcement of good dietary habits, (2) assessment of the stage of change of multiple behaviours, (3) selection of specific behaviours to change, (4) discussion of problems and pitfalls, (5) formulation of a concrete plan of action with specific and realistic goals and (6) providing specific brochures.

Between the sessions, in weeks five, ten and fifteen, the participants were requested to complete a short web-based questionnaire inquiring about the intake of fruit, vegetables, fish and on intake of foods with a high content of saturated fatty acids and dietary fibre. Based on the answers, the dietician wrote an email. The first paragraph included information on the current dietary intake. In the second paragraph, intake was related to the previous agreed goals and good behaviour was reinforced. The third paragraph included tips for helping to meet or maintain a healthy diet. In addition to the individually tailored emails, on-going weekly emails were sent with nutrition related facts and recipes for healthy meals to keep the participants motivated.

Primary outcome measure: diet quality

The primary outcome, change in diet quality, was investigated with the Dutch Health Diet-index (DHD-index).[20] This index, consisting of one physical activity component and nine dietary components, was calculated from the SQUASH, a short questionnaire to assess physical activity,[21] and two unannounced non-consecutive 24 h dietary recalls.

The recalls were self-administered via Compl-eat™, a web-based program that guides participants to report foods eaten during the previous day. Compl-eat™ is based on the five-step multiple-pass method[22] and includes foods commonly used in the Netherlands.[23] Portion

sizes of foods were reported by using household measures, standard portion sizes, weight in grams or volume in litres.[24] To calculate energy and nutrient intakes and assign foods to food groups the Dutch food composition database of 2010 was used.[24] The 24 h recalls were checked for unusual values and possible missing information on foods that are often consumed at main meals (i.e. bread and meat). If necessary, the participants were asked for the information.

From the recalls, the DHD-index components fruit, vegetable, dietary fibre, fish (EPA + DHA), saturated fatty acids, trans-fatty acids, sodium, alcohol and consumption occasions with acidic drinks and foods (ADF) were calculated. When participants fully adhered to a guideline ten points were allotted. If there was no full adherence, points were allotted linearly with upper or lower thresholds, as described by van Lee and colleagues.[20, 25] In the present study, fish oil supplements were not used to calculate fish intakes. The total DHD-index score ranged from zero to 100, with higher scores reflecting better adherence to the Dutch dietary guidelines.

Secondary outcome measures

Weight was assessed using a digital scale (SECA 703) and recorded to the nearest 0.1 kg. Height was assessed using a portable stadiometer (SECA 225) to the nearest 0.1 cm. BMI was calculated as kg/m^2. Waist circumference was assessed using a measuring tape (SECA 201) in the middle of the lowest rib and the hip bone to the nearest 0.1 cm. These measures were all conducted with participants wearing light clothing and without wearing shoes.

Blood pressure was measured with the Amron M10-IT automated sphygmomanometer three times after a five minute rest and with two minutes between measurements. The latter two measurements were used in data analyses.

Blood was collected from participants in fasting state for at least ten hours. After collection, blood samples were centrifuged and stored at -80 ℃ until further analysis at one sequence. Serum concentrations of total cholesterol, HDL cholesterol and triglycerides were determined with enzymatic methods using a commercial kit by the SHO centre for medical diagnostics, Velp, The Netherlands. Using the concentrations of cholesterol and triglycerides, LDL cholesterol levels were calculated.[26] Serum carotenoid concentrations were determined by HPLC analysis (Thermo Quest) and fatty acid methyl ester profiles with gas chromatography (Hewlett Packard 5890 Series II) by the laboratory of Human Nutrition, Wageningen University, Wageningen, the Netherlands. The percentage of eicosapentaenoic acid (EPA; C20:5n-3) and docosahexaenoic acid (DHA; C22:6n-3) of the 36 measured fatty acids in plasma cholesteryl esters was used as marker for intake of fish.[27] The sum of the serum carotenoids lutein, zeaxanthine, β-cryptoxanthin, α-carotene, β-carotene and lycopene was used as marker of fruit and vegetable intake.[28]

Participants collected a single urine sample in a 500-ml jug the day before the body measurements. The jugs were brought to the study centre, where the content was homogenised and stored in five mL tubes at -20 ℃. Urinary sodium and potassium concentrations were determined by an ion-selective electrode on a Synchorn LX20 analyser (Beckman coulter, Mijdrecht, The Netherlands). From concentrations, sodium to potassium ratios were calculated, as marker for salt, fruit and vegetable intake.

A questionnaire on general characteristics and the Dutch eating behaviour questionnaire (DEBQ)[29] were administered at baseline. The other questionnaires were administered at baseline and end of the study. Quality of life was assessed with the 'SF36'.[30] Food intake of parents' eldest child under 13 years of age was reported by the parents. This questionnaire was based on a validated food frequency questionnaire (FFQ) for adults.[31] The questionnaire included questions on the ten Dutch dietary guidelines.[2] Also questions on soft drink consumption were added, because consumption of soft drinks is associated with higher energy intake and unhealthy dietary patterns in children.[32] From reported weight and height, BMI (kg/m^2) was calculated. To assess if the child was overweight, BMI was compared with the Dutch growth charts.[33]

Statistical analysis

Duplicate baseline data were averaged and the same was done with the data at the end of the study. Baseline equality of the study groups was assessed with two-tailed t-tests or Fisher's exact tests. The DHD-index was only calculated for participants with complete data on the 24 h recalls and the SQUASH (*n* 178). To compare differential changes in primary and secondary outcome measures, ANCOVA was conducted with baseline values as co-variables. The results are reported as baseline mean values and adjusted least squares mean changes with 95% CI. We also examined the effects of energy adjustment of the primary outcome, because the DHD-index has shown considerable associations with energy.[20] All analyses were done with SAS version 9.3 (SAS Institute, Cary, NC, USA), considering $P < 0.05$ significant.

RESULTS

The baseline characteristics of the study population were comparable between randomisation groups (Table 3.1). The majority of the participants were women, normal weight, non-smoking and highly educated. The children were on average 8.8 years old, 58% were boys and 9% of them were overweight. Ninety-three percent (*n* 84) of the parents in the intervention group received all five counselling sessions and the intervention had no substantial effect on their quality of life ($P = 0.78$).

The mean baseline DHD-index scores were 66.1 (SD 13.5) and 64.5 (SD 12.8) for the intervention and control group, respectively (Table 3.2). After intervention, the improvement in DHD-index score was significantly greater in the intervention group than in the control group (difference = 6.7, 95% CI 3.27, 10.07). Examination of differential changes in overall DHD-index adjusted for energy resulted in similar results (difference 6.3, 95% CI 2.99, 9.59). The increase in total score in the intervention group was explained by increases in scores for physical activity, fruit, vegetable, dietary fibre, fish, saturated fatty acids and trans fatty acids. The changes in fruit and fish score were significantly greater ($P = 0.003$ and $P = 0.035$, respectively) in the intervention than in the control group. The intervention did not affect energy intake.

The increase in reported fish intake was supported by a significant higher differential increase in the percentage of EPA and DHA of total fatty acids in plasma phospholipids in the intervention group as compared to the control group ($P = 0.016$; Table 3.3). However, the sum of serum carotenoid concentrations, a biomarker for fruit intake, did not increase. For serum cholesterol concentrations, triglyceride concentrations and urinary sodium to potassium ratios no improvements were found. Waist circumference significantly decreased with 1.16 cm in the intervention group when compared to the control group ($P = 0.027$). For BMI and blood pressure no differential changes were found.

The children of the parents in the intervention group increased vegetable intake from 10.5 to 12.1 serving spoons, fruit intake from 8.8 to 10.2 pieces per week and fish intake from 2.9 to 3.5 times per month, these increases were all three larger than those found in the control group ($P = 0.012$, $P < 0.001$ and $P < 0.001$, respectively). Snack intake decreased from 11.8 to 9.8 snacks per week and soda intake from 14.1 to 12.3 glasses per week in the intervention group but these changes did not differ from those in the control group ($P = 0.07$ and $P = 0.16$, respectively). The intervention did not affect children's physical activity levels or BMI ($P = 0.330$ and $P = 0.390$, respectively).

DISCUSSION

The present study showed that a nutrition counselling intervention aimed at parents improved their adherence to the dietary guidelines. The differential change in overall DHD-index score was explained by increases in seven out of ten sub-index scores; especially by higher scores for fruit and fish. The higher fish intake was supported by increases in its biomarker. The intervention aimed at parents also showed improvements in reported intake of fruit, vegetable and fish in their children.

Table 3.1 Baseline characteristics (*n* (%)) of the intervention and control group.

	Intervention group (*n* 92)	control group (*n* 94)
Parents		
Age (years)	43.3[a] (5.1)	42.6[a] (5.9)
Sex (Female)	74 (80%)	77 (82%)
Education (High)[b]	66 (72%)	72 (77%)
BMI (kg/m^2)		
<25	56 (61%)	61 (65%)
25 - 30	25 (27%)	26 (28%)
≥30	11 (12%)	7 (7%)
Smoking (Yes)	4 (4%)	4 (4%)
DEBQ (Restraint score)	2.8[a] (0.7)	2.9[a] (0.7)
Children		
Age (years)	9.1[a] (2.4)	8.5[a] (2.5)
Sex (Female)	39 (42%)	40 (43%)
Overweight[c]	11 (12%)	6 (6%)

Abbreviations: DEBQ, Dutch Eating Behaviour Questionnaire.
[a] Mean (SD).
[b] "High education" includes completing university or higher vocational education.
[c] Overweight was obtained by comparing BMI (kg/m^2) with the Dutch growth charts.[33]

The intervention effect on dietary intake was comparable to those of two other interventions evaluating changes in diet quality of generally healthy participants. In a pilot study of Carpenter and colleagues, in which the intervention included 20 group sessions, participants in the intervention group increased their Modified Healthy Eating index (range 0 - 90) with 7.7 points.[18] In the study of Sallit and colleagues, in which the intervention included 12 educational classes, participants in the intervention group increased their Diet Quality Index-revised (range 0 - 100) with 11.4 points.[34] Thus we have confirmed that with nutrition interventions overall diet quality can be improved, which is important to reduce the risk for chronic diseases.[7, 9] The increase in 7.8 DHD-index points in the intervention group equals an increase of about 100 grams of fish per week and 50 grams of fruit or vegetables per day. Such increases in fish, fruit and vegetable intake may be considered as substantial since they have shown associations with lower risks of coronary heart disease.[35, 36]

Table 3.2 Mean (SD) baseline DHD-index score, component scores and total energy intake and mean changes with 95% CI within and between intervention groups.

	Intervention group (*n* 88)			Control group (*n* 90)			Differences between groups	
	Baseline Mean (SD)	Mean change[a]	95%CI	Baseline Mean (SD)	Mean change[a]	95%CI	Mean change[a]	95%CI
Total DHD-index	66.1 (13.5)	7.8	5.34, 10.17*	64.5 (12.8)	1.1	-1.30, 3.47	6.7	3.27, 10.07*
Energy (MJ)	8.5 (2.1)	-0.4	-0.76, 0.05	8.1 (2.1)	0.3	-0.72, 0.07	0.0	-0.60, 0.53
Physical activity	7.3 (3.5)	0.7	0.06, 1.30*	6.9 (3.4)	-0.2	-0.79, 0.44	0.8	-0.02, 1.72
Vegetables	6.3 (3.3)	1.2	0.56, 1.80*	6.2 (3.2)	0.4	-0.19, 1.04	0.8	-0.11, 1.63
Fruit	7.2 (3.5)	0.9	0.18, 1.57*	6.1 (3.9)	-0.6	-1.29, 0.09	1.5	0.50, 2.46*
Dietary fibre	8.0 (1.7)	0.5	0.23, 0.86*	7.8 (1.6)	0.2	-0.13, 0.49	0.4	-0.08, 0.80
Fish (EPA + DHA)	1.9 (3.2)	0.7	-0.02, 1.33	2.1 (3.4)	-0.4	-1.03, 0.30	1.0	0.07, 1.97*
Saturated fat	4.6 (3.8)	1.7	0.86, 2.47*	4.4 (3.7)	0.8	-0.01, 1.58	0.9	-0.25, 2.02
Trans fatty acids	7.6 (4.3)	1.4	0.72, 2.11*	7.8 (4.2)	0.5	-0.18, 1.19	0.9	-0.07, 1.88
ADF	9.9 (1.1)	-0.1	-0.22, 0.10	10.0 (0.0)	0.1	-0.10, 0.21	-0.1	-0.34, 0.11
Salt	3.7 (3.8)	0.7	-0.15, 1.59	3.7 (4.2)	0.5	-0.40, 1.31	0.3	-0.97, 1.48
Alcohol	9.5 (1.4)	0.0	-0.47, 0.48	9.5 (2.0)	-0.2	-0.70, 0.24	0.1	-0.36, 0.51

Abbreviations: DHD-index, Dutch Healthy Diet- index; ADF, consumption occasions with acidic drinks and foods.

[a] Mean changes were adjusted for baseline values.

* $P < 0.05$

Table 3.3 Mean (SD) baseline values for intermediate health outcomes and biomarkers and mean changes with 95% CI within and between intervention groups.

	Intervention group (*n* 90)			Control group (*n* 94)			Differences between groups	
	Baseline Mean (SD)	Mean change[a]	95%CI	Baseline Mean (SD)	Mean change[a]	95%CI	Mean change[a]	95%CI
Body composition								
Waist (cm)	84.8 (10.9)	-1.48	-2.22, -0.74*	83.8 (10.1)	-0.31	-1.03, 0.41	-1.16	-2.20, -0.13*
BMI (kg/m²)	24.6 (3.7)	-0.06	-0.20, 0.08	24.2 (3.2)	-0.17	-0.30, -0.03*	0.10	-0.09, 0.30
Blood pressure (mmHg)								
Systolic	117.2 (13.4)	-3.64	-5.07, -2.21*	116.7 (13.2)	-3.62	-5.02, -2.21*	0.02	-1.99, 2.03
Diastolic	74.3 (10.5)	-2.73	-3.79, -1.68*	72.9 (9.5)	-3.03	-4.06, -2.00*	0.30	-1.18, 1.77
Sum of serum carotenoids (µg/100ml)	132.8 (49.5)	0.46	-4.59, 5.51	125.1 (53.4)	-3.55	-8.49, 1.39	4.01	-3.1, 11.1
% EPA + DHA of total fatty acids in phospholipids	1.5 (0.6)	0.15	0.05, 0.25*	1.5 (0.6)	-0.02	-0.12, 0.08	0.17	0.03, 0.31*
Lipids (mmol/l)								
Total cholesterol	5.2 (0.8)	-0.09	-0.17, -0.01*	5.1 (0.8)	-0.01	-0.09, 0.07	-0.08	-0.19, 0.03
HDL cholesterol	1.7 (0.4)	-0.03	-0.06, -0.00	1.6 (0.4)	-0.01	-0.04, 0.02	-0.02	-0.06, 0.03
LDL cholesterol	3.1 (0.8)	-0.07	-0.13, -0.00	3.1 (0.8)	-0.01	-0.07, 0.52	-0.06	-0.14, 0.03
Triglycerides	1.0 (0.5)	0.05	-0.01, 0.11	1.0 (0.5)	0.02	-0.36, 0.08	0.02	-0.06, 0.11
Urinary sodium:potassium	1.8 (1.1)	-0.26	-0.45, -0.08	1.9 (1.0)	-0.14	-0.33, 0.05	-0.12	-0.39, 0.14

[a] Mean changes were adjusted for baseline values.

* *P* value is <0.05

The improvement in diet quality in the present study was explained by small changes in DHD-index sub-scores for seven components. Similar small changes were also observed in other intervention studies with comparable measures of dietary intake.[17, 18, 34, 37, 38] An increase in scores of multiple components was expected as the counselling was aimed at all sub-items DHD-index. This might indicate that the present intervention was successfully aimed at the overall dietary pattern and was not only effective on improving intake of single foods or nutrients. The lack of improvement in scores of consumption occasions with acidic drinks and foods and alcohol consumption may be explained by the high mean baseline scores for bothcomponents, leaving little room for improvement.

We measured a few markers of dietary intake to be able to support the results of the self-reported intakes. Unfortunately, the increase in reported fruit intake was not reflected in the summed serum carotenoid concentrations. Also β-cryptoxanthin serum concentrations, which may be a better biomarker for fruit intake than total carotenoids, did not increase (data not shown).[39] The lack of increases in carotenoid concentrations might be explained by the moderate associations between these biomarkers and fruit and vegetable intake.[40, 41] Also, the reported increase in fruit intake of 0.9 points, about 20 grams, was small. Therefore, the study might have had too little power to detect a difference in carotenoid concentrations.

Nevertheless, the increase in DHD-index score for fish in our study was supported by increased EPA and DHA as percentage of total plasma fatty acids. The DHD-index fish component score was calculated from EPA and DHA in the diet, excluding the contributions of fish oil supplements. These supplements were not included as information on the composition of the supplements was often unknown. Thereby, only nine participants reported fish oil supplement intake and supplements were used by the same participants before and after the intervention. Thus, it is likely that increases in EPA and DHA are derived from increases in intake of fish and not from increases in using fish oil supplements.

We did not observe a change in BMI, but this was expected. The intervention was developed to improve adherence to the Dutch dietary guidelines[2] and not to reduce body weight. Also, energy intake did not substantially change in the intervention group. Nevertheless, a decrease in waist circumference was found. This finding is difficult to explain, especially because we are not aware of studies with similar results. An explanation might be that the intervention group increased physical activity, as the group's changes in activity scores were borderline significantly higher than in the control group. This might have led to changes in body composition with a decrease in waist circumference,[42] however not in body weight.

The improvements in parents' diets were reflected in improvements in children's intakes of fruit, vegetables and fish. These results may confirm that interventions aimed at parents

potentially result in improvements in food intake of their children.[43] However, we must be careful in interpreting these results as they are based on parental reports and were evaluated for a selection of foods. Future studies are needed to confirm that interventions aimed at parents actually improve their children's dietary quality.

The present study had several strengths. First, the present study was well-founded by theory, which is essential in changing dietary behaviour.[11, 12] Second, the study had a high follow-up rate. The low drop-out rate may indicate that the participants were able to integrate the intervention elements into daily life. This is supported by the quality of life score, which remained the same. Third, the intervention was aimed at generally healthy parents, who usually do not receive dietary counselling. The results showed that for these parents there is room for improvement of dietary intake. Fourth, the counselling protocol was developed together with dieticians and fits well within their practices. Last, this study is one of the first that underpinned the self-reported increase of fish intake with an objective marker.

This study had also some limitations. First, dietary intake might have been misreported because we used Compl-eat™, a new web-based method for collecting 24 h dietary recalls. A study evaluating ASA-24, a similar web-based 24 h recall method, has shown that web-based recalls resulted in under-report of energy intake but had good correlations with telephone recalls.[44] Although using Compl-eat™ may have led to under-report and other types of error, we expect these errors to be similar before and after intervention and thus not affecting the change in DHD-index. Our expectations are confirmed by calculations based on a validated FFQ.[31] This FFQ was also completed by our participants. The FFQ results showed a comparable increase in DHD-index (7.4 points, range 0 - 70) in the intervention group as compared to no increase in the control group (P <0.001). It is thus likely that the intervention resulted in higher adherence to the dietary guidelines. However, comparable to other interventions evaluated by self-reports, we cannot exclude reporting to perceived social norms.[40] Second, the results cannot be generalised to other populations. This study was conducted in a well-educated female population, with better diet quality than the general population.[20] Thereby, the participants were motivated to change dietary intake. Thus, for populations with lower socio-economic status, that are probably less motivated to change, smaller or even lack of intervention effects may be expected.[45] Third, the outcomes were measured only a couple of weeks after the intervention ended. Based on previous studies we may expect a decline in adherence to the dietary guidelines after some months.[17, 34] We attempted to improve the long-term effect by guiding participants to make small dietary changes, which are easily incorporated in daily life, and by letting them set long-term goals. Unfortunately we did not have the resources to test the long-term effect.

CONCLUSION

A nutrition intervention, including five standardised face-to-face counselling sessions with a dietician, complemented with individually tailored emails was effective in improving adherence to the Dutch dietary guidelines of a highly educated, mainly female population with children aged 4 to 12 years. The changes that parents made seemed to have improved the food intake of their children.

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CHAPTER 4

Mediators of behaviour change in a nutrition counselling intervention

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ABSTRACT

Objective: To assess what determinants were changed by a nutrition counselling intervention and what changes in determinants mediated improvements in fruit, vegetable and snack intake.

Design: A randomised controlled trial.

Setting: A 20-week intervention to improve dietary intake. The intervention included five face-to-face counselling sessions with a dietician and three individually tailored emails.

Subjects: 92 adults were included in the intervention group and 94 adults in the control group.

Methods: At baseline and after 24 weeks, participants completed a food frequency questionnaire and a questionnaire on determinants of behaviour.

Results: After the intervention, the intention, attitude and habit for fruit intake changed more in the intervention group than in the control group. For vegetable intake, home accessibility of vegetables improved. For snack intake, scores for intention and subjective norm increased. Knowledge and self-identity also changed more in the intervention group than in the control group. Improvements in fruit intake were mediated by changes in attitude (effect size (ES) -14.9, 95% CI -28.9, -6.0) and habit strength (ES -18.4, 95% CI -32.3, -8.6). Decreases in snack intake were mediated by changes in self-identity (ES 6.0, 95% CI 2.4, 11.9).

Conclusions: The counselling intervention effectively changed multiple determinants of dietary intake. Further, changes in attitude and habit strength mediated increases in fruit intake and changes in self-identity as a healthy eater mediated decreases in snack intake. Because we are one of the first investigating these determinants, further well-designed evaluation studies are needed to investigate how behaviour change is established.

BACKGROUND

A healthy dietary pattern promotes health and reduces the risk of several chronic diseases.[1,2] However, most adults and children in the Netherlands do not meet the recommendations for a healthy diet.[3, 4] This indicates that there is a need for effective nutrition interventions.

Interventions are more likely to be successful if not only the behaviour of interest is targeted but also its determinants.[5, 6] Indeed, some interventions targeting determinants have been shown to be effective in increasing intakes of fruit and vegetables and decreasing intakes of total and saturated fat.[7, 8] Nevertheless, there is relatively little research showing that improvements in dietary intake are achieved through changes in the determinants of intake. In order to improve future interventions, more research is needed that investigates what determinants can be successfully changed with an intervention and if these changes are crucial for establishing improvements in dietary intake.[9, 10]

To evaluate how change in behaviour is established, mediation analyses can be performed.[10,11] For a determinant to be classified as a mediator, it should be established that the intervention causes changes in the determinant, and that changes in the determinant, in turn, are associated with changes in dietary behaviour. Finally, mediation is indicated if the effect of a nutritional intervention on dietary behaviour results from changes in determinants of the behaviour.[12]

Studies exploring mediators of intervention effects on dietary intake have shown that attitude,[13] knowledge,[13] self-efficacy,[10, 13-16] social support,[10] perceived barriers[13] and autonomous motivation[17] mediated changes in dietary behaviour. However, evidence is limited to a few studies, leaving a need for more studies evaluating mediators of change in dietary behaviour.

To gain insight into mediators of dietary behaviour change, we used data of a nutrition intervention that was aimed to improve adherence to the Dutch dietary guidelines in parents of children aged 4 to 12 years.[4] The 20-week intervention comprised five face-to-face counselling sessions, individually tailored feedback in three email messages and weekly generic emails. The intervention was effective in improving overall adherence to the Dutch dietary guidelines in a population predominantly consisting of highly educated women.

The determinants that were hypothesized to be mediators of improved dietary intake were derived from the theory of planned behaviour (TPB).[18] According to this theory, intention is assumed to be the most proximate predictor of behaviour. Intention, in turn, is a function of three determinants: (1) attitude; the personal beliefs towards the behaviour, (2) subjective norms; perceptions of how significant others think one should behave, and (3) perceived behavioural control; the perception of control over the behaviour. The determinants derived

from the TPB have previously been found to predict fruit, vegetable and fat intake.[19, 20] Next to these determinants, we investigated the following five determinants as potential mediators: habit strength, home food accessibility, knowledge, self-identity and perceived barriers. These determinants complement those of the TPB and have been proven relevant for understanding how dietary behaviour is established. First, habit strength is important because behaviour is often performed in repetition in similar situations, resulting in automatic cue-response associations that form habitual action. Given that the TPB assumes that behaviour results from reasoned processes, the role of habit strength is not addressed by the theory.[21-24] Second, home food accessibility (i.e., whether foods are available at home and easy to take) has shown to be crucial for actual behaviour change.[25, 26] Third, knowledge is a perquisite for behaviour change. Knowledge potentially influences attitude, subjective norm, perceived behavioural control, and thus the decision to consume fruit and vegetables.[22, 27] Fourth, self-identity with respect to healthy eating has shown to play an additional role in the prediction of intention.[28] People who strongly identify themselves with being a healthy eater report stronger intentions to eat healthy. Fifth, perceived barriers like a lack of time[29] and mood may hinder healthy dietary intake.[30] Barriers have been considered important in clarifying why intentions not always turn into behaviours.[22]

In the present study, we investigated how behaviour change was established in the counselling intervention by determining: (1) the intervention effect on determinants of dietary behaviours, (2) whether the successfully changed determinants were also associated with changes in dietary intake of fruit, vegetables and snacks, and (3) what changes in determinants mediated the intervention effect on dietary intake. It was hypothesized that the intervention was effective in improving the targeted determinants and that consequently this improvement mediated changes in intake of fruit, vegetables and snacks.

PARTICIPANTS AND METHODS

Participants

Between September 2011 and October 2012, parents of children aged 4 to 12 years were recruited through participant email databases and primary schools. Generally healthy people could participate and exclusion criteria were: known high blood pressure or cholesterol levels, recent considerable changes in dietary pattern, being pregnant or willing to become pregnant, weight loss or weight gain greater than 5 kg within the past six months, participating in another study and having a nutrition related profession. Of 218 parents who were screened, nine persons did not meet the inclusion criteria and 23 persons decided not to participate.

In total the study included 186 participants, of which 81% were women and 74% completed at least high level vocational training, college or university, indicating highly educated participants. The mean population age was 42.9 (SD 5.5) years and 37% had a body mass

index above 25 kg/m^2. The intervention and control group did not significantly differ in sex, age, educational level, BMI and smoking behaviour. During the study period, two men dropped out of the intervention group and as a result 184 participants completed the study. All participants signed an informed consent form and the study was approved by the Medical Research Ethics Committee of Wageningen University.

Study design

The participants were block-randomised to the intervention (*n* 92) or control group (*n* 94) based on sex and BMI derived from self-reported weight and height (under 25, 25-30 and over 30 kg/m^2). At baseline, participants completed web-based questionnaires on dietary intake and its determinants. After baseline measures, the intervention group received a 20-week counselling intervention to improve adherence to the Dutch guidelines for a healthy diet.[4] The control group did not receive any intervention elements. After 20 weeks, participants completed the same web-based questionnaires as before the intervention.

Individually tailored intervention

Two weeks after baseline, participants visited one of six registered dieticians for a session of 45 minutes. The other four sessions of 20 minutes each, were planned in weeks three, eight, thirteen and nineteen. The dieticians were trained to provide the dietary counselling via a protocol to standardise the counselling sessions among dieticians. The counselling was tailored to individuals' readiness to change dietary behaviour as described by the transtheoretical model.[31] In the sessions, also the behavioural determinants were addressed. The dieticians used motivational interviewing,[32] as the conversation style to facilitate and engage participants' intrinsic motivation to change behaviour.

In short, the sessions had the following outline; (1) the dietician discussed the dietary intake of the previous period and reinforced good dietary habits, (2) the dietician assessed the stage of change of multiple behaviours, (3) the dietician and participant selected specific behaviours that needed attention, (4) problems and pitfalls of the selected behaviours were discussed, (5) the participant formulated a concrete plan of action with specific and realistic goals and (6) the dietician provided specific brochures.

Between the sessions, in weeks five, ten and fifteen, the participants were requested to complete a short web-based questionnaire inquiring about the intake of fruit, vegetables, and fish and on intake of foods with a high content of saturated fatty acids and dietary fibre. Based on the answers, the dietician wrote an individually tailored email including information on the current dietary intake, compliance with their goals and additional tips. In addition, on-going weekly emails were sent with nutrition related facts and recipes for healthy meals.

Assessment of determinants

The determinants intention, attitude, subjective norm, perceived behavioural control, habits strength and home food accessibility were assessed separately for intake of fruit, vegetables and snacks. The determinants self-identity, knowledge and perceived barriers were assessed for healthy eating in general. The questions on intention, attitude, subjective norm, and perceived behavioural control were based on the questions and scales described by Fishbein and Ajzen.[22] Baseline data were used to calculate the Cronbach's α values of the question sets that included more than two items. For two-item question sets, Spearman-Brown coefficients were calculated.[33]

Intention was assessed as the mean scores of the following items: "I am planning to eat...", "I expect to..." and "I will try to..." "...eat 2 pieces of fruit per day / eat 200 grams of vegetables per day / replace unhealthy snacks with healthy snacks", with scales ranging from 1 = "totally disagree" to 7 = "totally agree". The Cronbach's α values were 0.91, 0.93 and 0.95 for fruit, vegetables and snacks respectively.

Attitude was assessed with a 7-point semantic differential scale and reported as the mean score of the following items: "Consuming at least 2 pieces of fruit per day / Consuming at least 200 grams of vegetables per day / Replacing unhealthy snacks with healthy snacks is...": simple – troublesome; easy – difficult; pleasant – unpleasant; expensive – cheap; vile – tasty; important – not important. The Cronbach's α of attitude towards fruit, vegetable and snack intake increased with about 0.10 points when the item on cost was removed. Therefore, we excluded cost from the scale, leaving attitude scales of five items. The Cronbach's α values were 0.84, 0.85 and 0.77 for fruit, vegetables and snacks respectively.

Subjective norm was assessed with mean scores for the following items: "Individuals with whom I spend much time..."; "...find it important that I consume 2 pieces of fruit per day / consume 200 grams of vegetables per day / replace unhealthy snacks with healthy snacks"; "...consume 2 pieces of fruit per day / consume 200 grams of vegetables per day/ replace unhealthy snacks with healthy snacks", "...support me if I want to consume 2 pieces of fruit per day / consume 200 grams of vegetables per day/ replace unhealthy snacks with healthy snacks", with scales ranging from 1 = "absolutely not" to 7 ="absolutely". The Cronbach's α values were 0.76, 0.78 and 0.76 for fruit, vegetables and snacks respectively.

Perceived behavioural control was assessed with mean scores of the following items: "Eating 2 pieces of fruit per day / Eating 200 grams of vegetables per day / Replacing unhealthy snacks with healthy snacks in the following month is under my control" and "I am sure that I can eat 2 pieces of fruit per day / eat 200 grams of vegetables per day / replace unhealthy snacks with healthy snacks if I want to", with scales ranging from 1 = "totally not true" to

7 = "totally true". The Spearman-Brown coefficients were 0.69, 0.71 and 0.63 for fruit, vegetables and snacks respectively.

Habit strength was assessed with a shortened version of the self-report habit index developed by Verplanken and Orbell.[34, 35] Habit strength was assessed with mean scores of four items; "Eating 2 pieces of fruit per day / Eating 200 grams of vegetables per day / Eating unhealthy snacks is something...": "...I do frequently"; "...I do without having to consciously remember"; "...makes me feel weird if I don't do it"; "...I don't have to think about doing it", with scales ranging from 1 = "totally disagree" to 7 ="totally agree". The Cronbach's α values were 0.92, 0.89 and 0.82 for fruit, vegetables and snacks respectively.

Home food accessibility was assessed with six statements. The questions and scoring were adapted from Nelson Laska and colleagues.[36] The participants rated how well the statements fit their current situation: "Fruit is available at home", "Fruit is available at a visible place at home", "Vegetables are available during the main meal", "Vegetables are accessible in-between meals", "Crisps or salty snacks are available at home" and "Chocolates or candies are available at home". Response categories ranged from "never" to "always" on a four-point scale (for fruit and vegetables never = 1 and always = 4; for snacks never = 4 and always = 1). A sum score was obtained for fruit, vegetables, and snacks, separately. The three scores ranged from 2 to 8 points.

Knowledge was assessed with two different types of questions. Participants first responded to eight statements on the Dutch dietary guidelines for a healthy diet[34] with "true", "false" or "I do not know". Next, participants selected the healthier choice from ten pairs of products or answered "I do not know". These pairs were obtained from the Dutch food based dietary guidelines.[3] We excluded the question on the recommended amount of fish consumption from data analyses, because participant remarks indicated that this question was wrongly interpreted by the majority of the participants. Each right answer received one point and the sum score ranged from 0 to 17 points.

Self-identity with respect to healthy eating was measured in a similar way to Armitage and Connor.[37] The mean score of the following three questions was used: "I am someone who eats healthy", "I am someone who is mindful about what I eat" and "I try to eat healthy for my health later in life", with answering scales ranging from 1 = "totally disagree" to 7= "totally agree". The Cronbach's α was 0.87.

Perceived barriers were assessed with mean scores for the total of the thirteen statements: "Eating healthy costs too much time", "I have little time to prepare dinner", "I have little time for grocery shopping", "In the evenings I do not feel like cooking dinner", "I often do not have time to eat breakfast", "I do not have the time to consume

three meals a day", "I eat unhealthy because I am tempted to buy unhealthy foods", "I eat unhealthy because I like unhealthy foods too much", "I eat unhealthy because I fall into old habits", "I eat unhealthy because I do not know how to prepare healthy foods", "I eat unhealthy because I do not know which foods are healthy", "I eat unhealthy because I eat away from home" and "I eat unhealthy because someone else prepares the food". All statements were rated on a 7-point scale with answering scales ranging from 1 = "totally disagree" to 7 ="totally agree". The Cronbach's α was 0.74.

Assessment of dietary intake

A 160-item validated food frequency questionnaire[38] was used to assess daily food intake of the previous month at baseline and end of the study. Frequency of consumption was assessed with a scale ranging from "never or less than once per month" to "7 days a week". Number of servings was asked with serving sizes related to the foods or food groups. To estimate daily intake, we multiplied the intake per month with the reported serving sizes, which were converted into grams.

Fruit, vegetable and snack intake were obtained from specific items. Fruit intake was obtained from one item on fresh fruit. Total vegetable intake was obtained by summing the results of the three items on raw, boiled and stir-fried vegetables. Total snack intake was obtained by summing the items on cookies, cake, sweet pastry, chocolate, candy, fried and savoury snacks in-between meals.

Data analyses

Data analyses (IBM SPSS Statistics 21) were done for participants with complete data on both dietary intakes and its determinants (*n* 174).

The intervention effects on dietary intake and its determinants were examined by using ANCOVA with baseline values added as covariates. The determinants that significantly changed more in the intervention than in the control group were included as predictor variables in linear regression analyses with dietary intake as outcome measure. These analyses were adjusted for baseline measures of both outcome and predictor. If changes in the determinant were significantly associated with change in dietary intake these were included in mediation analyses. Mediation analyses were performed with the method of Preacher and Hayes,[39] via the PROCESS dialog box for SPSS.[40] PROCESS uses least squares and logistic regression-based path analytical frameworks for estimating direct and indirect effects of mediator models. We used 5000 bootstrap re-samples to construct the bias-corrected 95% CI around the mediated effects.[39] For the mediation analyses we used residuals calculated from the regression analyses of the previous step. Mediation was considered significant if the 95% confidence intervals from the indirect effect of the intervention on dietary intake did not include zero.

RESULTS

Intervention effects

Effectiveness of the intervention on dietary intake was evaluated by comparing changes between intervention group and control group (Table 4.1). On average, the participants in the intervention group increased their fruit intake with 40.5 (SD 19.2) grams, which was significantly more than in the control group (P = 0.010). Changes in vegetable and snack intake did not significantly differ between study groups.

Table 4.1 Baseline mean (SD) intakes of fruit, vegetables and snacks with mean changes (95% CI) within study groups and P-value for difference between groups.

	Intervention group (n 86)		Control group (n 88)		P-value for difference between groups
	Baseline mean (SD)	Mean change[a] (95% CI)	Baseline mean (SD)	Mean change[a] (95% CI)	
Fruit (g)	171.5 (108)	40.5 (21.6, 59.4)*	146.3 (103)	5.2 (-13.5, 23.8)	0.010
Vegetable (g)	188.3 (100)	39.9 (20.7, 59.2)*	172.8 (90)	19.0 (-0.1, 38.0)	0.129
Snacks (g)	73.2 (42)	-28.0 (-33.4, -22.1)*	72.6 (50)	-20.3 (-25.8, -14.7)*	0.063

[a] Mean changes were adjusted for baseline values. * P value <0.05

The effects of the intervention on the determinants of dietary intake are described in Table 4.2. With regard to consuming at least two pieces of fruit per day, the intervention group increased its scores for intention, attitude and habit strength more than the control group did. Further, the intervention group increased accessibility of vegetables at home more than the control group. The intervention also successfully increased the scores for intention and subjective norm to replace unhealthy snacks with healthy snacks. For the determinants assessed for healthy eating in general, scores for knowledge and self-identity, but not perceived barriers, increased more in the intervention group than in the control group.

Association between change in determinants and change in dietary intake

The associations between the successfully targeted determinants and improvements in dietary intake are described in Table 4.3. Increases in fruit intake were associated with changes in intention, attitude and habit strength with respect to eating two pieces of fruit per day, and general dietary knowledge. Changes in self-identity as a healthy eater were not associated with increases in fruit intake. For vegetables, none of the hypothesized determinants that were affected by the intervention were associated with increases in intake (i.e., home vegetable accessibility, self-identity as a healthy eater or general dietary knowledge). Further, decreases in snack intake were associated with changes in self-identity as a healthy eater, subjective norm to replace unhealthy snacks with healthy snacks and general dietary knowledge, but not with intentions to replace unhealthy snacks with healthy snacks.

Table 4.2 Baseline median and interquartile ranges (IQR) of determinant scores for fruit, vegetables and snacks with mean changes (95% CI) within study groups and *P*-value for difference between groups.

	Intervention group (*n* 86)		Control group (*n* 88)		
	Baseline median (IQR)	Mean change[a] (95% CI)	Baseline median (IQR)	Mean change[a] (95% CI)	*P*-value for differences between groups
Fruit					
Intention	6.0 (2.3)	0.82 (0.58, 1.06)*	5.0 (2.3)	-0.04 (-0.28, 0.20)	<0.001
Attitude	6.4 (2.1)	0.40 (0.23, 0.57)*	5.6 (2.4)	-0.12 (-0.29, 0.05)	<0.001
PBC	7.0 (1.0)	0.03 (-0.23, 0.28)	7.0 (1.0)	-0.16 (-0.42, 0.09)	0.300
Subjective norm	4.7 (2.0)	0.29 (0.07, 0.50)*	4.3 (1.9)	0.03 (-0.19, 0.24)	0.093
Habit	5.0 (2.8)	0.90 (0.66, 1.15)*	3.8 (2.9)	0.06 (-0.19, 0.30)	<0.001
Accessibility at home	8.0 (0.0)	0.08 (-0.43, 0.21)	8.0 (2.3)	-0.01 (-0.14, 0.11)	0.296
Vegetables					
Intention	6.0 (2.0)	0.33 (0.12, 0.54)*	6.0 (2.0)	0.07 (-0.14, 0.27)	0.079
Attitude	6.0 (2.1)	0.18 (0.00, 0.36)*	6.2 (2.2)	0.09 (-0.09, 0.27)	0.463
PBC	7.0 (1.0)	-0.14 (-0.37, 0.10)	7.0 (1.0)	-0.16 (-0.40, 0.07)	0.875
Subjective norm	5.0 (1.8)	0.19 (-0.05, 0.42)	4.5 (2.0)	0.14 (-0.09, 0.37)	0.784
Habit	5.5 (1.8)	0.21 (-0.04, 0.45)	5.5 (1.9)	0.08 (-0.16, 0.32)	0.446
Accessibility at home	7.0 (1.0)	0.42 (0.26, 0.60)*	7.0 (2.0)	0.12 (-0.05, 0.29)	0.012
Snacks					
Intention	5.0 (2.0)	0.57 (0.31, 0.84)*	5.0 (2.0)	0.11 (-0.14, 0.37)	0.014
Attitude	4.6 (1.4)	0.29 (0.07, 0.52)*	4.6 (1.6)	0.04 (-0.18, 0.26)	0.107
PBC	6.5 (1.5)	-0.02 (-0.23, 0.19)	6.5 (1.4)	-0.03 (-0.93, 1.39)	0.945
Subjective norm	4.7 (1.5)	0.24 (0.16, 0.45)*	4.7 (1.3)	-0.07 (-0.29, 0.14)	0.049
Habit	4.5 (1.8)	0.19 (-0.03, 0.41)	5.0 (2.3)	0.17 (-0.04, 0.39)	0.912
Accessibility at home	4.0 (2.3)	0.29 (0.06, 0.52)*	4.0 (3.0)	0.15 (-0.08, 0.38)	0.390
Knowledge	16.0 (2.0)	0.55 (0.30, 0.79)*	15.5 (2.0)	0.09 (-0.15, 0.33)	0.010
Self-identity	5.3 (1.1)	0.39 (0.26, 0.52)*	5.5 (1.0)	0.02 (-0.11, 0.15)	<0.001
Perceived barriers	2.6 (0.9)	-0.05 (-0.18, 0.08)	2.6 (1.0)	-0.02 (-0.15, 0.11)	0.747

Abbreviations: IQR= inter quartile range; PBC= perceived behavioural control.

[a] Mean changes were adjusted for baseline values.

* *P* <0.05

Table 4.3 Adjusted linear regression coefficients (*b*) with 95% CI of changes in successfully targeted determinants on changes in dietary intake.

	Fruit intake		Vegetable intake		Snack intake	
	b	95% CI	*b*	95% CI	*b*	95% CI
Intention	15.6	4.9, 26.3*	-	-	-0.7	-4.0, 2.5
Attitude	33.3	17.9, 48.7*	-	-	-	-
PBC	-	-	-	-	-	-
Subjective norm	-	-	-	-	-	-
Habit	27.2	16.9, 37.6*	-	-	-	-
Accessibility at home	-	-	14.1	-2.7, 30.1	-	-
Knowledge	12.2	0.6, 23.8*	2.6	-9.2, 14.4	0.3	-3.2, 3.7
Self-identity	19.9	-1.2, 41.0	9.1	-12.2, 30.6	-17.3	-22.9, -11.4*
Perceived barriers	-	-	-	-	-	-

Abbreviations: PBC = perceived behavioural control.
* *P* <0.05.

Mediators of change in dietary intake

Mediation analyses were performed to examine whether improvements in dietary intakes were mediated through changes in determinants. Two determinants for fruit intake, one determinant for snack intake, but none for vegetable intake, were found to be mediators. Changes in attitude (ES -14.9, 95% CI -28.9, -6.0) and habit strength (ES -18.4, 95% CI -32.3, -8.6) with respect to eating two pieces of fruit per day mediated increases in fruit intake. Furthermore, changes in self-identity as a healthy eater (ES 6.0, 95% CI 2.4, 11.9) mediated decreases in snack intake.

DISCUSSION

In this study, the mediators of change in dietary intake were investigated in a counselling intervention to improve participants' adherence to the Dutch dietary guidelines. The purpose was to identify changes in determinants that were important for establishing improvements in dietary intake. The intervention successfully achieved changes in eight determinants, but only three determinants mediated improvements in dietary intake. Changes in attitude and habit strength with respect to eat two pieces of fruit a day mediated increases in fruit intake and changes in self-identity as a healthy eater mediated decreases in snack intake. No mediators for vegetable intake were identified.

The results showed that changes in attitude towards eating two pieces of fruit per day, mediated changes in fruit intake. We investigated attitude because many observational studies have shown that attitude is an important predictor of fruit intake.[19, 21, 41] Thereby, our results are consistent with the findings of the study evaluating the Maryland WIC 5 a Day Promotion Program in which attitude towards fruit in the family setting was found to be a mediator of increases in fruit intake.[13]

Changes in habit strength, which was defined as repetition and automaticity of eating two pieces of fruit per day, mediated changes in fruit intake. To our knowledge, the present study is the first investigating habit strength to be a potential mediator for changes in dietary intake. The finding that changes in habit strength are associated with changes in fruit intake is consistent with observational data on the importance of habit strength for fruit intake.[21, 42] Our findings also confirm that it is important to investigate habit strength as determinant of fruit intake, next to the determinants of the TPB.[21] Although we find support for habit strength as a mediator, it should be noted that previous studies also found habit strength to be a moderator of the intention-behaviour relation.[23] Because we are not aware of other studies evaluating the mediating effect of habit strength on change in dietary intake, future studies on this effect are warranted.

Changes in self-identity mediated the relationship between intervention and snack intake. Thus, the intervention made participants view themselves more as someone who eats healthy and by this snack intake was decreased. Although we are not aware of any other studies investigating changes in self-identity on changes in dietary intake, observational studies have shown that self-identity is associated with the intention of having a low-fat diet, healthy eating and dieting behaviour.[28] Thereby, our results confirm the suggestion of Rise and colleagues that self-identity may be a distinct target for persuasive strategies to change behaviour.[28] However, more studies are warranted to be able to conclude on the effect of self-identity on snack intake. Interestingly, self-identity did not mediate changes in fruit and vegetable intake. It could be that participants do consider the removal of unhealthy foods from their diet more of an expression of their identity as a healthy eater than adding healthy foods.

The results showed that although the intervention was successful in changing intention to eat fruit or snacks and general dietary knowledge, these changes were not sufficient to result in improved dietary intake. This finding that the intervention affected intention, but that intention was not a mediator, was also found in a study on the short-term efficacy of a web-based computer-tailored nutrition intervention to improve intakes of fruit, vegetables and fat.[43] Also, previous studies demonstrated that in many cases intentions do not translate into behaviours.[44] Our finding that general nutrition knowledge was not mediating change in dietary intake is in contrast with the results of other studies where knowledge was found to be

a mediator of changes in fruit and vegetable intake.[13, 16] These studies aimed at low-income populations that were more likely to have little knowledge about healthy nutrition. The highly educated population in the present study already had a high level of knowledge at the start of the study. Thus, knowledge may still be potentially important for establishing behaviour change, but only when there is sufficient room for improvement.

It should be noted that the intervention was not effective in improving perceived behavioural control for the three dietary behaviours. This may be explained by the low correlation between the two questions for assessing this determinant for both fruit and snack intake (Spearman-Brown coefficient <0.70). However, this finding might as well illustrate a ceiling effect. The participants' median scores were almost maximal at pre-test and little room for further improvement was left.

The present study is one of the few studies evaluating determinants of behaviour as mediators of change in a nutrition intervention. It confirms the suggestion that attitude is a potential mediator for fruit intake and it suggests new determinants that are potentially important for establishing change in dietary intake. Nevertheless, our study was also subject to some limitations. First, the intervention was performed in a highly educated, mainly female population. This population had a healthier dietary intake than the general Dutch population[45] and had high median scores for the determinants already at the start of the intervention. It is unknown whether the findings of the present study would be similar in a population with more men or lower educational levels. Second, the counselling intervention was aimed to improve adherence to the Dutch guidelines for a healthy diet, which includes more than just intakes of fruit, vegetables and snacks. Participants received individually tailored advice to improve adherence guidelines that were important for that individual and it might be that they did not receive counselling for fruit, vegetable or snack intake. This is a potential reason why we did not find significant differences in improvements in vegetable and snack intakes between intervention and control group. Thereby, this may explain why the intervention was not effective in establishing change in the majority of the determinants of vegetable and snack intake. We did not have the resources to evaluate determinants of the other behaviours at which the intervention was aimed, and therefore we only have the results on a part of the determinants targeted in this nutrition counselling intervention. Third, the assessment of dietary intake and determinants relied on self-report. Although we used reliable methods to assess variables of interest, the results could have been influenced by social desirability of answers. This may have led to an overestimation of fruit and vegetable intake[46] and a systematic difference in reporting of dietary intake between intervention and control group.[47] Last, we cannot prove causality of the mediating effects, as the determinants and dietary intake were measured at a similar point in time.[16] It is possible that the changes in dietary

intake were established before the changes in determinants took place. To conclude on causality, future studies should preferably include multiple measures of determinants and dietary intake throughout the intervention period.

CONCLUSIONS

This study is one of the few studies that have examined the mediators of nutrition interventions to improve dietary intake. It was found that the counselling intervention effectively addressed several determinants in a highly educated, mainly female population. The increases in fruit intake were mediated by changes in attitude and habit strength, and decreases in snack intake by a reinforced self-identity as a healthy eater. These results suggest that it is important to aim nutrition counselling at the determinants attitude, habit strength and self-identity to effectively change dietary intake. Nevertheless, further well-designed evaluation studies are needed to confirm that these determinants are important mediators of change in dietary intake in other settings.

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CHAPTER 5

Evaluation of using spot urine to replace 24 h urine sodium and potassium excretions

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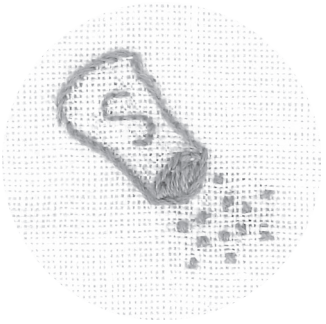

ABSTRACT

Objective: The most accurate method to estimate sodium (Na) and potassium (K) intakes is to determine 24 h urinary excretions of these minerals. However, collecting 24 h urine is burdensome. Therefore it was studied whether spot urine could be used to replace 24 h urine samples.

Design: Participants collected 24 h urine and kept one voiding sample separate. Na, K and creatinine concentrations were analysed in both 24 h and spot urine samples. Also 24 h excretions of Na and K were predicted from spot urine concentrations using the Tanaka and Danish methods.

Setting: In 2011 and 2012, urine samples were collected and brought to the study centre at Wageningen University, the Netherlands.

Subjects: Women (*n* 147) aged 19-26 years.

Results: According to p-aminobenzoic acid excretions, 127 urine collections were complete. Correlations of Na:creatinine, K:creatinine and Na:K between spot urine and 24 h urine were 0.68, 0.57 and 0.64, respectively. Mean 24 h Na excretion predicted with the Tanaka method was higher (difference 21.2 mmol/d, $P < 0.001$) than the measured excretion of 131.6 mmol/d and mean Na predicted with the Danish method was similar (difference 3.2 mmol/d, $P = 0.417$) to the measured excretion. The mean 24 h K excretion predicted with the Tanaka method was higher (difference 13.6 mmol/d, $P < 0.001$) than the measured excretion of 66.8 mmol/d. Bland-Altman plots showed large individual differences between predicted and measured 24 h Na and K excretions.

Conclusions: The ratios of Na:creatinine and K:creatinine in spot urine were reasonably well associated with their respective ratios in 24 h urine and appear to predict mean 24 h Na excretion of these young, Caucasian women.

BACKGROUND

A high intake of sodium (Na) and a low intake of potassium (K) are both associated with increased risks for elevated blood pressure, cardiovascular disease and all-cause mortality.[1,2] Decreasing Na intake and increasing K intake could contribute to the prevention of hypertension[3] and therefore has the potential to reduce risk of cardiovascular disease. Although much research has been conducted on improving dietary intake of Na, people still have a higher Na intake than the recommended amount of 2 g/d.[4, 5] High intakes are explained mainly by contributions of salt from processed or restaurant-prepared foods.[5] For K, the majority of the European women do not comply with the dietary recommendation of at least 3510 mg/d.[6, 7] K intakes may be increased by consuming diets high in fresh fruits and vegetables.[6] These undesirable population intakes of Na and K indicate that new interventions are needed. Easy and reliable methods for monitoring and evaluating effects of these interventions are of interest.

To assess intakes of Na and K, self-reports of dietary intake or 24 h urine collections can be used.[8, 9] Because self-reports are subjective and prone to errors, the most accurate method is to determine excretions of Na and K in 24 h urine. Unfortunately, collecting 24 h urine samples is a burdensome task, which might lead to incomplete collections.[10, 11] Therefore, it would be much more convenient if Na and K concentrations in single urine samples, so-called spot urine samples, could be used as indicators of 24 h Na and K excretions.

The use of spot urine to replace 24 h urine collection has been studied for both Na and K in healthy populations, although most research has focused exclusively on Na.[10-16] Studies have shown good correlations between Na:creatinine and K:creatinine in spot urine and respective ratios in 24 h urine.[12, 14, 16] In addition, Brown and colleagues showed that β coefficients derived from regression analyses of spot urine samples versus 24 h urinary Na excretions can be used to predict 24 h excretions with reasonable accuracy.[15] These results indicate that spot urine has the potential to replace 24 h urine in epidemiological studies.

Also, methods to predict 24 h Na and K from spot urine have been evaluated.[12-14, 17] Tanaka and colleagues developed a method to predict both 24 h Na and K excretions from a spot urine sample and a Danish method was developed to predict only Na excretions.[12, 13] With these methods, 24 h excretions are estimated from the Na:creatinine or K:creatinine ratios in spot urine and the predicted 24 h creatinine excretion. The predicted 24 h creatinine excretion is derived from an individual's age, body weight and height. As these prediction methods have been developed in specific populations and include individuals' characteristics, the methods might not perform similarly in different populations. To our knowledge, evaluation of these methods is limited to Asian and Danish populations.

Until now, there is still not enough evidence on the reliability of Na and K excretion from spot urine collections to replace 24 h urine collections for monitoring populations on adherence to a healthy diet.[16] Therefore, the associations between Na and K excretions in spot urine and 24 h urine in healthy, young, Caucasian women were investigated. We also studied the accuracy of predicting 24 h levels of urinary Na and K excretions from spot urine samples using the Tanaka and Danish methods. Based on literature, it was expected to find correlations in a range of 0.50 to 0.80 between Na concentrations in spot and 24 h urine.[16] Thereby, it was hypothesized that 24 h Na excretions can be predicted with reasonable accuracy from spot urine samples. It was assumed that the Danish[13] method would perform better in young, Caucasian women than the Tanaka method[12] because the Danish method was developed in a European population and includes gender-specific equations. For K, we did not have clear expectations since spot urine K has only been studied in a Japanese population.[12]

METHODS

Participants

The participants were students taking a course on nutritional research methodology at Wageningen University. In May 2011 and in May 2012 respectively, ninety-eight and ninety-seven students took part in the course, 160 of whom provided 24 h urine and spot urine collections. Because of the small number of men (*n* 13), only the data of the 147 women were used, of whom 138 reported birth date, height and weight.

Urine collection

Students were requested to collect 24 h urine in a 3-litre jug except for one spot urine sample, which the participants collected in a 500-ml jug. Collection of 24 h urine started after the first voiding in the morning and ended after the first voiding on the morning of the following day. Within these 24 h, participants were allowed to select any time for collection of spot urine except for the first morning urine, because of lower urinary Na and K excretions during the night.[18] Participants recorded time of spot urine collection, whether 24 h urine collection was incomplete and the use of specific medication or supplements that might interfere with the laboratory analysis. Urinary excretions of p-aminobenzoic acid (PABA) were used to check for completeness of 24 h urine collections.[19] For this purpose participants took a tablet containing 80 mg PABA at three occasions i.e. breakfast, lunch and dinner.

Chemical analysis

Participants brought both urine jugs to the laboratory of the Division of Human Nutrition of Wageningen University. The jugs were weighed and after homogenization of the contents,

two 4-ml urine samples were taken from each jug that were immediately frozen and kept at -20 °C. Thereafter, the empty jugs were weighed to calculate the net weight of the collected urine. Urinary Na and K were determined by an ion-selective electrode on a Synchron LX20 analyzer (Beckman coulter, Mijdrecht, The Netherlands). Urinary creatinine concentrations were determined at 520 nm on the Synchron LX20 by the modified Jaffé procedure using a commercial kit. PABA was determined with two different methods. In 2011, the colorimetric diazocoupling method[19] was used to determine the total aromatic amines derived from PABA and its metabolites by means of UV-visible spectrophotometry at 540 nm (Jasco V-530 UV/VIS spectrophotometer, Jasco Inc., Easton, MD, USA). In 2012, high-performance liquid chromatography (HPLC)[20] was used to quantify the peak area of PABA. The HPLC system (Thermo Separation Products Spectra; Thermo Scientific Inc., Waltham, MA, USA) was equipped with a binary pump (model P2000), a solvent degasser (model SCM400), a temperature controlled auto sampler (model AS3000), a UV-visible forward optical scanning detector (model UV3000), and control and integration software (Chromquest 5.0).

Check using p-aminobenzoic acid

The 24 h PABA excretions were calculated by adding the amount of PABA determined in the spot urine to the amount of PABA determined in the 3-litre jug. Seven women had PABA recoveries below the cut-off value of 85% for colorimetric assay[19] and three women had PABA recoveries below the cut-off value of 78% for HPLC.[20] The data of these ten women and ten women who reported having incomplete urine collections were excluded from data analyses.

Predicting 24 h Na and K excretion

Both the Tanaka method and the Danish method were used to predict 24 h Na excretions and only the Tanaka method could predict K excretions.[12, 13] The method of Tanaka was developed using urine collections of 591 Japanese participants aged 20-59 years, of whom 50% were women.[12] Participants collected spot urine just before starting 24 h urine collection. Participants were interviewed to assess whether 24 h urine collections were complete. Na and K concentrations were determined by emission flame photometry and creatinine concentrations by the Jaffé method. The Danish method was developed using urine collections of 473 Danish participants aged 28-74 years, of whom 78% were women.[13] Spot urine was collected on a separate day within two weeks of the 24 h urine collection. Complete 24 h urine collections with PABA recoveries of 78% or more determined with HPLC were included. Na and creatinine concentrations were determined using Na and creatinine slides and Vitros Chemistry Products calibrator kits on a Vitros 250 chemistry system.

The prediction methods were developed in two steps.[12, 13] First, regression analysis was used to predict 24 h urinary creatinine excretions from age, sex, weight and height. Then a second

regression analysis was performed to predict 24 h Na or K excretions. For this analysis, the 24 h urinary excretions were used as outcome measures and the Na:creatinine or K:creatinine, predicted 24 h urinary excretions of creatinine, age, weight and height as independent variables. The equations were transformed into the natural logarithm and the final model was obtained by using the exponential function. This led to the following equations:

$$PRCr = c1 \times age\ (years) + c2 \times weight\ (kg) + c3 \times height\ (cm) - c4$$

and

$$PRNa = c5 \times (SUNa/SUCr \times PRCr)^{c6},$$

where PRCr = predicted 24 h creatinine excretion (mg/24 h), c1 to c6 are coefficients differing between methods and between minerals,[12, 13] SUNa = spot urine Na (mmol/l), SUCr = spot urine creatinine (mg/l) and PRNa = predicted 24 h Na excretion (mmol/24h). In the Tanaka method spot urine Na is replaced by spot urine K to predict 24 h K excretion.

Data analyses

Data were analysed with IBM SPSS statistics version 20. From weight and height BMI in kg/m^2 was calculated. Pearson correlation coefficients between spot and 24 h urine were estimated for ratios of Na:creatinine, K:creatinine and Na:K in participants with complete urine collections (*n* 127). Predictions of 24 h Na and K excretion were only done for participants with complete data on age, weight and height, and complete urine collections (*n* 118). Student's t test was used to test for mean differences between the measured and predicted 24 h Na and K excretions based on spot urine samples. Two-tailed probability levels for statistical test were reported and $P < 0.05$ was considered to be statistically significant. To evaluate individual differences Bland-Altman plots were made, in which the differences between the predicted and measured 24 h Na or K excretions were plotted against the average of the two methods.[21] Regression analyses were done to obtain equations estimating 24 h urinary Na and K excretions based on spot urine Na or K concentrations, spot urine creatinine concentrations, BMI and age.

RESULTS

Participants were aged between 19 and 26 years (Table 5.1). The mean weight of the 24 h urine was 1820 (SD 645) grams and the mean weight of the spot urine samples was 250 (SD 125) grams. Five participants collected their spot urine samples in the morning (07.00 to 12.00 hours), 100 participants in the afternoon (12.00 to 18.00 hours) and thirty-four participants in the evening (18.00 to 24.00 hours). The remaining eight participants did not report the time of spot urine collection.

Table 5.1 Descriptive characteristics of the participants; women (*n* 138[a]) aged 19-26 years, Wageningen, the Netherlands.

Characteristic	Mean	SD
Age (years)	20.2	1.1
Height (cm)	171.3	6.7
Weight (kg)	63.1	7.8
BMI (kg/m^2)	21.5	2.3

[a] Number includes only those women with data on birth date, height and weight.

The correlations between Na:creatinine, K:creatinine and Na:K in spot urine and those in 24 h urine were 0.68, 0.57 and 0.64 respectively (for all correlations $P < 0.001$).

The mean predicted and measured 24 h Na and K excretions are presented in Table 5.2. The mean 24 h Na excretion predicted with the Tanaka method was 21.2 mmol higher ($P < 0.001$) than the measured 24 h Na excretion. The prediction of mean 24 h Na excretion with the Danish method was not significantly different from the measured excretion ($P = 0.417$). The estimated mean 24 h excretion of K, only predicted with the Tanaka method, was 13.6 mmol lower ($P < 0.001$) than the measured excretion. Finally, the measured 24 h creatinine was overestimated by the Tanaka method ($P < 0.001$) and underestimated by the Danish method ($P = 0.004$).

The Bland-Altman plots (Fig. 5.1) showed that the limit of agreement were -98 to 56 mmol/d for Na predicted with the Tanaka method and -87 to 80 mmol/d for Na predicted with the Danish method. For K, the limits of agreement were -26 to 53 mmol/d predicted with the Tanaka method. In addition, the plots show an increasing underestimation of 24 h Na excretions predicted from spot urine samples with increasing measured 24 h Na excretions.

Regression analyses provided equations for Na and K excretions (Table 5.3). The β for spot urine Na was 0.53 (95% CI 0.34, 0.71) and the β for spot urine K was 0.54 (95% CI 0.29, 0.78). Age did not significantly contribute to the regression model and was therefore excluded.

Table 5.2 Comparison of 24 h levels of sodium, potassium and creatinine measured in 24 h urine and predicted from spot urine with the Tanaka[12] or Danish[13] prediction method; women (*n* 118) aged 19-26 years, Wageningen, the Netherlands.

	Measured 24 h urine		Tanaka prediction method		Danish prediction method[a]	
	Mean	SD	Mean or Mean difference or Correlation coefficient	95% CI	Mean or Mean difference or Correlation coefficient	95% CI
Na, mmol/d[b]	131.8	50.9	153.1	37.4	135.0	16.6
Mean difference[c] (measured-predicted)	-	-	-21.2	-28.4, -14.1	-3.2	-10.9, 4.6
Correlation coefficients[d] (measured/predicted)	-	-	0.64	-	0.62	-
K, mmol/d[a]	66.8	24.8	53.2	12.5	-	-
Mean difference[b] (measured-predicted)	-	-	13.6	9.9, 17.3	-	-
Correlation coefficients[c] (measured/predicted)	-	-	0.58	-	-	-
Creatinine, mmol/d[a]	11.7	2.2	12.5	1.7	11.2	0.8
Mean difference[b] (measured-predicted)	-	-	-0.8	-1.2, -0.5	0.5	0.2, 0.9
Correlation coefficients[c] (measured/predicted)	-	-	0.49	-	0.53	-

[a] The Danish method does not provide coefficients to predict K.
[b] Data presented are means and standard deviations.
[c] Data presented are mean difference with 95% confidence intervals.
[d] Data presented are correlation coefficients; all *P*-values < 0.001 (two-tailed)

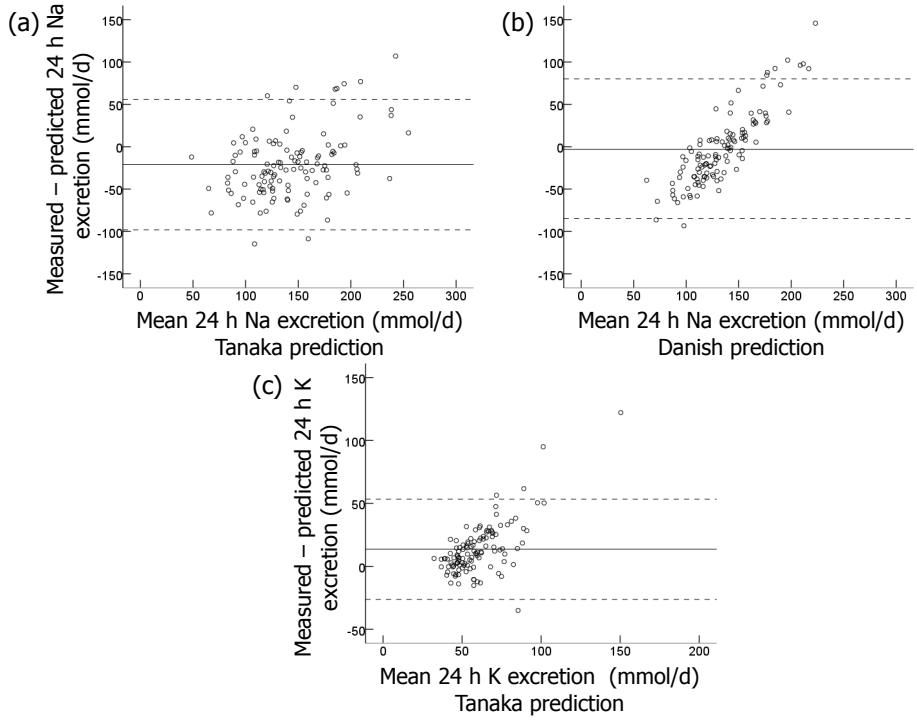

Figure 5.1 Bland-Altman plots showing differences between the measured and predicted 24 h sodium or potassium excretions plotted against the mean of the two methods: (a) sodium excretion and Tanaka prediction; (b) sodium excretion and Danish prediction; (c) potassium excretion and Tanaka prediction. ——— indicates the mean bias; — — indicates the 95% limits of agreement.

Table 5.3 Results of the linear regression models of the association between 24 h sodium and potassium with spot urine sodium or potassium, spot urine creatinine and BMI; women (*n* 118) aged 19-26 years, Wageningen, the Netherlands.

	Na[a]		K[b]	
Variable	β	95% CI	β	95% CI
Intercept	12.08	-64.91, 89.06	47.76	0.09, 95.43
Spot urine Na (mmol/l)	0.53	0.34, 0.71	N/A	N/A
Spot urine K (mmol/l)	N/A	N/A	0.54	0.29, 0.78
Spot urine creatinine (mmol/l)	-4.21	-5.77, -2.65	-2.67	-3.92, -1.42
BMI (kg/m^2)	5.23	1.67, 8.79	0.66	-1.51, 2.83

N/A, not applicable.
[a] adjusted R^2= 0.28.
[b] adjusted R^2= 0.14.

DISCUSSION

It was studied whether excretions of Na and K in spot urine samples could be used as indicators of 24 h urinary Na and K excretions, and thus of intake, in healthy, young, Caucasian women. The present study showed good correlations between Na:creatinine, K:creatinine and Na:K in spot urine and 24 h urine. The Danish method provided a reasonably accurate estimate of mean 24 h Na excretion from spot urine samples. However, the Tanaka method presented less accurate estimates for both Na and K. The Bland-Altman plots showed large limits of agreement, indicating substantial individual differences between the predicted and measured 24 h Na and K excretions. Regression analyses presented significant contributions of BMI, spot urine creatinine and spot urine Na or K to 24 h urinary excretions of Na or K.

The observed correlations of 0.68 for Na:creatinine and 0.57 for K:creatinine between spot and 24 h urine are comparable to those of 0.65 and 0.67 found by Tanaka and colleagues.[12] Thereby, the correlations are in the range of 0.50 to 0.80 as hypothesized.[16] The observed β coefficients of 0.53 and 0.54 for spot urine Na and K, respectively, are higher than the β of 0.34 for spot urine Na that Brown and colleagues found in women.[15] Based on these findings, we suggest that the order of individuals according to both ratios and levels of Na and K in spot urine is similar to the respective ratios in 24 h urine. Therefore, ratios of Na and K in spot urine can be useful to monitor intake and assess adherence to a healthy diet.

The use of spot urine to predict mean 24 h Na and K excretions of populations was also evaluated. The measured mean Na excretion of 3035 mg/d, equals a salt intake of about 8.2 grams when assuming a urinary Na excretion of 95%.[10] Consequently the women in the present study exceeded the maximum recommended salt consumption of 5 g/d;[4] nevertheless their Na consumption is comparable to those of other Caucasian women.[5] The Tanaka method overestimated the mean Na excretion by 16% and the Danish method more accurately estimated Na as compared to the measured excretion. These findings indicate that the Danish prediction method is the preferred method in the present study population.

The mean K intake was 3383 mg/d, when assumed that 77% of the K is excreted in urine.[22] The mean intake is thus slightly lower than the recommended intake level,[6] nevertheless the intake is comparable to those in European women.[7] With the Tanaka method a 20% underestimation of mean 24 h K excretion was found, which is higher than the 8% underestimation that Tanaka and colleagues found. These results indicate that it was not possible to accurately predict 24 h K excretion.

The results of the present study indicate that spot urine Na and K excretions have the potential to replace 24 h urine samples on population level. First, the advantage of using Na:creatinine, K:creatinine and Na:K to place individuals in order is that the data can be used

without using regression or prediction models. However, ratios might be more difficult to interpret than levels. Second, developing a regression model on data of a part of the study population provides estimates of 24 h Na and K excretions and will have the best fit on those specific data. The disadvantage is that additional 24 h urine samples are needed from a subpopulation. Third, using the Tanaka or Danish prediction methods provides 24 h Na or K estimates without collecting 24 h urine, but these methods may not provide the best estimate for all study populations.

The wide limits of agreement of the Bland-Altman plots indicate that spot urine cannot be used to accurately predict 24 h Na and K excretions of individuals.[21] These wide limits could be expected since spot urine represents Na and K excretions at one point in time. Excretions are influenced by circadian rhythms and are directly related to intake from meals and exercise; therefore, they excretions are not constant within 24 hours.[14, 23] Also other studies indicated that spot urine samples cannot be used to predict 24 h Na and K excretions of individuals.[12,13,23]

The Bland-Altman plots showed that with increasing levels of measured 24 h Na excretion both prediction methods had a tendency to increase underestimation. This excretion-related underestimation was also shown in the studies of Tanaka et al. and Toft et al.,[12, 13] which indicates that for populations with higher mean 24 h excretions of Na, e.g. populations including men, the prediction methods might become less accurate.

The Danish prediction method gave more accurate results for estimating 24 h Na excretion than the Tanaka method. First of all, this might be due to the comparability of the mean Na excretions between the investigated populations. In the present population a mean excretion of 132 mmol/d was observed which was closer to the mean excretion of 139 mmol/d in the Danish women[13] than to the 187 mmol/d in the Japanese population.[12] Second, the present study only included women. It is known that Na and K intakes[24] and creatinine excretions[25] are gender dependent and therefore the Danish method including gender-specific equations might have performed better than the Tanaka method that combined values for men and women.

The PABA concentrations in the urine samples were measured with two different methods: the colorimetric diazocoupling method and HPLC. The first method might lead to higher estimated PABA excretion by co-determination of aromatic enzymes, whereas the second method might lead to lower estimated PABA excretion because not all PABA metabolites in the urine are converted to PABA.[19, 20, 26] However, differences in estimation between the methods were taken into account by using the method-specific cut-off values for completeness of urine collection. It is expected that the use of two different methods for PABA analyses did not affect the results.

The strength of this study is that it adds evidence to the limited number of studies investigating the association between spot and 24 h urine Na and K excretions in healthy participants,[16] especially as our study is the first in reporting findings in healthy, young, Caucasian women. However, the study also had some limitations. First, due to the small sample size it was not possible to develop and test regression models to predict 24 h Na and K excretions. Second, this study was conducted in generally healthy, young, Caucasian women and therefore the outcomes cannot be generalized to other populations. Populations with different age, body weight and height might provide a different accuracy of the prediction methods. Third, the effect of timing of spot urine collection was not evaluated. This might be of major importance as Na and K excretions vary considerably during the day.[23]

There is a growing body of literature on the use of spot urine collections to replace 24 h urine collection. This indicates that there is a need for methods that are less burdensome for participants. Although the spot urine method associates well with the 24 h method, it is not as accurate as the 24 h urine collection method to estimate daily Na and K excretions. Thus, the 24 h urine collection method remains the preferred tool. To reduce the burden of 24 h urine collection for participants, and at the same time increasing the accuracy of estimating daily Na and K intake, we suggest examining the association between multiple spot urine collections and 24 h urine collections in future studies.

CONCLUSION

In conclusion, the ratios Na:creatinine, K:creatinine and Na:K in spot urine samples were reasonably well associated with the respective ratios in 24 h urine samples in young, Caucasian women and may be useful to evaluate intake of these minerals as replacement of 24 h urine collection. Also, spot urine samples can be used to predict mean 24 h Na excretion of this population with reasonable accuracy using the Danish prediction method.

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CHAPTER 6

General discussion

A majority of Dutch adults and children have unhealthy dietary patterns which may lead to higher risks for chronic diseases.[1, 2] Thus it is important to improve the dietary patterns of both adults and children. As parents' modelling of dietary behaviour is one of the factors influencing children's diets,[3] improving parents' diets potentially also results in improved dietary intake of their children.

This thesis describes research that was conducted to develop and evaluate a nutrition counselling intervention for parents to improve their adherence to the Dutch guidelines for a healthy diet.[4] The intervention was theoretically underpinned by the theory of planned behaviour[5] and the transtheoretical model of behaviour change.[6] Dietary counselling was provided in five standardised face-to-face sessions by registered dieticians via motivational interviewing.[7] In addition, parents received three individually tailored email messages. The intervention was evaluated in a randomised controlled trial with 92 parents receiving the counselling and 94 parents as controls. The primary outcome of the trial was overall improvement in parental adherence to the dietary guidelines i.e. diet quality. Secondary outcome measures were changes in intermediate markers of health and children's dietary intake. In addition, we investigated via what determinants of behaviour improvements in dietary intake were established. This thesis also includes research about eating behaviours in relation to diet quality in order to identify behaviours that are potentially important in establishing healthy diets and which could be addressed in dietary counselling. Thereby, we evaluated if we could replace 24 h urinary sodium and potassium excretions, the most objective marker for sodium and potassium intake, with spot urine samples that are less burdensome to collect.

In this chapter the main findings of this thesis are summarised and the corresponding methodological considerations are discussed. Furthermore, implications for practice and suggestions for future research are described. The overall conclusion will close the chapter.

MAIN FINDINGS

The effects of the nutrition counselling intervention on dietary intake and secondary outcome measures are described in Chapter 3. The parents in the intervention group successfully improved their adherence to the Dutch dietary guidelines with 7.8 points as measured with the Dutch Healthy Diet-index (DHD-index).[8, 9] This improvement was significantly greater than the change of 1.1 points in the control group. The change in dietary score that we observed is comparable to the changes observed in other studies evaluating the effects of nutrition counselling on overall diet quality.[10, 11] The increase in overall diet quality was considered substantial as comparable changes in fruit, vegetable and fish consumption have

shown associations with lower health risks.[12, 13] Because the increase in total DHD-index score was achieved by small increases in seven components, we conclude that the intervention was effective in changing multiple components. The most substantial changes in component scores were shown in the components fruit and fish. The increases in fish intake were supported by higher percentages of fish fatty acids in relation to total fatty acids in blood plasma. The changes in self-reported overall dietary intake were reflected in decreases in waist circumference, but not in improvements in the other intermediate health outcomes. Besides improvements in parental dietary intake, we also observed improvements in children's intakes of fruit, vegetables and fish in the intervention group as compared to controls. These results indicate that the intervention for parents was effective in changing food intake of their children. However, for children's dietary intake we relied on parental reports of only a few foods, which may not be representative of overall diet quality.[14] Thus, we conclude that the counselling intervention effectively improved overall diet quality of the parents and that the intervention also seemed to have improved the food intake of their children.

In Chapter 4 we describe the results of a study in which we investigated via what determinants of behaviour the intervention improved parental dietary intake. For this purpose, we investigated the determinants of behaviour derived from the theory of planned behaviour[5] and determinants that complement this theory.[15, 16] These determinants were intention, attitude, subjective norm, perceived behavioural control, habit strength and home food accessibility for intakes of fruit, vegetables and snacks. Also self-identity, knowledge and perceived barriers for healthy eating in general were included.[17] To evaluate these determinants, we asked the participants to answer questions that were based on validated items of other questionnaires.[5, 15, 18-22] In general, the items relating to a specific determinant showed good internal consistency. After the intervention ended, intention, attitude and habit strength for fruit intake changed more in the intervention group than in the control group. For vegetable intake, home accessibility of vegetables improved. For snack intake, scores for intention and subjective norm increased. Knowledge and self-identity also changed more in the intervention group than in the control group. Only three of these determinants were mediators of improvements in dietary intake. Improvements in fruit intake were mediated by changes in attitude and habit strength. Decreases in snack intake were mediated by changes in self-identity as a healthy eater. Thus, changes in attitude, habit strength and self-identity as a healthy eater were likely to be involved in establishing changes in dietary behaviour by our nutrition counselling intervention. Because we are one of the first investigating these determinants, we cannot conclude on the generalizability of these effects. Nevertheless this research provides valuable knowledge that can be used in the development of effective nutrition interventions.

To obtain more knowledge about behaviours that are important for dietary counselling, it was investigated if selected eating behaviours were associated with the DHD-index and the results are described in Chapter 2. For this purpose, we used the data from 24 h recalls from 2055 adults in the Dutch national food consumption survey of 2010. It was observed that breakfast skipping by women and having dinner away-from-home by both sexes were associated with lower adherence to the Dutch dietary guidelines. For soft drink consumption and snacking no associations with lower diet quality were observed. Unexpectedly, soft drink consumption was associated with higher DHD-index scores in men and these higher scores were mainly explained by lower alcohol intakes. Because soft drink consumption is associated with higher intakes of energy and sugar,[23] we still perceive soft drink consumption a potential factor for lower diet quality. For snacking it was impossible to draw conclusions as our results differed from those of other studies, which was partly due to differences in definition of snacking.[24] Although breakfast skipping and dinner away-from-home were significantly associated with diet quality, they only explained a small part of the variance in diet quality. These results might indicate that other factors are more important in establishing healthy dietary intake. Nevertheless, since breakfast skipping and having dinner away-from-home were associated with lower adherence to the dietary guidelines, it may be valuable to address these eating behaviours, amongst others, during dietary counselling.

The effects of the nutrition counselling intervention on intakes of sodium and potassium were evaluated with single urine samples, also named spot urine samples. The decision to use the spot urine samples was based on the results described in Chapter 5. In this chapter we evaluated if collection of 24 h urine samples, the most objective measure for estimating sodium intake, could be replaced with the spot urine method which is less burdensome for participants. The results showed that ratios of sodium to creatinine can be used to predict mean 24 h sodium excretion of young, Caucasian women. We also found that ratios of sodium to potassium in spot urine were reasonably well associated with their respective ratios in 24 h urine. Therefore, spot urine can be used to rank individuals based on their ratios of sodium to potassium.

METHODOLOGICAL CONSIDERATIONS

In this section, we discuss a few important methodological issues for the research that we conducted. This includes discussion of general aspects related to the theoretical underpinning and the development of the counselling intervention, intervention implementation, study population, randomisation and possible effects of the selected outcome measures on the results.

Parents as role models for their children

It was hypothesized that by improving dietary intake of the parents, also the dietary intake of their children would improve. This hypothesis was based on the knowledge that modelling of eating behaviours by parents is reflected in children's dietary patterns.[25, 26] However, modelling is not the only pathway via which dietary behaviours of children are established. Children's individual characteristics, parenting styles, feeding practices, and food availability and accessibility also play a role in children's eating behaviours.[3, 27] Thus, interventions aiming at more factors influencing children's dietary behaviours are expected to result in even greater improvements than the improvements in children's food intake that we observed.

Overall dietary intake and eating behaviours

We aimed to improve the dietary pattern as a whole because foods are merely consumed in combinations and not as single items. Thereby the whole diet has shown considerable associations with the occurrence of chronic diseases.[28, 29] We have shown that with nutrition counselling, substantial changes in overall diet quality can be established on population level. Nevertheless, changes in overall diet quality were not supported by changes in most intermediate health outcomes. This may indicate that the mean changes in the individual diet quality components were too small to observe changes in the concurring health outcomes on short term. This may also indicate that there was too little room for improvements in intermediate health outcomes of the selected study population. Thus in our study we were not able to show improvements in health, however, changes in dietary intake of this magnitude are still hypothesized to reduce the risks for chronic diseases.[12, 13]

The dietary counselling was not only aimed at the dietary guidelines, but also at eating behaviours that potentially affect diet quality. The four investigated eating behaviours 'breakfast skipping', 'having dinner away-from-home', 'soft drink consumption' and 'snacking' only explained a small part of the variance in DHD-index. Nevertheless, the results showed that skipping breakfast and having dinner away-from-home were associated with considerable lower diet quality scores. Unfortunately we did not observe similar associations of soft drink consumption and snacking with diet quality. These results are not in line with those of the majority of other studies in which soft drink consumption and snacking were associated with energy intake and obesity in both adults and children.[23, 30-32] Therefore, we still perceive it important to include these eating behaviours in dietary counselling.

Theoretical underpinning of the intervention

Theory was used to underpin the design of the intervention, to increase the likelihood of intervention effectiveness.[33, 34] Using theory helped us in systematically developing the intervention, which potentially resulted in including the most important determinants of

behaviour change.[35] To build our intervention, we selected the theory of planned behaviour[5] and the transtheoretical model[6] to encompass determinants of behaviour and processes of behaviour change. Both are well-established in behavioural research and are found useful in predicting or changing dietary behaviour.[36-39] By selecting this theory and model, we aimed at the individual determinants of dietary behaviour and behaviour change. We did not specifically target our intervention at environmental factors and we acknowledge that aiming at environmental factors can be important in establishing changes in dietary intake.[40, 41] Yet, by targeting individual determinants we also aimed to increase participants' control over environmental determinants such as food choices at public places.

The use of motivational interviewing

The dieticians were trained in motivational interviewing and they confirmed using its principles in their nutrition counselling practices.[7] Unfortunately, training and using the principles in dietary counselling does not warrant effective use of motivational interviewing.[42] The level of training in motivational interviewing and the dieticians' personalities might have influenced the level of application. The motivational interviewing treatment integrity scale could have been used to evaluate the competence of the dieticians in applying motivational interviewing,[43] but we did not use this scale. Therefore, we cannot conclude on the extent in which motivational interviewing was used in our counselling intervention, however, we do know that the dieticians were acquainted with using motivational interviewing.

Nutrition counselling intervention

The intervention was a combination of face-to-face counselling sessions by registered dieticians working in dietetic practices in Wageningen and surroundings and individually tailored email messages. Studies examining counselling or tailored messages have shown that both methods are effective in improving dietary behaviour.[34, 44, 45] We also added other elements to the intervention, such as the specific themes for the counselling sessions. The combination of these elements provided a practical framework to standardise the counselling among dieticians. These multiple intervention components were included to obtain the potentially most effective intervention strategy and they were likely to have interacted.[46] Therefore, we cannot conclude on effectiveness of the individual components, however, we can conclude that the intervention as a whole was effective in improving dietary intake.

Intervention implementation and evaluation

Overall the majority of the counselling sessions were implemented as intended. Ninety-three percent (*n* 84) of the parents in the intervention group received all five sessions, five participants received four sessions and only one participant received three sessions. The most reported reason for missing a session was not being able to find a time to meet. The majority

of the emails were also implemented as intended. The dieticians reported to have sent over 90% of the emails. These results indicate that it was possible to incorporate this intervention into the current dietician practices and into parents' lives.

Also the interviews with the dieticians supported that the sessions were implemented as intended. The dieticians viewed the protocol as helpful in guiding the participants towards a healthy diet. Nevertheless, a few dieticians experienced difficulties with improving the dietary patterns of this specific population, because several participants already had quite a healthy diet. Fortunately, all dieticians were still able to set specific goals to improve dietary intake and thus the intervention was performed as planned.

The tailored email messages were mostly sent as intended; however, the dieticians stated that they did not always know what type of information to present in the emails. The dieticians were not used to send such emails and therefore the protocol for the emails had not enough detail. This lack of detail potentially resulted in differences in email compositions among dieticians. For example, two dieticians always included referrals to websites with recipes and nutrition information whereas others did not. Nevertheless, all emails included feedback on dietary intake and a message to motivate the participant to maintain or improve dietary intake.

The results of the acceptability of the intervention are not reported in the other chapters; therefore we highlight these results here. Parents rated the face-to-face sessions for usefulness to change dietary behaviour with a mean score of 4.0 out of 5.0. The parents' answers on statements on the different aspects of the counselling sessions (i.e. whether the information was useful, whether the conversations with the dieticians were valuable and whether the sessions stimulated to eat healthier) resulted in mean scores of 3.6 or higher. These results indicate that the intervention was generally well accepted by the parents. From the interviews with the dieticians we conclude that the intervention was well implementable within current dietician practices and that the intervention was perceived useful in changing behaviour.

For the following statement: "The number of counselling sessions is too high", parents provided varying answers leading to a mean score of 2.6 out of 5.0, with 30% of the parents reporting scores of 4.0 or higher. These results indicate that at least a part of the parents would like to decrease the number of sessions. Also the dieticians perceived it sometimes difficult to plan the five sessions in 20 weeks, mainly because of the busy schedules of the parents. Thus the counselling may have been too time-consuming for some parents. It may also indicate that the latter sessions were not interesting enough for the parents. As most parents provided positive ratings on the other aspects of the counselling intervention, we do not expect that the number of sessions substantially affected parents' motivation to change dietary behaviour.

The three individually tailored email messages and the weekly generic emails were also rated positively by the participants (mean scores >3.0 out of 5.0). Nevertheless, a few individuals made explicit remarks about the weekly email messages. These weekly emails were not tailored and they did not always comply with the parents' specific behaviour change goals. The weekly emails were sent to remind participants about the intervention, which was expected to motivate participants to eat healthy. Since this information was not always perceived applicable, these weekly generic messages may only have been effective for a specific group of participants.[47]

Study population

We recruited participants for the counselling intervention in Wageningen and surrounded areas, because the participants had to come four times to the study centre in Wageningen. This recruitment strategy has resulted in the inclusion of a highly educated group of participants as many of our participants studied or worked at Wageningen University. Since the parents voluntarily participated in our study, they were likely to be interested in a healthy diet and they were likely to be motivated to improve dietary intake. The specific interest in a healthy diet is shown in the high baseline mean DHD-index score of 65.3 (Chapter 3), which is substantially higher than the score of 61.2 in the general Dutch population (Chapter 2). On the one hand, the high DHD-index scores of participants resulted in decreased opportunities to improve dietary intake in the study population. On the other hand, these participants were motivated to change dietary intake, and therefore substantial changes in intake were expected. Nevertheless, it is important to keep in mind that the intervention was evaluated in a highly educated population with healthier dietary intake than the general population when transposing the results of the counselling intervention to other populations.

Randomisation

We randomised participants by gender and on self-reported height and weight from which BMI was calculated. It is generally known that people under-report weight and over-report height, and it is suggested that with higher BMI under-reporting of weight might be larger than for normal weight individuals.[48] However, we expected that bias in report was systematic and that we misclassified about the same number of people in the intervention and control group. This is reflected in comparable mean baseline BMI scores for both groups. Thus, misreporting probably did not affect our randomisation.

One of the aspects that we did not take into account during randomisation was that friends took part in this study. Therefore, it occurred that one friend received the counselling intervention and the other friend did not. These participants were likely to have conversations about the study in which the participant in the intervention group may have set a norm for

the importance of healthy eating. This social influence could have resulted in changes in the intention to eat healthy and increased the likelihood of acting according to these intentions.[5] Nevertheless, the participants in the control group did not significantly increase their mean diet quality score and thus social influence did not substantially affect our intervention.

Outcome measures

All outcome measures were conducted at baseline and directly after the intervention period ended. Other studies have shown that improvements in dietary intake declined six months after the intervention ended.[10, 49] Therefore, it is expected that the observed improvement in overall adherence to the dietary guidelines by our nutrition counselling intervention has been declined after six months. We attempted to improve the long-term effect by guiding participants to make small dietary changes, which are easily incorporated in daily life. The participants were also encouraged to set long-term goals in the last counselling session. Unfortunately, we did not have the resources to test the effects of these attempts to improve long-term effects of our counselling intervention.

Since we aimed to improve adherence to the Dutch dietary guidelines, we used the DHD-index as primary outcome measure. Although this index provides valuable information on overall diet quality, to get insight in what changes contributed to the increase overall diet quality one should examine the changes in the individual index components. By investigating these, we have shown that on population level the participants changed seven out of ten components, but no changes were observed in consumption occasions with acidic drinks and foods, alcohol and salt. With regard to acidic drinks and foods and alcohol consumption high baseline scores were observed in our population, leaving almost no room for improvement. Conversely, baseline scores of salt intake were low and left ample room for improvement. That no change in salt was observed may be explained the main sources of salt intake. The vast amount of salt intake is derived from consumption of processed foods.[50] Therefore it could have been hard for participants to reduce their salt intake as they had to change from processed to unprocessed foods that are often less convenient to prepare. Reducing salt intake may cost more effort than for example increasing consumption of fruit and vegetables, and thus needs higher motivation to change. As we aimed to improve the whole dietary pattern, parents may therefore have chosen to change other behaviours instead of lowering salt intake. Thus, to reduce salt intake, it may be needed to direct interventions more explicitly at reduction of salt consumption.

The lack of observed changes in the component salt may also be caused by the inability of our outcome measures to reflect changes in salt consumption. First, the web-based 24 h recall did not include specific questions about adding salt while cooking or at the table, which are

both behaviours at which the intervention was aimed. Therefore changes in added salt may not have been reflected in the web-based 24 h recalls. Second, the use of spot urine samples to evaluate ratios of sodium to potassium might have been limited in reflecting changes in salt intake. Spot urine collection was perceived useful in ranking individuals according to their sodium to potassium ratios. Nevertheless, it has not yet been investigated if spot urine sodium to potassium ratios can be used to evaluate changes in dietary intake.[51] Thus, the selection of 24 h dietary recalls and spot urine as evaluation methods for salt intake may have reduced the likelihood to observe changes.

The focus on overall diet quality limited our abilities to evaluate via which behavioural determinants change in dietary intake was established. In theory one would like to use measures for the behavioural determinants that encompass overall diet quality. However, such measures would exist of an enormous number of questions because they need to include specific questions for each guideline.[52] Asking this many questions in addition to the other measures in our randomised controlled trial was perceived too burdensome for participants. Therefore, it was decided to only include questions about fruit, vegetables and snacks. By focussing on only three dietary components we could not evaluate how changes in the other components of diet quality were established. Nevertheless, we perceived it important to collect information on these behavioural determinants. Only little research is available that explores how behaviour change is established and therefore all additional knowledge is valuable to inform the development of effective nutrition interventions.

PUBLIC HEALTH IMPLICATIONS

The findings from the studies discussed in the current thesis have several implications for public health. These implications relate to promoting healthy diets and implementing the counselling intervention.

Interventions aimed at parents to promote child dietary intake

As reported previously, we aimed the intervention at parents because we perceive them as role models for their children, and therefore it was expected that interventions for parents establish changes in children's diets.[3, 26, 53] The counselling was aimed at dietary behaviours that occur within the family setting and accessibility of foods at home. Nevertheless, other factors are also important for the dietary behaviours of children.[3, 54-57] For example, children in this age group also consume drinks and foods at schools, sport clubs and with friends. To establish larger improvements in dietary intake of children it may be beneficial to link the investigated nutrition counselling intervention for parents with other interventions such as nutrition projects at primary schools.[58]

Promoting adherence to the dietary guidelines

Interventions to increase adherence to dietary guidelines might benefit from including elements that incorporate eating behaviours, such as breakfast skipping and having dinner-away-from home. These behaviours potentially affect overall dietary intake as they have been associated with lower adherence to the dietary recommendations. Although the research on eating behaviours and diet quality is inconclusive yet, addressing these eating behaviours among others in nutrition counselling may provide practical opportunities in improving overall diet quality.

Implementation of the counselling intervention

The intervention improved adherence to the Dutch dietary guidelines in parents with 4 to 12 year old children. Thereby, the intervention was generally well implemented and accepted by both dieticians and participants. Thus it seems that this intervention can be implemented in practice as it is. Nevertheless, for implementation, it may be worthwhile to supply dieticians with elaborated examples of how to write the individually tailored email messages. Dieticians have the knowledge to put into these email messages, but because they are not used to compile these, a few examples might benefit the intervention protocol. Also a short training for the dieticians may be helpful to increase the effectiveness of the individually tailored email messages.

This nutrition counselling intervention with standardise face-to-face counselling by dieticians has shown to be an effective method to improve the dietary intake of parents. Nevertheless, the intervention may put stress on parents' full schedules and may be too costly to implement in a real-life setting. Therefore, it may be beneficial to adapt parts of the intervention to web-delivered tailored tools or mobile applications on smartphones or tablets. These tools can be theoretically underpinned by behaviour change theories and could for example include dietary assessment with direct feedback related to the reported food intake. Studies have repeatedly shown that web-delivered tailored methods can effectively change dietary intake.[44, 59] Although mobile applications are relatively new in dietary interventions, they are assumed to effectively change dietary intake.[60-62] A limitation of both approaches is that people have to continue using them and consequently people have to be motivated to return to the websites or the applications. It may be easier to omit to return to a website or mobile application than to ignore an appointment with a dietician. It may be worthwhile to build in motivational aspects to get people engaged and increase the likelihood of participants' use of the applications.[60,63] Another challenge of web-delivered tools or mobile applications is that direct face-to-face contact with a dietician is limited. Personal contact is an important principle of motivational interviewing,[64] and therefore, should not be fully neglected in the search for

new approaches of behaviour change counselling. Options for including personal contact in web-delivered tools and mobile applications can be personal chats and messages.[65]

This intervention was effective in a population that was motivated to change dietary behaviour. Consequently, most participants were in the preparation or action stages of change and thus needed detailed information and specific guidance on how to change dietary behaviour.[6,66] People who are unaware of their unhealthy diets or not motivated to change dietary behaviour need first to be motivated before this way of counselling can be effective.[67] Thereby, it is not likely that these individuals voluntarily visit a dietician or tailored websites. To change the dietary intake of people who are unaware of their unhealthy dietary habits or not yet motivated to change behaviour more extensive interventions that are community delivered may be needed.[68, 69]

SUGGESTIONS FOR FUTURE RESEARCH

Based on the results of this thesis and the aforementioned considerations, suggestions for future research are provided.

Improving children's diets

Although numerous cross-sectional studies evaluated what determinants are associated with children's dietary intake,[26, 70, 71] it would be valuable to evaluate what changes in parents and environment established changes in child dietary intake. For this purpose, questionnaires for parent and child on behavioural determinants of child dietary intake could be administered. This could provide knowledge on whether changes in parents' modelling behaviours or changes in other factors established dietary behaviour change. This knowledge potentially benefits the development of cost-effective interventions to improve children's diets.

Evaluating overall dietary intake and dietary behaviours

The changes in dietary intake of children were evaluated for specific foods or food groups and not the overall dietary pattern as was evaluated in parents. To evaluate if the changes in child dietary intake are comparable to those of the parents, a dietary index which reflects the overall dietary patterns of children can be used. Already numerous of these dietary indexes for children exist, nevertheless, as far as to our knowledge these do not exist for the Dutch dietary guidelines.[72] Even though the Dutch guidelines are developed for adults, these could be a good starting point for developing an index for children. This index should thereby also include eating behaviours that are of importance for children's health. One could think of adding components including snacking behaviour and soft drink consumption as these are both associated with higher energy intake and obesity in children.[31, 32]

We evaluated four eating behaviours that potentially were associated with adherence to the Dutch dietary guidelines. Two of them, breakfast skipping and having dinner away-from-home, showed negative associations with the DHD-index. Although, our study did not confirm our expectations about snacking and soft-drink consumption, we still expect these behaviours to be associated with lower diet quality.[23, 73, 74] Thereby, other behaviours that were not addressed in our study, may also be associated with adherence to the Dutch dietary guidelines, such as timing of meals, evening snacking, large portion sizes and energy density of meals.[75,76] More detail on the associations between specific eating behaviours and diet quality, provides additional knowledge that could be used to guide dietary counselling practices of dieticians.

Evaluating nutrition counselling interventions

The absence of an objective marker to evaluate improvements in overall diet quality limits our conclusions to self-reported changes in adherence to the dietary guidelines. Except for EPA and DHA derived from blood plasma, the used biological markers of dietary intake may not have been sensitive enough to reflect small changes in intake of food groups or nutrients. Because we were one of the first that attempted to underpin changes in overall diet quality with objective markers, future research is recommend to evaluate changes in diet quality with objective markers of intake.

One of those objective markers could be spot urine samples. These can be used for estimating sodium excretion on population level or for ranking individuals based on their ratios of sodium to potassium. The use of spot urine samples as marker of dietary intake is relatively new, but interest in its validity is increasing.[77-81] Although, studies indicate that spot urine can be used as marker of sodium intake on population level, collecting 24 h urine is still perceived to be the most objective marker. Therefore, it may be considered evaluating if collection of multiple spot urine samples might increase the precision of the sodium estimation as compared to single samples.[82] Thereby, research merely focusses on the use of spot urine to estimate mean sodium intake of populations. However, the use of spot urine as objective marker of changes in dietary intake has not yet been confirmed.

We are one of the few who evaluated which determinants are important for establishing change in intakes of fruit, vegetables and snacks. Research repeating these findings or investigating other dietary behaviours is highly warranted to obtain more knowledge on how behaviour change is established. In addition, research evaluating the effects of individual the intervention components such as the specific themes discussed during the counselling sessions or the use of weekly generic email messages, could inform the development of more effective dietary behaviour change interventions.

The nutrition intervention outcomes were evaluated directly after the intervention period ended. As it is likely that the interventions effects will have declined after six months,[10, 49] it would be valuable to know how much of the changes in dietary behaviour were maintained. Thus, we recommend studies evaluating nutrition counselling interventions to include longer-term measures of outcome, at least three months after the intervention ended, to evaluate whether changes in dietary behaviour are maintained.

OVERALL CONCLUSION

We aimed to improve parents' adherence to the Dutch guidelines for a healthy diet. By improving parents' dietary patterns it was hypothesized that children's dietary intake would also improve. This thesis described research that was conducted to develop and evaluate a theoretically-underpinned counselling intervention provided by dieticians to improve dietary intake. The intervention showed substantial increases in adherence to the dietary recommendations in parents. Thereby, the intervention seemed also effective in improving the intake of specific foods in children. This thesis also showed that dietary behaviour change was mediated by changes in specific determinants of dietary behaviour, which provides insight in how behaviour change is established. Concluding, this thesis provides empirical knowledge on potential effective elements for counselling interventions aiming at improving the dietary pattern as a whole of parents and provides knowledge on methods to evaluate changes in dietary intake.

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Summary in Dutch (Samenvatting)

SAMENVATTING

In Nederland eet het merendeel van de volwassenen en de kinderen ongezond en dit kan mogelijk leiden tot hogere risico's op chronische ziekten. Het is daarom belangrijk het eetgedrag van zowel volwassenen als kinderen te verbeteren. Een belangrijke factor die het eetgedrag van kinderen beïnvloedt, is het eetgedrag van hun ouders. Kinderen waarvan de ouders gezond eten, hebben in het algemeen een gezonder eetpatroon dan kinderen van wie de ouders een ongezond eetpatroon hebben. Dus als we het eetgedrag van ouders verbeteren, verwachten we dat het eetgedrag van hun kinderen ook verbetert. Dit proefschrift beschrijft onderzoek dat is uitgevoerd om een voedingsinterventie voor ouders te ontwikkelen en te evalueren. Deze interventie had als doel om ouders volgens de richtlijnen goede voeding te laten eten.

In Hoofdstuk 1 worden de keuzes die zijn gemaakt tijdens de ontwikkeling van de voedingsinterventie geïntroduceerd. Er is gekozen om de theorie van gepland gedrag en het transtheoretisch model van gedragsverandering te gebruiken als theoretische onderbouwing voor de ontwikkeling van de interventie. De voedingsinterventie zelf bestond uit individuele counseling door de diëtist, verspreid over vijf sessies. In deze sessies probeerde de diëtist via motiverende gespreksvoering de deelnemers gezonder te laten eten. Naast deze counselingsessies ontvingen de deelnemers ook drie persoonsgebonden e-mails met voedingsadvies. De effecten van de interventie zijn geëvalueerd in een gerandomiseerde gecontroleerde trial waarin 92 ouders de interventie ontvingen en 94 ouders als controle groep dienden. Onze primaire uitkomstmaat was een positieve verandering in de kwaliteit van het voedingspatroon, gemeten met de Dutch Healthy Diet-index (DHD-index). Met deze index kan worden vastgesteld in hoeverre er aan de tien richtlijnen goede voeding wordt voldaan, waarbij lage scores een ongezond voedingspatroon weergeven en hoge scores een gezond voedingspatroon (scores kunnen variëren tussen nul en 100). Onze secundaire uitkomstmaten zijn positieve veranderingen in intermediaire gezondheidsmaten en voedingsinname van de kinderen. Ook hebben we onderzocht via welke determinanten van eetgedrag de interventie het voedingspatroon heeft veranderd.

In hoofdstuk 2 is een onderzoek beschreven naar de associaties van vier eetgedragingen, 'ontbijten', 'buitenshuis eten', 'frisdrank consumptie' en 'snacken', met de DHD-index. Voor dit onderzoek hebben we de gegevens van 2055 deelnemers aan de nationale voedselconsumptiepeiling gebruikt. Deze deelnemers zijn geïnterviewd over hun voedingsinname van de dag voordat ze gebeld zijn. Uit deze gegevens bleek dat 'ontbijten' was geassocieerd met lagere DHD-index scores voor vrouwen, maar niet voor mannen. Daarbij was 'buitenshuis eten' geassocieerd met ongezondere voedingsinname voor zowel

mannen als vrouwen. Voor het gebruik van frisdrank en snacken vonden we geen associaties met ongezondere voedingsinname. Onverwacht vonden we dat frisdrank consumptie was geassocieerd met hogere DHD-index scores. Deze hogere scores waren voornamelijk verkregen door lagere innames van alcohol. Omdat ander onderzoek aangeeft dat frisdrankconsumptie geassocieerd is met hogere energie- en suikerinname denken we nog steeds dat frisdrankconsumptie een risicofactor is voor een ongezonder voedingspatroon. Voor snacken kunnen we geen duidelijke conclusies trekken omdat onze uitkomsten verschillen van andere onderzoeken. Deze verschillen worden met name veroorzaakt door verschillen in definitie voor snacken. Ondanks dat zowel ontbijten als buitenshuis eten duidelijk lagere scores op de DHD-index laten zien, verklaren deze maar een klein deel van de variantie in het voldoen aan de richtlijnen goede voeding. Dit wijst erop dat andere factoren belangrijker zijn bij het verklaren van gezonde voedingsinname. Desalniettemin, denken wij, vanwege de duidelijke inverse associaties van ontbijten en buitenshuis eten met de DHD index scores, dat het belangrijk is om deze eetgedragingen, naast anderen, te bespreken tijdens voedingscounseling.

In hoofdstuk 3 staan de uitkomsten vanonze gerandomiseerde gecontroleerde trial beschreven. In vergelijking met de deelnemers in de controlegroep zijn de ouders in de interventiegroep gezonder gaan eten. Deze ouders verhoogden hun DHD-index score met gemiddeld 7.8 punten. Deze verandering was significant groter dan de verhoging van 1.1 DHD-index punten in de controlegroep. De verbetering in het voldoen aan de richtlijnen goede voeding kwam tot stand door kleine veranderingen in zeven van de tien componenten van de DHD-index. Dus de interventie was effectief in het veranderen van meerdere componenten van de DHD-index. De grootste veranderingen zagen we in fruit- en visinname. De verbetering in visinname was ook te zien in een verhoging in het percentage visvetzuren van de totale concentratie vetzuren verkregen uit bloedplasma. Daarbij zagen we een vermindering in middelomtrek, maar niet in BMI, bloeddruk en cholesterol. De ouders in de interventiegroep rapporteerden ook dat hun kinderen meer fruit, groente en vis zijn gaan eten dan de kinderen in de controlegroep. Helaas omvat de door de ouders gerapporteerde consumptie niet het totale voedingspatroon van hun kinderen. Dus het blijkt dat de ouders in de interventiegroep gezonder zijn gaan eten en dat het waarschijnlijk ook voor hun kinderen het geval is.

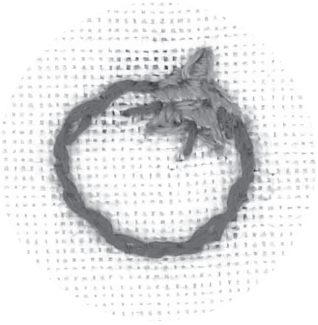
Hoofdstuk 4 beschrijft welke determinanten van gedrag zijn veranderd door de interventie en of deze verandering heeft geleid tot verandering in voedingsinname. De keuze voor de onderzochte determinanten is gebaseerd op de theorie van gepland gedrag en is aangevuld met determinanten die aantoonbaar belangrijke voorspellers van intentie tot gedrag zijn. Voor de laatste determinanten zijn de volgende geselecteerd: intentie, attitude, subjectieve norm, ervaren gedragscontrole, sterkte van gewoontegedrag, eigen-identiteit, kennis, ervaren barrières en de beschikbaarheid van voedingsmiddelen in huis. Na de interventie

waren de scores op de determinanten intentie, attitude en gewoontegedrag voor fruitinname meer veranderd in de interventiegroep dan in de controlegroep. Ook vonden we dat de interventiegroep een hogere aanwezigheid van groente in huis rapporteerde na de interventie. Daarbij waren de scores voor intentie om ongezonde snacks te vervangen voor gezonde snacks en sociale norm omtrent snacken meer veranderd in de interventiegroep dan in de controlegroep. Voor gezonde voeding in het algemeen, waren kennis en eigen-identiteit meer veranderd in de interventie dan in de controle groep. De resultaten indiceerden dat veranderingen in attitude en gewoontegedrag mediatoren waren van verhoging in fruit inname. Ook hebben we gevonden dat veranderingen in eigen-identiteit in relatie tot gezond eten een mediator was voor vermindering in snack inname. Omdat we een van de eersten zijn die onderzoek hebben gedaan naar deze specifieke determinanten als mediatoren van eetgedrag, kunnen we het effect van deze determinanten niet generaliseren naar andere interventies en populaties. Wel geven deze resultaten belangrijke informatie voor de ontwikkeling van effectieve voedingsinterventies.

Het effect van de voedingsinterventie op natrium- en kaliuminnames is gemeten met spot urinemonsters. Onze beslissing om spot urine te gebruiken is gebaseerd op de resultaten beschreven in hoofdstuk 5. In dit hoofdstuk staat een onderzoek beschreven naar de overeenkomt tussen natrium en kalium excretie in één urinemonster en in 24-uurs urine. Dit hebben we onderzocht omdat het verzamelen van 24-uurs urine, de gouden standaard voor het evalueren van natriuminname, een lastige methode is voor deelnemers en vaak leidt tot onvolledige urineverzameling. De resultaten geven aan dat de natrium/kreatinine ratio's in één urinemonster kunnen worden gebruikt om op populatieniveau 24-uurs natrium excretie te kunnen schatten in een jonge populatie vrouwen. Ook vonden we dat natrium/kalium ratio's in één urinemonster geassocieerd waren met deze ratio's in 24-uurs urine en dus kunnen we op basis van een urinemonster deelnemers indelen naar hun natrium/kalium ratio's.

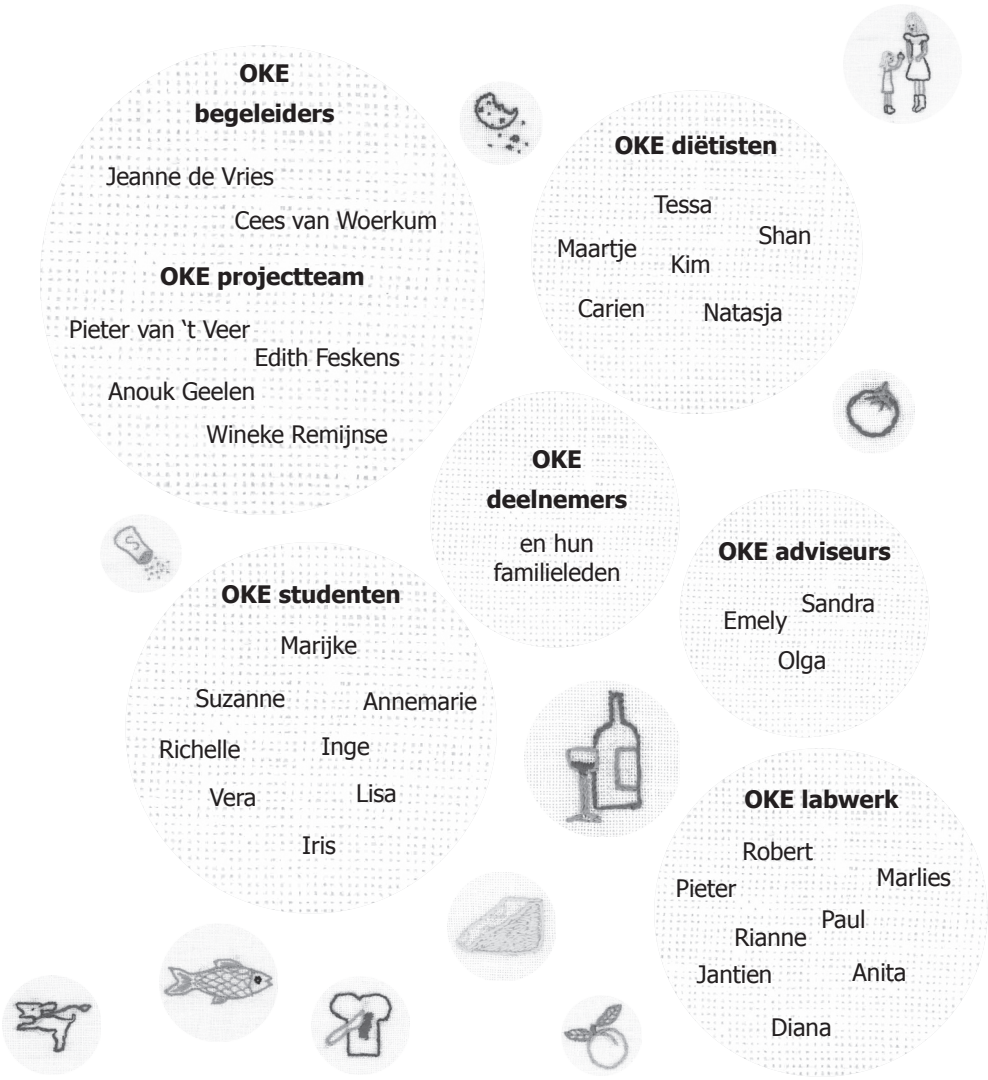
Het laatste hoofdstuk van dit proefschrift vat alle bevindingen samen. Daarbij geeft het overwegingen met betrekking tot methodologische aspecten van het onderzoek betreffende het ontwikkelen van de voedingscounseling interventie en de implementatie en evaluatie daarvan. Ook worden implicaties voor de praktijk besproken en belangrijke aspecten voor toekomstig onderzoek komen aan bod. De hoofdconclusie is dat dit proefschrift empirische kennis bevat over de effectieve elementen voor persoonsgebonden gedragsveranderingsinterventies gericht op het totale voedingspatroon van ouders en dat het bijdraagt aan kennis over methoden om veranderingen in voedingsgedrag te evalueren.

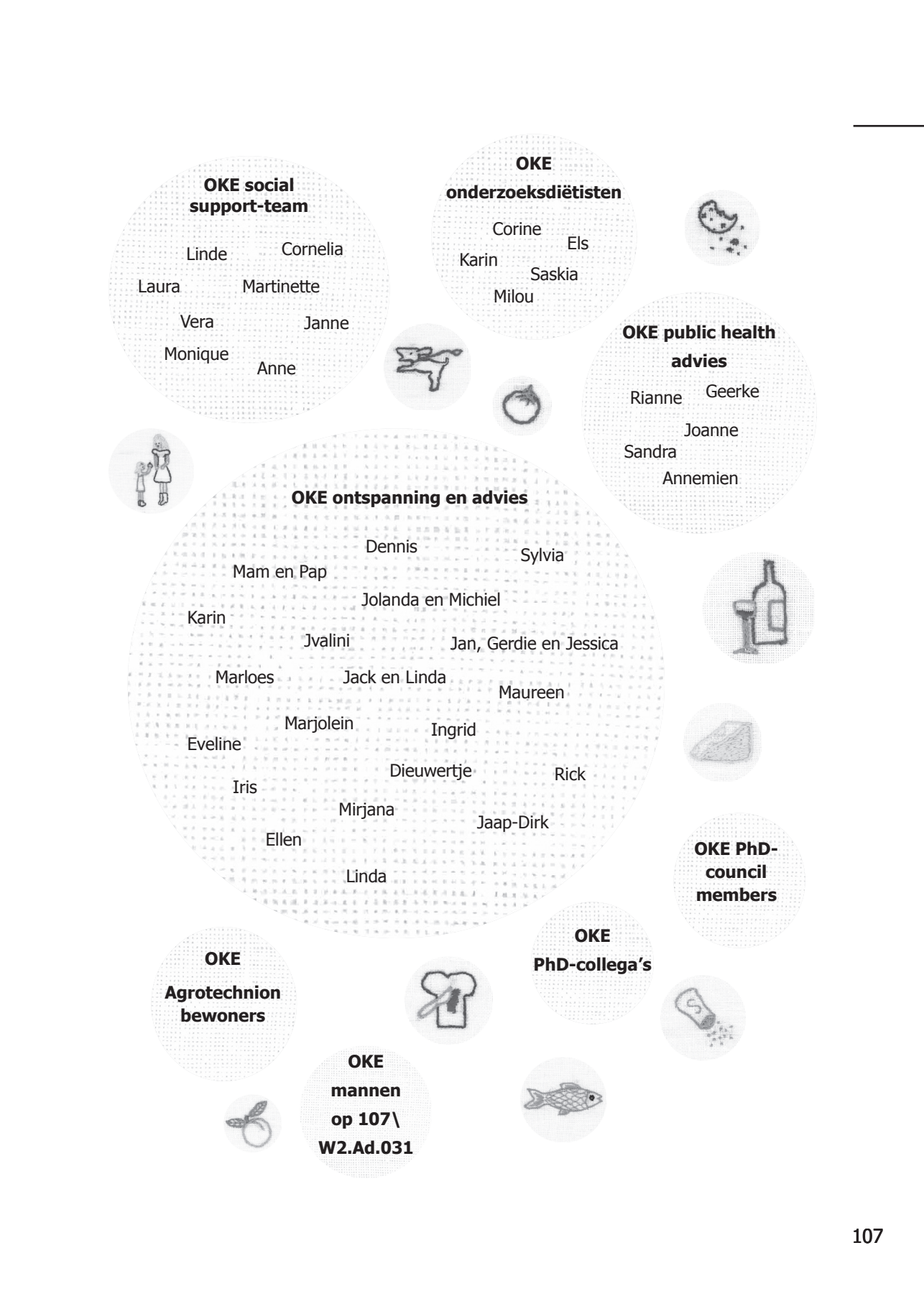
Acknowledgements (Dankwoord)



BEDANKT!

Na ruim vier jaar onderzoek kunnen jullie een deel van de resultaten lezen in dit proefschrift. De andere resultaten zijn de dingen die ik heb geleerd van mijn collega's, vrienden en familie. Zo heb ik bijgeleerd op wetenschappelijk- en werkgebied, maar ook zeker op persoonlijk gebied. Daarom wil ik jullie bedanken voor jullie bijdrage aan het Ouder, Kind en Eten onderzoek (OKE onderzoek), dit proefschrift en mij als persoon. En natuurlijk ben ik niet alleen wijzer geworden, ik heb de afgelopen vier jaar ook veel leuke momenten beleefd en veel lol gehad. Dus daarom wil ik concluderen, jullie zijn helemaal oké!




OKE social support-team
Linde
Cornelia
Laura
Martinette
Vera
Janne
Monique
Anne
OKE onderzoeksdiëtisten
Corine
Els
Karin
Saskia
Milou
OKE public health advies
Rianne
Geerke
Joanne
Sandra
Annemien
OKE ontspanning en advies
Dennis
Sylvia
Mam en Pap
Jolanda en Michiel
Karin
Jvalini
Jan, Gerdie en Jessica
Marloes
Jack en Linda
Maureen
Marjolein
Ingrid
Eveline
Dieuwertje
Rick
Iris
Mirjana
Jaap-Dirk
Ellen
Linda
OKE PhD-council members
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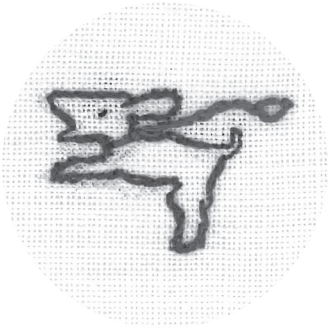
About the author



CURRICULUM VITAE

Eveline Johanna Catharina Hooft van Huysduynen was born on January 16, 1986 in Eindhoven the Netherlands. In 2004 she completed secondary school at Lorentz Casimir Lyceum in Eindhoven and started studying Nutrition and Health at Wageningen University. As part of her studies she conducted a minor thesis at the departement of Strategic Communication. Her major thesis took place at the division of Human Nutrition and was in the field of Epidemiology and Public Health. For her internship she went to Wrexham County Borough Council in Wales, UK, to develop a public health strategy to reduce overweight and obesity. In April 2010, Eveline started her PhD project with the aim to improve dietary intake in parents and children, of which the results are described in this thesis. This PhD thesis was part of the project 'Variation and changeability of dietary patterns: a prerequisite for public health interventions', which fell under the 'Healthy Nutrition' program of ZonMw. The aim of the program was to stimulate research about the relation between dietary patterns and chronic diseases. She joined the educational program of the Graduate School VLAG and she was involved in teaching and supervising students at the BSc and MSc level. From September 2010 to December 2013 she was a member of the VLAG PhD committee and the Wageningen University PhD committee. Currently, she is working at the department of heart and lungs at UMC Utrecht.

LIST OF PUBLICATIONS

Publications in peer-reviewed journals

Hooft van Huysduynen E.J.C., Hulshof P.J.M., van Lee L., Geelen A., Feskens E.J.M., van 't Veer P., van Woerkum C.M.J., de Vries J.H.M. Evaluation of using spot urine to replace 24 h urine sodium and potassium excretions. Public Health Nutr 2014: 17; 2505 - 2511.

van Lee L., Feskens E.J.M., Hooft van Huysduynen E.J.C., de Vries J.H.M., van 't Veer P., Geelen A. The Dutch Healthy Diet-index as assessed by 24 h recalls and FFQ: associations with biomarkers from a cross-sectional study. J Nutr Sci 2014; 3.

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Hooft van Huysduynen E.J.C., Hiddink G.J., van Woerkum C.J.M. The use of theory in research on nutrition guidance practices by primary care physicians from 1995 to October 2008: A review. Fam Pract 2012: 29(SUPPL. 1); 56-60.

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Hooft van Huysduynen E.J.C., de Vet E., van Lee L., Geelen A., Feskens E.J.M., van 't Veer P., van Woerkum, C.M.J., de Vries J.H.M. Mediators of behaviour change in a nutrition counselling intervention.

Hooft van Huysduynen E.J.C., van Lee L., Geelen A., Feskens E.J.M., van 't Veer P., van Woerkum, C.M.J., de Vries J.H.M. Associations of breakfast skipping, dinner away-from-home, soft drink consumption, and snacking with healthy diets in a Dutch population.

van Lee L., Geelen A., Hooft van Huysduynen E.J.C., de Vries J.H.M., van 't Veer P., Feskens E.J.M. Evaluation of a short food frequency questionnaire to asses diet quality in the Netherlands.

Lee L., Geelen A., Baks T.L., Hooft van Huysduynen E.J.C., de Vries J.H.M., van 't Veer P., Feskens E.J.M. Dietary patterns and metabolic syndrome: a cross-sectional analysis within the NQplus study.

Lee L., Geelen A., Kiefte - de Jong J.C, Witteman J.C.M., Hofman A., Vonk N., Jankovic N., Hooft van Huysduynen E.J.C., de Vries J.H.M., van 't Veer P., Franco O.H., Feskens EJ.M.. Adherence to the Dutch dietary guidelines is inversely associated with 20-year mortality in a large prospective cohort study.

OVERVIEW OF COMPLETED TRAINING ACTIVITIES

Discipline specific activities	**Organizor and Location**	**Year**
Workshop 'Kennis moet Bewegen'	AGORA, Zutphen	2010
Exposure Assessment in Nutrition Research	VLAG, Wageningen	2010
Nutritional Science Days	NWO, Deurne	2010
Master Class Public Health Interventions in Real-life Settings	VLAG, Wageningen	2010
Heelsum VI: Practice-based Evidence for Weight Management	NZO, Heelsum	2010
Workgroup Nutrition	WeVo, Wageningen	2011
Nutritional Science Days	NWO, Deurne	2011
Symposium Nudging	WeVo, Utrecht	2012
8th International Conference on Diet and Activity Methods	ICDAM / FAO, Rome (IT)	2012
Course Quantitative Data Analysis: Multivariate Techniques	WUR, Wageningen	2012
Masterclass: Effective Interventions in Public Health Practice	VLAG, Wageningen	2012
Congress of International Society of Behavioral Nutrition and Physical Activity	ISBNPA, Gent (B)	2013
Workshop: Implementation of the DHD-FFQ.	ZonMw, WUR	2013
Nutritional Science Days	NWO, Deurne	2013
General Courses		
VLAG PhD Week	VLAG, Baarlo	2010
PhD Competence Assessment	WGS, Wageningen	2011
'Bessensap' – Research Meets Press	NWO, Den Haag	2011
Effective Behavior in Your Professional Surroundings	WGS, Wageningen	2011
Techniques for Writing and Presenting a Scientific Paper	WGS, Wageningen	2011
Supervising MSc Thesis Students	WGS, Wageningen	2012
Scientific Writing	WGS, Wageningen	2012
Optional courses		
Literature group 'Oldsmobiles'	HNE, Wageningen	2010-2012
PhD study tour Australia	HNE / VLAG	2013
PhD council member for VLAG and WUR	VLAG / WUR	2010-2013
A series of research seminars and presentations	HNE, Wageningen	2010-2014

NOTES

COLOPHON

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