FOOD INTAKE MEASUREMENTS:
THEIR VALIDITY AND REPRODUCIBILTY

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FOOD INTAKE MEASUREMENTS: THEIR VALIDITY

AND REPRODUCIBILITY

PROEFSCHRIFT

TER VERKRIJGING VAN DE GRAAD VAN

DOCTOR IN DE LANDBOUWWETENSCHAPPEN

OP GEZAG VAN DE RECTOR MAGNIFICUS

DR. C.C. OOSTERLEE

IN HET OPENBAAR TE VERDEDIGEN

OP WOENSDAG 4 SEPTEMBER 1985

DES NAMIDDAGS TE VIER UUR IN DE AULA

VAN DE LANDBOUWHOGESCHOOL TE WAGENINGEN.

STELLINGEN

1. De uitspraak van Dr. J.S. Garrow: "Food intake measurements are for
   Saints and for Fools" is correct, wanneer voedselconsumptieonderzoek
   uitsluitend toegepast zou worden bij obesen; in zijn algemeenheid is
   deze uitspraak niet correct.

   > Third C.R.C. International Symposium. Harrow Middlesex,
   > September 1984.

2. Bij indeling van individuen uit eenzelfde onderzoekspopulatie - uitsluitend
   op basis van voedselconsumptiegegevens - in categorieën van lage en hoge
   energieopneming is vermindering van het aantal misclassificaties in de
   extreme categorieën slechts tot op zekere hoogte te bereiken door het
   aantal waarnemingen per persoon te vergroten.

3. In wetenschappelijke publicaties zijn veelal de methoden van onderzoek
   afgedrukt in kleine letters. Dit weerspiegelt niet de betekenis van de
   methoden voor de uiteindelijke resultaten en onzorgvuldig lezen leidt -
   evenals bij verzekeringspolissen - veelal tot onjuiste interpretaties.

4. Het berekenen van de samenstelling van een doorsnee Nederlands dagrantsoen
   op een "home computer" geeft onjuiste resultaten, omdat van een te klein
   voedingsmiddelenbestand moet worden uitgegaan.

5. Het bezuinigen op het voedselverstrekkingspakket in instellingen in
   Nederland, gedurende de huidige economische crisis levert financieel
   weinig op en is nadelig voor de gezondheid van de bewoners van deze
   instellingen.

6. Eén van de meest decadente verschijnselen in onze welvaartsmaatschappij
   is het overvoeren van troeteldieren met bio-industrieprodukten.

7. Het feit dat dieetadviezen door geregistreerde diëtisten nog steeds niet
   opgenomen zijn in het ziekenfondspakket, geeft aan hoe weinig belang de
   Minister van Welzijn, Volksgezondheid en Cultuur hecht aan de betekenis
   van voeding bij het genezingsproces.

8. De Nederlandse wet, die de 2e en 3e graads onderwijsbevoegdheid regelt,
   kent niet de vakken voedingsleer en dieetleer. Daardoor blijft een
   vakbekwaam onderwijzen in deze vakken aan leerlingen van het lager en
   middelbaar beroepsonderwijs ernstig in gebreke.

9. De wijze van informatie verstrekken door het Ministerie van Onderwijs
   en Wetenschappen is geen goed visitekaartje voor het Nederlandse
   onderwijs.

10. Het valt buiten de doelstellingen van de Landbouwhogeschool een krant
    te onderhouden, die een groot aantal van haar kolommen wijdt aan roddels
    en eenzijdige voorlichting.

11. Het Europees jaar voor de muziek te wijden aan Bach, Händel en Scarlatti
    is vergelijkbaar met melkpropaganda in een zuivelland.
    Het is geen van beide innoverend.

C O N T E N T S

VOORWOORD

Mijn vader hechtte een grote betekenis aan de voeding van elke dag
voor de gezondheid van zijn patiënten en voor die van ons, zijn kinderen.
Destijds was hij daarin waarschijnlijk één van de zeer weinige huis-
artsen in Nederland. In huiselijke kring bleef, mede door de grote kennis
en kunde van mijn moeder, de betekenis niet beperkt tot gezondheidskundige
aspecten. De gastronomische vreugden en de gezelligheid tijdens de maal-
tijden gaven een belangrijke extra waarde aan het onderwerp voeding. Mede
hierdoor werden de fundamenten gelegd voor mijn belangstelling voor
voeding, die in het begin vooral op de praktijk gericht was. Gedurende de
tien jaar, die ik op het Centraal Instituut voor Voedingsonderzoek T.N.O.
onder de inspirerende leiding van Professor Dr. J.F. de Wijn heb gewerkt,
raakte ik echter steeds meer in de ban van het voedingsonderzoek. In dit
voedingsonderzoek neemt "het voedselconsumptieonderzoek", onderwerp van
dit proefschrift, een centrale plaats in.

Ik wil mijn promotor Professor Dr. J.G.A.J. Hautvast bijzonder hartelijk
danken voor de grote stimulans en zijn deskundige begeleiding bij de tot
stand koming van dit werk. Aan het onderzoek is door heel veel medewerkers
van de Vakgroep Humane Voeding van de Landbouwhogeschool een bijdrage
geleverd en ik dank iedereen zeer hartelijk voor deze bijdrage en de
bijzonder prettige samenwerking.
Jan Burema bedank ik voor zijn adviezen voor de verwerking van de gegevens,
de grondigheid en het geduld waarmee hij de analyses heeft uitgewerkt en
toegelicht. Voor de hulp bij het verwerken van de gegevens wil ik tevens
bedanken Hannie van Oosten-van der Goes, Ben Scholte en Gebca Velema.

1. INTRODUCTION

The concept of food consumption to be measured varies with the objectives of the survey. The objectives may be a food consumption survey as the basis of national food planning and administration or a survey with the main emphasis on the relation between nutrition, health and disease. Such a distinction is necessary because each objective demands a different type of information.

For the planning of food supply one needs to know the demand for and prices of foods so data are required on the amounts of foods bought from different distribution channels by various categories of users at different times. The results of such a survey should be expressed in terms of amounts of foods purchased. For economic analysis, there is less interest in what happens with the food after it has been bought. If the study serves to compare the nutritional value of the diet with the requirements or to assess the exposure to environmental chemicals through food, the amounts of foods eaten are important. To assess the nutritional value of the diet in relation to nutritional status, results are commonly expressed in terms of amounts of nutrients consumed.

For each objective, there are various types of survey methods. In general, the objective can be approached at different levels, viz.

- national accounts of annual food availability per head of the population;
- family budget and household consumption surveys;
- individual food consumption studies.

This thesis concentrates on methods designed to assess the diet of Dutch adults as a factor which might affect health and disease. For this purpose, dietary methods distinguishing individual food consumption

patterns are needed.

Individual food consumption data have been collected by recording present intakes and recalling current and past intakes. Food consumption data may be converted into nutrients by either direct analysis or with the help of food consumption tables. In addition, the level of some nutrient intake data can be measured directly by biochemical indicators of the nutritional status.

Outline of the thesis

This thesis contains seven articles either published, in press, or submitted. In Chapter 2 the definitions of validity and reproducibility are given and the state of the art on methods assessing food consumption is described. Chapters 3 through 8 report on six studies on the validity and/or reproducibility of current methods assessing the individual food consumption and nutrient intake of adults in the Netherlands.

Chapter 3 deals with a seven-day record method assessing the energy and dietary fiber consumption in 100 adults. In this study the emphasis was put on the ratio of the between-person and within-person variation in the intake of these dietary components. This information is necessary in study designs to define sample size and number of records per person required for a given precision of the estimate.

Chapter 4 reports on the validity and reproducibility of a dietary history method estimating the usual food intake during one month in 44 adults. The validity was examined by comparing the protein intake as assessed both with the dietary history method and by 24-hour nitrogen excretion. The reproducibility was determined in a test-retest design with a one-month interval between the two tests.

Chapter 5 describes a study (carried out in 1983) on the relative
validity of a retrospective dietary history method estimating the food
consumption of 91 adults seven years ago,in 1976. The relative validity
was assessed against the current dietary history data obtained in this
group in 1976 and the current dietary history taken in 1983, the same year
as the retrospective history. A method assessing food consumption
retrospectively may be of use in case-control studies on the relation of
diet and cancer.

Seasonal variation in food consumption may affect the validity as
well as the reproducibility of food intake estimates. In Chapter 6 the
effect of the season on food consumption, pattern of physical activity
and body weight is described. Food intake and pattern of physical activity
were assessed in 114 young adult women with a 19 times repeated 24-hour
recall method during $2\frac{1}{2}$ years (August 1981 through December 1983).

In Chapter 7 the validity of the repeated 24-hour recall used in
the previous study is set forth. To examine the validity of the repeated
24-hour recall method, energy intake and pattern of physical activity
on the one hand were compared with fluctuations in body weight on the
other hand. The validity was further checked by comparing the mean daily
protein intake as assessed with 14 repeated 24-hour recalls with the
mean protein intake as assessed with the nitrogen excretion in 14
collections of 24-hour urine.

As another example of assessing nutrient intake by a biochemical
parameter, the fatty acid composition of adipose tissue was examined as
an indicator of the fatty acid composition of the diet in individuals.
Fifty-nine adult women who also participated in the study described in
the Chapters 6 and 7 were involved. Their 19 times repeated 24-hour

food recalls were considered valid and Chapter 8 reports on this study.

Chapter 9 discusses the importance of the results of these studies for furture research on the relation between diet and health.

2. FOOD CONSUMPTION SURVEYS: FRUSTRATIONS AND EXPECTATIONS*.

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RESUME

In this paper the possibilities of quality control of the various methods of
assessing food consumption and the main components of these methods are
discussed. Frustrations experienced in the past are summarized and expectations
created by new approaches are mentioned.

INTRODUCTION

In studying the relation between diet and disease the first step is very
often to compare geographical data on the incidence of the disease with the
availability of energy and nutrients per capita derived from the national food
balance sheets. Figure 1 compares the intake of fat with the incidence of breast
cancer in several countries (1).

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* Paper presented at the 4th Nordic Symposium on dietary research.

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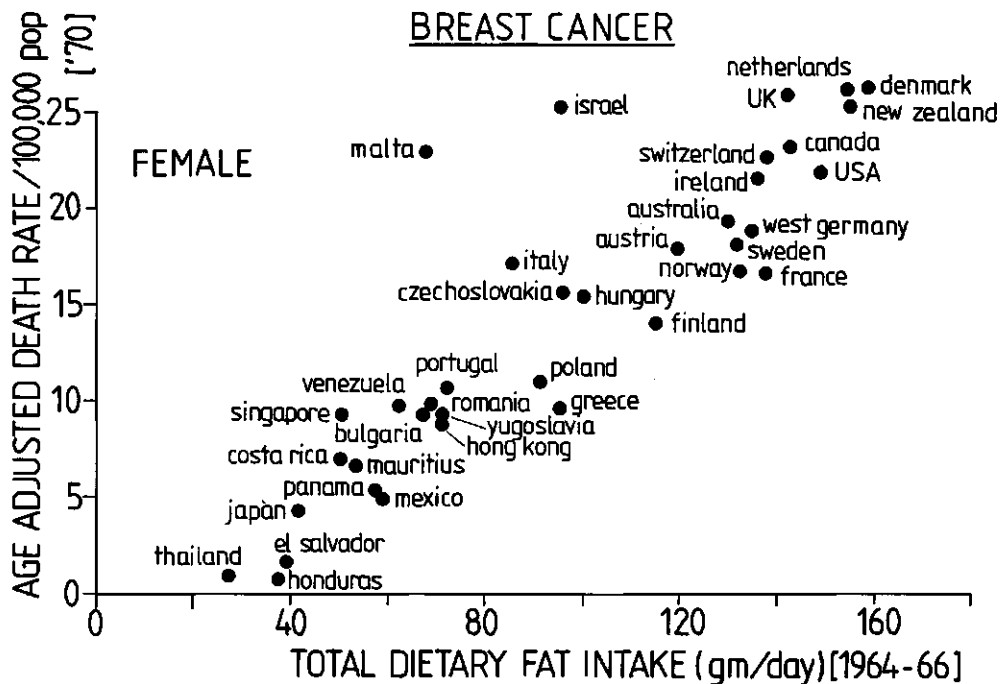
Fig. 1. Comparison of the incidence of breast cancer in several countries with the intake of fat. Figure adapted from Carroll, 1975 (1).

The results of such comparisons should be interpreted very cautiously. Differences between countries in collecting data on food availability per capita make comparisons between countries in fact unwarranted. Furthermore it is a long way - with many possible variations - from national food availability to the fate of the nutrient in the body as is shown in Figure 2 (2).

Rather than data on national food availability, results from national household food consumption surveys should be used in developing a hypothesis for a nutritional factor in the etiology of some chronic diseases. To test the hypothesis, however, individual food consumption surveys are required.
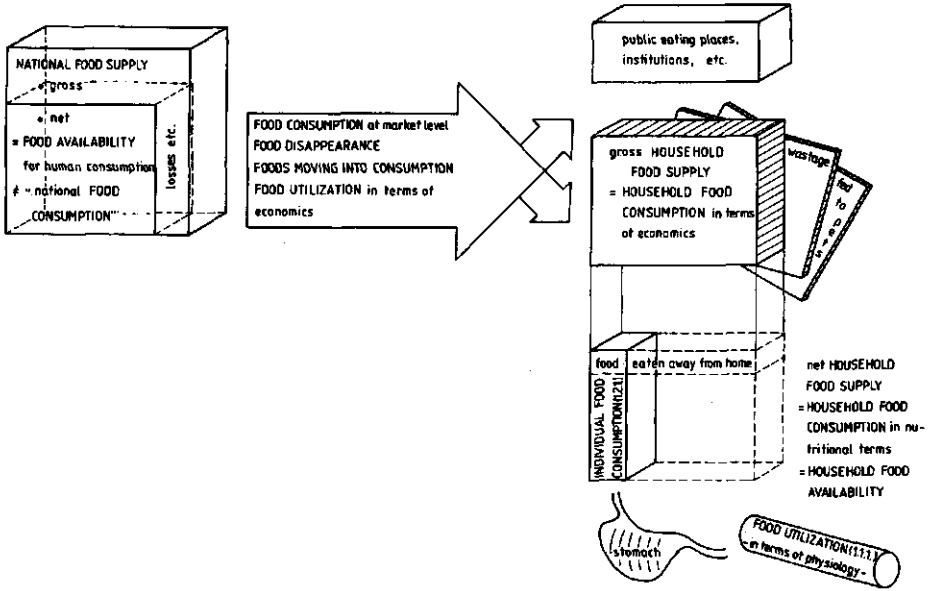
Fig. 2. Basic concepts of food supply, consumption and utilization. Figure adapted from Klaver et al., 1982 (2).

METHODS OF ASSESSING INDIVIDUAL FOOD CONSUMPTION

Table 1 shows the methods used most frequently. The greater part of these methods were already applied 50-60 years ago and have been used since then with minor adjustments for different purposes and target populations.

Table 1. Dietary survey methods, usually applied.

Dietary survey methods characterised by				
Conversion into nutrient			Food frequency	
Chemical analysis of food samples	Calculation from food tables			
	Record	Interview	Record	Interview
Duplicate portion, Aliquot sampling, Equivalent composite.	Precise weighing, Weighed inventory, Record in household measures.	Recall, Dietary history.	Open ended, Structured.	Open, Structured.

What do we know about the quality of these methods?

In the last decade several review articles have been published on the possibilities and limitations of methods of assessing food consumption (3, 4, 5, 7, 8). It is evident that the quality of these methods is doubted, partly due to the discrepancy between what the investigator wants to estimate and what the technique actually estimates, and partly because of the estimation or observation per se.

Inherent to the observation (technique and respondent) the following sources of error and variation are to be distinguished:

- Information bias, due to the discrepancy between what the investigator wants to estimate and what the technique actually estimates.

- Systematic and random response error; due to the instruction and wording of the questionnaire, ability of the respondent, skill of the interviewer, the interaction between respondent and interviewer and the research setting.

- Biological within-person variation, due to the true variation in the daily (current) food intake of a person, which depends on the food pattern.

- Between-person variation, due to the variation among people in their usual (habitual) food intake, which is connected with the homogeneity of the study

population as regards their food pattern.

A problem in the evaluation of methods assessing food consumption is to
distinguish between sources of error due to incorrect measurement and true
biological variation.

VALIDITY

The quality of a measurement is determined by its validity and reliability or
reproducibility.
The validity of a method, that is the demonstration that a method measures what
it is intended to measure, can only be assessed by comparing it with an
independent method of indisputable accuracy. There is no such absolute method
because of the nature of the data to be collected. For many research purposes
the investigator ideally wants to measure the usual intake of nutrients by
individuals over a prolonged period of time; for an independent method this
would imply direct observations of many individuals over a long time. This is
almost impossible. Instead, it may be possible to establish the relative
validity by evaluating the method in terms of another generally accepted method,
designed to measure the same concept. We may think of validating e.g. the
24-hour recall method against the observed, and preferably weighed, amount of
food intake during the same period. But there is no point in comparing the
recall method with a dietary history, because the concepts of these methods
differ with respect to the time frame.

Another way of validating methods is to compare the results of a technique
with a biological marker. Isaksson (9) compares the 24-hour protein intake
estimated by recording or recalling with the nitrogen excretion in 24-hour
urine. In social science this type of validating, which expresses the relation
between the results of a measurement by a technique and other criteria, is
called concurrent validity. For the moment the 24-hour urine nitrogen excretion

is considered the best biological marker against which food consumption surveys
can be validated (10). However, this method also has several drawbacks, for
example:

- the problem to ensure that urine collection is complete
- extra-renal nitrogen losses (for which a "correction" by 2 g per day might be
  made)
- daily variation in nitrogen excretion.

Depending on the purpose of the study other markers may also be considered, for
instance

- adipose tissue concentration of fatty acids (11)
- blood α-tocopherol levels (12).

Investigators engaged in longitudinal studies tend to validate trends in the
results of the studies against trends in national surveys e.g. food balance
sheets and household food consumption surveys. Such validations can be objected
to however, owing to differences in premisses and designs of the studies.
Consequently methods, levels of observation (nation, household, individual) and
time frame vary.

REPRODUCIBILITY

In addition to getting an answer to the question "How valid is my method", we
should also like to know how reliable or reproducible the method is. A method is
commonly called reliable or reproducible if it gives the same results when used
repeatedly in the same situation. The problem in food consumption surveys (as in
other behavioural studies) is that the situation is never absolutely identical.
Reproducibility refers to biological within-person variation (or true day-to-day
variation) as well as to random response errors, because these two sources of
variance can hardly be separated. This makes it also questionable whether

reproducibility is an appropriate measure to compare the quality of various food consumption techniques. If we compare the reproducibility of a dietary history with a 3 times repeated 24-hour recall method, the former method is better because day-to-day variation is not included in that concept.

In the test-retest design the most desirable time interval between the measurements is a dilemma (13). On the one hand we must try to avoid the second measurement from being influenced by the previous one, due to e.g. recollection of the first interview. On the other hand, the longer the time intervals, the greater is the probability of changes in food habits. The length of the time interval between the measurements depends on the time of reference of the method. For example, if the time of reference is the usual food consumption in spring, all measurements have to be done within three months as far as the Netherlands are concerned.

ESTIMATING THE AMOUNTS OF FOOD CONSUMED

Up to now research on the quality of techniques measuring food consumption mostly has been concentrated on the technique as a whole. However, in a technique three main components may be distinguished:
- collecting data by record, tape-recorder or recall;
- measuring the amount of food consumed;
- conversion into nutrients.

Although there is a great deal of literature on the validity and reproducibility of techniques measuring food consumption, only a few studies distinguish between errors due to lack of memory (14, 15, 16, 17) and those due to lack of accuracy in estimating the amount of food by weighing, the use of food models and standard household portions.

Weighing food

Weighing of all foods is considered to be the most precise technique.
Different scales are available with a degree of exactitude to the nearest 0.1,
1, 2, 5, or 10 grams. We think that a degree of exactitude of one gram for most
food consumption studies is sufficiently precise. The scales should be
calibrated and easy to read. There are two fundamental problems with the
weighing technique. Firstly, weighing all foods is a hard task for the subjects
participating in the study. Therefore, the technique may result in poor response
rates and selection bias. Secondly, weighing makes the subject conscious of the
foods eaten and may change his food habits. This is a particular problem with
women who are anxious about their body weight (18). To overcome these two
problems, simplified methods for weighing are being developed in several places.

Estimating with household measures

Estimating with household measures is less demanding than weighing: the foods
must be described in terms of household measurements. The descriptive terms have
to be converted into weights, which may be done by using standard household
measures. In estimating food intakes of individuals based on standard household
measures, we have to realize that their household utensils and portion sizes may
vary during the period of observation (within-person variation). Moreover, there
is an extensive between-person variation in these measures (19).

Table 2 shows the average, median and range in content (ml) of households
utensils and weights (g) of portion sizes found in about 30 households. The
average and median figures agree to the standard measures, however the range
reflects a large between-person variation in portion sizes. A diet of 2000 kcal.
(8.4 MJ) based on standard household measures, might contain 1400 kcal (5.9 MJ)

when the lowest values would have been used and 2800 kcal (11.8 MJ) when the highest values were used.

Table 2. Variation in household measures and portion sizes (19).

	n	$\bar{x}$	median	range	standard measure
Slice of brown bread (g)	30	30	30	25- 38	30
butter/margarine (g)	60	4	4	2- 12	5
Gouda cheese (g)	34	21	20	9- 42	20
Teacup (ml)	30	136	128	110-175	125
Drinking-glass (ml)	19	184	173	85-300	150
Teaspoon of sugar (g)	43	5	4	2- 13	3

Food models

Many articles on food consumption surveys mention the use of food models to estimate portion sizes. A great variety of food models are used, viz:
- food samples
- plastic, clay or wooden natural coloured food models
- polystyrene models
- geometric models
- natural sized coloured paintings
- photographs.

Moore et al. (20) reported on the effectiveness of the use of graduated food models in taking dietary history. It appeared that the use of food models was shown to be better reproducible than that of descriptions in terms of household

measures. In general, little has been published on the validation of food

models. In describing the methods used to assess food consumption, investigators

refer to unofficial reports and rarely mention the accuracy of households

measures or the use of food models.

CONVERSION INTO NUTRIENTS

The conversion into nutrients by using food composition tables is a specific

topic. The problems of sampling of analytical methods and their limits are

clearly presented by Southgate (21). From publications comparing data obtained

by calculations from local food composition tables and direct estimations

(22-25) it may be concluded that local food composition tables are sufficiently

accurate for most study purposes as far as energy and macro nutrients are

concerned. Table 3 presents a comparison of analysed and calculated values of

energy and macro nutrients in a duplicate portion of a test diet for a dietary

experiment (26).

Table 3. Difference between analysed (a) and calculated (c) data of a
duplicate portion of a one-day test diet (26).

	Analysed	Calculated	Difference c-a	Difference c-a in %	Difference c-a in energy %
Energy (kJ)	8895	9050	155	1.7	
Protein (g)	60	64.9	4.9	8.1	0.7
Fat (g)	103	110.7	7.7	7.5	2.6
Carbohydrate (g)	233	220.0	-13.0	-5.6	-3.2
Mono- and disaccharides (g)	108	103.1	- 4.9	-4.5	-1.2

The table shows that the differences are all within 10 percent, which is not

sufficiently accurate for a dietary experiment in a metabolic ward. However, as

the results of the comparisons are consistent in the same direction, the data derived from the food composition table may be adequate for epidemiological studies in free-living populations aiming at classifying individuals or groups of individuals according to their nutrient intake.

For most of the vitamins and minerals, food composition tables are of limited value. Sodium and potassium should rather be estimated in 24-hour urine excretion (27). If food composition tables are used for international studies, compatibility of tables is a must. This is the main goal of the Infood organisation (28) and the Eurofood organisation (29).

FRUSTRATIONS

Table 4 shows the main sources of error and variation associated with five methods of estimating food consumption. There is no method of indisputable accuracy, but the sources of error seem to be less in number in the duplicate portion technique. However, this technique is considered to be unsuitable for large-scale epidemiological studies; because it takes a lot of time from subject and investigator while, moreover the analyses are very expensive.

It is impossible to summarize the conclusions found in the literature on the validity and reproducibility of the various methods assessing food consumption, since most methods have been applied in different contexts. Understanding these different contexts has led to other approaches in evaluating studies on diet and health.

Table 4. Sources of errors in techniques estimating food consumption.

Sources of error	24-h recall	dietary history	estimated record	weighed record	duplicate portion
Response errors					
* omitting foods	+	+	±	±	-
* adding foods	+	+	-	-	-
* estimation of weight					
of foods	+	+	+	-	-
* estimating frequency					
of consumption of foods	-	+	-	-	-
* day to day variation	+	-	+	+	+
* changes in diet	-	-	±	+	+
Coding errors	+	+	+	+	-
Errors in conversion					
into nutrients					
* food composition table	+	+	+	+	-
* sampling errors	-	-	-	-	+
* direct analysis	-	-	-	-	+

+ error is likely
- error is unlikely

EXPECTATIONS

Block (7) points out clearly that validation must be seen in the context of the inferences that are to be drawn from the research carried out with these methodologies. Gordon et al. (30) stress the importance of appreciating the

Table 5. General purposes, limitations and advantages of an experimental and and observational design for food consumption studies (31)

	General purpose	Limitations	Advantages
Food balance study (experimental design)	To examine the effect of changing nutrient intake during a fixed period of time on parameters of the nutritional status	- strongly limited period of time - limited number of subjects - artificial conditions	- collecting of data easy to control
Observation of free living subjects (in general a cross-sectional design)	To examine the association between characteristics of diets of different individuals (groups) with other characteristics which these indivi-duals (groups) exhibit	- collecting of data difficult to control - limited period of time	- large groups - data reflect real life situations

differences in purposes of dietary experiments in metabolic wards and of

observational studies of diets in so called "free-living" populations. Whereas

the nutrition experiments examine the effect of changing nutrient intake on

parameters of the nutritional status, population based observations examine the

association between dietary characteristics of individuals (or groups) with

other characteristics which these individuals (groups) exhibit. There is a

tendency to consider the results from metabolic studies as being more accurate

than population-based observations. For the study of nutrition and health

however, both designs are useful since their purposes, limitations and

advantages are different as Table 5 shows (31).

Beaton (32) makes suggestions for approaches at different levels of analysing

(Table 6). These levels are discussed in the paper of the "Nordisk samarbets

grupp för Kosthallsforskning" (33).

Table 6. Selection of methods to estimate usual nutrient
intake of "free living" subjects*).

Desired information	Preferred approach
- group average	- one day intake in a large group with adequate repre- sentation of all days of the week.
- proportion of population "at risk"	- 1. replicate observations. 2. diet history.
- individual nutrient intake, for correlation or regression analyses.	- multi-replication of obser- vation on each individual

*) Suggestions made by Beaton (32).

However, next to the purpose of the study the selection of a method also

depends on practical considerations: the capacity of the target group, personnel

available and finances. In chosing a method the benefit/cost and feasibility

considerations, have frequently shown to be decisive. Such arguments might become a problem in international studies, because the actual situation differs from country to country. To facilitate international studies on diet and health, and more specifically to discuss the methods to be used an international handbook on methods assessing food consumption would be very helpful. This is why the IUNS Committee on Food Consumption Surveys has proposed an outline for such a handbook (34).

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3. DIETARY FIBER CONSUMPTION IN AN ADULT DUTCH POPULATION

A METHODOLOGICAL STUDY USING A SEVEN-DAY RECORD

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It has been suggested by Burkitt et al. (1) that the incidence of
atherosclerosis and large bowel diseases in Western communities might be
linked to a low intake of dietary fiber. Dietary fiber has been defined
as the plant polysaccharides and lignin which are resistant to hydrolysis
by the digestive enzymes of man. The main components of dietary fiber
are cellulose, hemicellulose, pectic substances (polygalacturonic acid
compounds) and lignin (2). Different components of dietary fiber have
different physiological effects. Pectic compounds have been reported to
be effective in lowering serum cholesterol, and compounds from wheat
bran stimulate colonic function (3,4).

Dietary fiber consumption can be estimated from food balance sheets.
These assess the national food supply by adding imported food and home
produced food and by subtracting exported food and food used by non-civi-
lians. According to Dutch food balance sheet data (5-7), dietary fiber
consumption has changed. It decreased between 1951 and 1961, mainly
because of a decline in the consumption of bread, other unrefined cereal
products, and potatoes (Table 1). Although the consumption of these
products continued to decrease in the following decades, total dietary

fiber consumption did not decrease, because of an increase in the
consumption of other vegetables and fruits.

Table 1. Dietary fiber consumption in The Netherlands per person per day
as determined from Dutch food balance sheets, 1951-1976 (5-7)

| foods | dietary fiber intake | | | | | |
| | 1951 | | 1961 | | 1976 | |
	gm./day	% of daily intake	gm./day	% of daily intake	gm./day	% of daily intake
bread and						
cereals	13.6	50	9.9	41	8.0	32.5
potatoes	6.4	24	5.5	23	5.2	21
other						
vegetables	4.6	17	5.1	21	6.3	26
fruit	1.7	6	2.3	10	3.5	14
other						
(nuts, raisins,						
chocolate,						
etc.)	0.7	3	1.2	5	1.6	6.5
Total	27.0	100	24.0	100	24.6	100
Energy						
(kcal per day)	2,820		2,930		2,955	
Dietary fiber (gm.						
per 1,000 kcal)	9.6		8.2		8.3	

Since food balance sheet data can give only a very rough picture of
the annual per capita availability of foods (8), we decided to conduct a
survey to assess total dietary fiber and pectin intake of a representative
sample of the adult Dutch population (25 to 65 years of age), using a
seven-day record method. As a byproduct we obtained an estimate of the
size of a sample providing one-day records that is required to give the
same precision as seven-day records for assessing the average energy and
dietary fiber intake of a group.

METHODOLOGY

Selection of the population sample

In order to obtain a sample that was representative of the Dutch
population, a random sample of 150 adults (25 to 65 years old) was taken
from the registration of the municipality of Rhenen (a city with 15,500
inhabitants). The population of Rhenen has been shown to resemble the
Dutch population in the following demographic characteristics (9):

. Distribution of different age categories: zero to 19 years of age, 37
   and 36 percent for Rhenen and the Netherlands, respectively; 20 to 39
   years of age, 26 and 26 percent; and 65 years of age and older, 11 and
   10 percent.

. Proportion of people married: 49 percent for Rhenen and 48 percent for
   the Netherlands.

. Number of persons per household: 3.6 for Rhenen and 3.7 for the
   Netherlands.

. Educational level of the working population: elementary school, 43 and
   34 percent for Rhenen and the Netherlands, respectively; high school,
   40 and 44 percent; college and postgraduate level, 6 and 7 percent;
   and unknown, 11 and 15 percent.

. Distribution of workers over occupational categories: 69 white collar
   workers per 100 blue collor workers for Rhenen and 87 per 100 for the
   Netherlands.

Data collection

The advantages and disadvantages of different dietary survey methods
have been reviewed by Marr (10). As no single method has been shown to
give completely accurate results and to be free from the limitations of
carrying out consumption studies with free-living subjects, the choice

of the method to be used depends primarily on the objectives of the study. Other factors influencing the choice of method include: the characteristics of the people to be tested and the availability of funds, personnel, time, and equipment (10,11).

To reach the objective of our study, we selected a seven-day record method. We asked the participants to note, in specially designed diaries, their daily food consumption in household measurements for seven successive days in January and February 1977. Trained dietitians and postgraduate students in human nutrition visited the participants on four occasions. The first visit was an introductory talk to explain the objectives of the study and to ask subjects to participate. A second visit was made one day before the participants were scheduled to start with their food-intake records for seven days. During this visit instructions on filling in the diaries were given. Three days later a third visit was made to check if the participants did fill in the diaries correctly. During the last visit (one day after the participants had finished their food-intake record), the diaries were checked and portions of foods frequently used were weighed. According to earlier studies, such a method is comparable with a seven-day weighing inventory but is considered less demanding for the participants (12,13).

In order to avoid bias in the information on food intake through systematic differences in consumption on different days of the week, an equal number of persons commenced recording their food intakes on each day of the week.

Calculation of nutrient intake

Each item on the food record was coded by the interviewer and checked by a colleague. For the conversion into nutrients, we used a computer program based on a nutrient file compiled from the Dutch food composition table (14,15) and from additional data on dietary fiber and pectin (Table 2)

Table 2. The proportions of dietary fiber and pectin in some foods[*]

foods	dietary fiber	pectin[+]
	gm./100 gm.)	
whole wheat bread	8.5	0.1
white bread	2.7	0.1
potatoes (Solanum tuberosum L.), old, cooked	3.0	0.2
carrots (Dauscus carota L.), raw	3.2	0.7
lettuce (Lactuca sativa L.), raw	1.3	0.3
peas (Pisum sativum L.), canned	4.7	0.2
tomatoes (Solanum lycopersicum L.), raw	1.4	0.3
apples (Malus pumila Mill.), flesh only	2.2	0.5

[*] Data from Stasse-Wolthuis et al. (28) and from Katan (32).
[+] Values are expressed as polygalacturonic acid; 1 gm. pure citrus pectin contains about 0.8 gm. polygalacturonic acid.

Statistical methods

A mixed model analysis of variance (20) with two factors was applied, namely random person's effects and fixed day-of-the-week effects. Expressions were derived for sample sizes of equivalent one-day and seven-day record methods. These expressions make it possible to estimate, for instance, the number of participants giving one-day records that would have been needed to equal the precision of the 100 participants giving seven-day records in this study.

RESULTS AND DISCUSSION

Respondents

One hundred reliable records were received from the 150 persons contacted; 7 were away at the time of the study; 7 submitted unreliable records; and 36 refused to participate. The group that did provide reliable records was still representative of the adult population of Rhenen with regard to age, sex, and the average number of persons per

household. In comparison with other studies, the non-response rate of 33.3 percent is not exceptionally high (10).

Energy and dietary fiber intake

Average energy intake was 2,370 kcal (2,790 kcal for men and 2,040 kcal for women) per day; protein, carbohydrate, fat, and alcohol contributed 14, 42, and 4 percent of kilocalories, respectively. This level and pattern of energy intake can be considered as "normal" for an adult population in a highly industrialized country where people, generally speaking, do not perform heavy physical work.

As shown in Table 3, mean dietary fiber consumption for the group was about 24 gm. per day. The mean dietary fiber intake per 1,000 kcal was 10.5 gm.

Table 3. Intake of dietary fiber and pectin in adult Dutch men and women assessed by a seven-day record method

fiber and pectin	men (n=44)	women (n=56)	total sample (n=100)
dietary fiber (gm./day)	27.5 ± 7.8[*]	21.3 ± 4.7	24.0 ± 6.9
dietary fiber (gm./1,000kcal)	10.1 ± 2.5	10.8 ± 2.6	10.5 ± 2.6
pectin (gm./day)	2.5 ± 0.8	2.4 ± 0.7	2.4 ± 0.8

[*] Mean ± standard deviation.

This is comparable with other data collected in food consumption studies by our institute for other groups of the Dutch population. In a large number of 6- to 10-year-old school children (n=675), average dietary fiber intake was 9.2 gm. per 1,000 kcal (21): in 136 adolescents a value of 9.7 was found (22); and about a hundred adult men forming part of the Dutch cohort of the Seven Countries Study (23) were found to consume an average of 8.8 gm. of dietary fiber per 1,000 kcal (24).

The Dutch food balance sheets for 1976 indicate a dietary fiber availability in the daily food intake of 24.6 gm. or 8.3 gm. per 1,000

kcal (Table 1).

The level of dietary fiber intake in the Netherlands seems to be close to that recently reported for West Germany and Great Britain. Average daily intake of dietary fiber was about 22 gm. per day for various West German groups (25), 19.9 gm per day for British adult population (26), and 24 gm. per day for our subjects. The Germans, however, derived an average of 11 gm. per day from cereals and the British only 6.1 gm. For the Dutch this figure was 7.7 gm. Although these differences partly reflect the amounts of bread consumed (27,28), the type of bread also appears to play a role. In 1978, white bread accounted for about 80 percent of the British bread consumption (29), whereas in West Germany dark, fiber-rich bread is generally consumed. The situation in the Netherlands is intermediate, with 50 to 60 percent of the bread consumed being brown or wholemeal (7). Such data suggest that the differences between these countries in the consumption of specific types of fiber may be appreciable and larger than the differences in total fiber intake.

Pectin intake in our study was 2.4 gm. per day as opposed to 3 gm. for British subjects (26). However, the methods used to determine the pectin contents of foodstuffs were not comparable, which makes the apparent difference in pectin intake difficult to interpret.

Important food sources of dietary fiber and pectin

Table 4 shows the sources of dietary fiber and pectin, devided into five main groups of foodstuffs. The large standard deviations show that the main sources of fiber varied widely between persons. Thus, measurement of the consumption of just a few fiber sources (e.g., bread and vegetables) would lead to large errors in the estimation of total fiber intake. As already suggested by the food composition data in Table 2, most of the dietary pectin was contributed by fruits and vegetables. Thus, measurement of the consumption of fruits and vegetables alone might

be a useful shortcut method for estimating pectin intakes.

Table 4. Contribution of various food groups to the average dietary fiber and pectin intake of an adult Dutch population (n=100)

food	dietary fiber		pectin	
	gm./day	percent of intake	gm./day	percent of intake
bread and cereals	7.7 + 5.4[*]	32	0.18 + 0.09	7
potatoes	4.1 + 2.5	17	0.35 + 0.22	14
other vegetables	5.7 + 3.3	24	0.81 + 0.31	34
fruit	3.6 + 2.4	15	0.96 + 0.63	40
other sources	2.9 + 3.2	12	0.11 + 0.08	5
total intake	24.0	100	2.41	100

[*] Mean + standard deviation.

Identification of subgroups with high or low fiber intakes

In order to evaluate different ways of identifying subjects with high or low dietary fiber intake in the community, subjects were divided into quartiles according to either their average daily fiber intake or their intake per 1,000 kcal (fiber density). Men and women in the lowest quartile of total fiber intake ate less than 21.4 and 18 gm. per day, respectively, while men and women in the highest quartile of the distribution ate more than 30 and 22.5 gm. per day, respectively. The very narrow range of dietary fiber intake of women is due to a narrow range of energy intake and also to little variation in eating patterns.

As shown in Figure 1, classification by fiber density of the diet (grams of fiber per 1,000 kcal) yielded entirely different groups of high and low fiber consumers. For example, eight subjects (indicated by encircled points in Figure 1) fell into the highest quartile of fiber consumption according to one classification but into the lowest quartile according to the other.
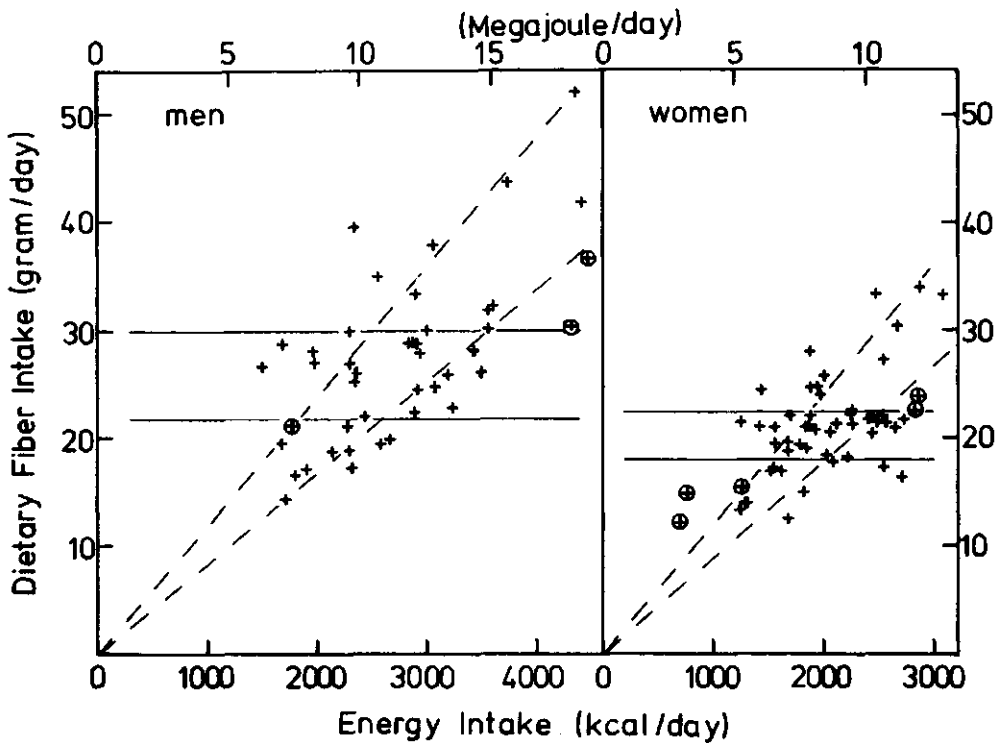
Fig. 1. The relation between the average daily dietary fiber and energy intake. The horizontal lines represent the 25th and 75th percentile of total dietary fiber intake, expressed in grams per day. The oblique broken lines represent the 25th and 75th percentile of fiber density, i.e. the dietary fiber intake expressed in grams per 1,000 kcal. All points to the left of the upper broken line refer to subjects with fiber densities in their diets exceeding the 75th percentile of fiber density. Encircled points refer to subjects with absolute fiber intakes above the 75th percentile but fiber densities below the 25th percentile, or vice versa.

More than half of the participants who were graded as low medium, or high fiber consumers by one criterion would have to be reclassified if the other criterion were used. If this should prove to be a general finding, then the interpretation of epidemiological studies relating fiber consumption to disease may depend on whether intake is expressed in grams per day or grams per 1,000 kcal. There appears to be at present no physiological reason to prefer either method.

Differences between dietary fiber intake on weekdays and weekends

Food consumption patterns of individuals are known to vary considerably from day to day (10). However, part of this apparent variation may be due

to systematic effects of specific days of the week on food intake. Analysis
of variance did in fact reveal a significant between-days effect on the
intake of dietary fiber. This can mainly be attributed to a difference
between dietary fiber intake on days during the week and during weekend.
As shown in Table 5, dietary fiber intakes were significantly lower during
the weekends. This stresses the importance of a design that is well-balanced
over the days of the week in order to avoid bias in the estimation of the
population mean.

Table 5. Comparison of the dietary fiber intake on weekdays (Monday to
Friday) and on weekends (Saturday and Sunday)

days	dietary fiber intake			
	men (n=44)		women (n=56)	
	gm./day	gm./1,000 kcal	gm./day	gm./1,000kcal
weekdays	28.7 ± 8.5*	10.7 ± 2.8	21.9 ± 5.0	11.4 ± 2.7
weekends	24.5 ± 10.2	8.8 ± 3.7	19.7 ± 6.7	9.6 ± 3.5
significance of the difference	$p < 0.01$	$p < 0.01$	$p < 0.05$	$p < 0.01$

* Mean ±standard deviation.

Sample size requirements for different designs

The aim of a food consumption study is often to obtain an estimate of
the mean intake of energy or of certain nutrients in a population. The
precision of the estimated group mean, as expressed by its standard error
or variance, depends on the number of subjects or respondents (N), the
number of daily records (k) provided by each respondent, the between-subject
variance (V_B), and the residual within-subject variance (V_R). The precision
can be increased by increasing N or k or both. The variance component V_B
cannot be influenced by the investigator, and the variance component V_R to
only a small extent. The variance component V_R includes random day-to-day

variations within one person and errors in measurement. The variance (V_M) of the estimated group means can be expressed as: $V_M = (V_B + V_R/k)/N$.

As can be seen from this formula, increasing the number of food record days (k) reduces only the contribution of the variance component V_R, whereas the contribution of both variance components is influenced by the sample size. A certain required precision (e.g., a 95 percent confidence interval, not greater than about 10 percent of the mean value) does not fix k and N but can be attained by a number of equivalent(k,N) combinations. The optimal choice for a combination could be based on considerations of cost (20,30). We wish to demonstrate which designs are equivalent in the sense of yielding the same precision and how these different combinations of k and N depend on the ratio of the within-persons variance over the between-persons variance. We will call this ratio λ, where $\lambda = V_R/V_B$.

The design requires that data be collected evenly over the various days of the week. This can be accomplished by increasing the sample size to the nearest multiple of seven and by having an equal number of subjects starting their record(s) on each day of the week.

It follows from the above formula that two different designs can yield the same group mean variance V_M and thus the same precision for the estimated group mean when: $N_k/N_h = (1 + \lambda/k)/(1 + \lambda/h)$, where k and h indicate two different choices for the number of food record-days per subject. In our study the number of days for each person was seven (h=7). It follows that for an equivalent design with a smaller number of food record-days per subject (k), the required sample size is given by:
$N_k = N_7(1 + \lambda/k)/(1 + \lambda/7)$.

The value of λ for a specific nutrient in a specific population can be estimated either beforehand from other data or afterwards, as in the present study. From an analysis of variance with two factors, namely person's effects and day-of-the-week effects, λ may be estimated as

h/ F-1), where F is Fisher's F-ratio of the mean squares of the between-persons component and the residual component of the variance, and where h = 7 in the present case. In Table 6 the results from our study regarding λ and sample size of equivalent designs for the intake of energy and dietary fiber are given. As can be observed from this Table, there is little difference between the λ values of men and women.

Table 6. Fisher's F for the between-persons variance, ratio of observed within-individual variation (V_R) over between-individuals variation (V_B) and calculated ratio of sample sizes in equivalent one-day (N_1) and seven-day (N_7) designs yielding the same precision.

energy and fiber		F[*]	V_R/V_B[+]	N_1/N_7[+]
energy	men	13.01	0.58	1.5
	women	11.32	0.68	1.5
dietary fiber	men	6.44	1.29	1.9
	women	5.62	1.52	2.1

[*] Fisher's F for the between-persons variance.
[+] V_R/V_B = 7/(F - 1) = λ = ratio of the within-persons over the between-persons variation.
[+] N_1/N_7 = (1 + λ/1)/(1 + λ/7) = ratio of sample sizes of equivalent one-day (N_1) and seven-day (N_7) designs yielding the same precision.

These findings show that the precision for measurement of dietary fiber intake obtained by using one-day food records from twice the number of individuals is comparable to that obtained from a seven-day food record. For the measurement of energy intake, only 1.5 times the number of individuals is required for the one-day record method to obtain the same precision as with the seven-day record method.

However, the choice between a one-day and a seven-day record method also depends on the aim of the study. For example, if the purpose is to compare the nutrient intake during the week with that at weekend, a seven-day method would be preferable to a one-day record method. If the

aim is to study the contribution of various food groups to nutrient intake, on an aggregate level, a one-day or two-day record method may be more appropriate.

As an illustration of the use of λ values, we applied them on the results of our own study. The approximate number of one-day records required for a 95 percent confidence interval for the population mean, allowing for a specified imprecision of 2d, is given by the following well-known equation: $N_1 = (4/d^2)(V_B + V_R)$. For a design with k records per person, this generalizes to: $N_k = (4/d^2)(V_B + V_R)(1 + \lambda/k)/(1 + \lambda)$.

In Table 7, estimates of $V_B + V_R$ and the required sample size (N) for one-day and seven-day records are given when d equals 10 percent of the group mean. For comparable values when d equals 5 percent of the group mean, the values of N obtained above should be multiplied by a factor of 4, i.e., $(10/5)^2$.

Table 7. Sample size required to estimate the group mean of energy and dietary fiber intake with a standard error of less than 5 percent, using one-day or seven-day records

energy and fiber		mean	$V_B + V_R$ *	N_1 +	N_7 +
energy (kcal)	men	2,790	930^2	45	31
	women	2,040	640^2	40	26
dietary fiber (gm.)	men	27.5	10.8^2	63	33
	women	21.3	6.8^2	41	20

* $V_B + V_R$: sum of the between-persons variance and the residual
within-persons variance.
+ $N_k = (4/d^2)(V_B + V_R)(1 + \lambda/k)/(1 + \lambda)$ for k = 1,7: number of one- or seven-day records required for a 95 percent confidence interval for the population mean, allowing for a specified imprecision of 2d, where d = mean/10.

The question arises of how far the results given in Table 7 can be applied to other population groups. It is clear that these results depend on the sum of the residual within-person and between-person variance and on the ratio of

the two variances (λ). At present, the literature provides only a few estimates of this ratio, and the values reported vary widely. For instance in a study involving 30 men and 30 women, Beaton et al. (30) reported a value of λ for the energy intake of 1.0 and 1.2, respectively. In our study we found a value of 0.58 for men and 0.68 for women, whereas Liu et al. (31) reported a value of 1.8 for 181 Japanese men living in Japan and a value of 2.2 for 318 Japanese men living in Hawaii.

In comparing these results, one should bear in mind that in addition to different life styles and food habits, the design of the study may also influence the value of λ. Dietary survey method (record or recall), interviewer, day of the week, and possibly effects of time all contribute to the residual variance in addition to the variability of a person's daily consumption under similar circumstances.

In data presently available, there is a tendency for λ values to be relatively low for energy intake, intermediate for protein, fat and carbohydrate, and high for fatty acids, dietary fiber, minerals, and . vitamins.

In conclusion we recommend, in order to estimate sample size, that the ratio of the residual (V_R) over the between-persons variance (V_B) - i.e., λ - for different nutrients be estimated. The value of λ can be estimated either from other data collected beforehand or from a pilot study.

SUMMARY AND CONCLUSIONS

The intake of dietary fiber was studied in an adult Dutch population aged 25 to 65 years using a seven-day record method. It was found to be 24.0 ± 6.9 gm. per day (mean $\pm$ SD) or 10.5 ± 2.6 gm. per 1,000 kcal. The dietary fiber intake per 1,000 kcal (fiber density) was virtually identical to that observed in other age groups of the Dutch population

and somewhat higher than values calculated from the Dutch food balance sheets (8.3 gm. per 1,000 kcal). The intake of pectin (as polygalacturonic acid) was 2.4 ± 0.8 gm. per day.

Important sources of dietary fiber were bread and other cereals (32 percent of daily intake), potatoes (17 percent), other vegetables (24 percent), and fruits (15 percent). For pectin, the proportions in those foods were 7, 14, 34, and 40 percent of the daily intake. Comparison with German and British figures suggests that, although overall intakes of dietary fiber are similar to those in the Netherlands, differences in consumption of dietary fiber from specific sources such as bread may be appreciable.

The intake was significantly higher on weekdays than on weekends.

Ranking the subjects by absolute dietary fiber consumption, expressed in grams per day, and by fiber density of the diet, expressed in grams per 1,000 kcal, yielded entirely different results. Therefore, if one wants to select individuals with "high" or "low" dietary fiber consumption, the decision as to whether the basis of the classification is total daily intake or fiber density of the diet has a great impact on the result.

For estimating group means of daily dietary fiber intake, equal precision can be obtained by using a seven-day record method or by collecting one-day records from twice the number of the subjects.

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4. VALIDITY AND REPRODUCIBILITY OF A DIETARY HISTORY METHOD ESTIMATING THE USUAL
FOOD INTAKE DURING ONE MONTH.

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SUMMARY

   The validity and reproducibility of a dietary history method with a time of
reference of one month was assessed with 44 young adults (aged 19-32 years). The
concurrent validity of the method was assessed by means of the 24-hour urine
nitrogen excretion. The mean difference between N-intake and N-excretion
(24-hour urine N-excretion plus 2 g for extra renal nitrogen losses) was 0.0 g
with 95%-confidence limits of $\pm$ 1.1 g. These limits for the mean difference
between excretion and intake indicate a valid assessment of the protein intake
of this group.
   The reproducibility was evaluated in the same group through a test-retest
design. The intraclass correlation coefficients were high over a weighted
average of week-days and for an average workday as regards the intakes of energy
and selected nutrients. As to the Saturday and Sunday intakes, the intraclass
correlation coefficients were lower for the energy intakes and most of the
nutrients (except alcohol), indicating a poorer reproducibility for week-end
assessments.

KEY WORDS: Dietary methods, validity, reproducibility, nitrogen excretion.

In the context of a longitudinal study on the etiology of obesity in young adults a methodological study was carried out on the validity and reproducibility of a dietary history method. This method is one of the preferred methods available to estimate the usual dietary intakes of individuals. The quality of methods estimating food consumption can be expressed by their validity and reproducibility. Validity tries to give an answer to the question whether the method actually measures what the investigator intends to measure. The central methodological problem of food consumption studies is that there is no "golden standard" for directly assessing the validity (1, 2). This is especially a problem for the dietary history method, since this method estimates the habitual food intake over a longer period of time up to one year. Therefore investigators usually determine either the relative validity, i.e. comparison with the weighed record method, or the concurrent validity, i.e. comparison with clinical or biochemical criteria. In former reports, the relative validity (3, 4, 5, 6, 7) as well as the concurrent validity (8, 9, 10)of the dietary history method has been evaluated. In a review on the validity of dietary assessment methods Block (1) concludes that it is difficult to gather from the reports published, whether a dietary history is a valid method in the sense of that it reflects the nutrient intake accurately. In Block's report no validation of nitrogen intake against 24 hour urine nitrogen excretion (10, 11, 12) is included. As this method is considered (13) as one of the best biochemical criteria against which to validate a dietary intake method, we decided to validate the dietary history method on an aggregate level against this biochemical marker.

Hankin et al. (14) have recently reported on the reproducibility of a dietary history questionnaire. An assessment is called reproducible if it gives the same

results in the same situation. In Hankin's study the dietary history covered a
usual week of the subjects; in order to test the reproducibility of the method,
another usual week was selected within three months after the first interview.
They suggested that in studying the food consumption of Caucasians for most
nutrients a longer period was required to estimate the usual intake. Our study
concerns the concurrent validity and reproducibility of a dietary history method
in which the usual food consumption of a specific month was recalled.

METHODS

Selection of samples. Young adults aged 19 to 32 years were contacted by
telephone in a town (more than 30,000 inhabitants) near Wageningen. The
methodological character of this study does not require a representative sample.
Based on data found in literature, about 50 young adults would be sufficient to
obtain an "acceptable imprecision" in the estimated mean difference between
nitrogen excretion and nitrogen intake (10, 17), i.e. the half width of the
95%-confidence interval of the mean difference is ten per cent of the level of
nitrogen excretion or less.

Collection of data. A dietary history method based on Burke's method (15) was
carried out in March 1980 (first interview) and in April 1980 (second
interview). The participants were visited at home by dietitians and post-
graduate students in human nutrition trained for this purpose. The training
included interview training, estimating portion sizes and coding. To assure
comparability in the data all interviewers coded several times the same
interview. Each subject was visited by the same interviewer for the test
interview as well as for the retest interview. In both interviews the
participants were questioned about their usual food consumption of the preceding
month. The questionnaire was open-ended and consisted of three parts: one for
the usual food consumption on a workday, one for the usual consumption on a

Saturday and one for the usual consumption on a Sunday. Workdays, Saturdays and Sundays were recorded separately because earlier studies have shown systematical weekend effects on nutrient intake in comparable groups (16, 17, 18). From these data a weighted average of week-days was calculated according tot the formula

$$\frac{(5 \times \text{workday} + 1 \times \text{Saturday} + 1 \times \text{Sunday})}{7}.$$

Portions of food frequently consumed were checked for weight. A Soehnle 8600 balance was used by the dietitian for weighing, e.g. slices of bread, spreads on bread such as butter, contents of cups, glasses and dishes for porridge or pudding, sugar and milk in coffee and tea. Other portions of food not directly available at home were estimated.

Food consumption was converted into nutrient intake using a computer programme based on a nutrient file compiled from the Dutch food composition table (19).

Twenty-four-hour urine was collected twice in two and a half litre containers with five ml of a ten percent thymol solution in isopropanol to prevent oxidation. For the whole group, collecting was evenly distributed over all days of the week in order to obtain the mean urine nitrogen excretion of an average week-day. The total nitrogen content of urine was determined by the Kjeldahl method. To express nitrogen excretion in terms of protein or nitrogen intake the formula of Isaksson (10) was applied:

$$\frac{\text{Protein intake in 24 hour}}{6.25} = \underset{\substack{\text{Intake in} \\ \text{24 hours}}}{N} = \underset{\substack{\text{Excretion in} \\ \text{24 hour urine}}}{N} + 2\,g$$

Two grams of nitrogen were added to the 24-hour nitrogen excretion in urine to compensate for losses via faeces and skin. As this amount depends on the

quantity and quality of protein consumed and on the nutritional status and physical activity, it was tested first whether extra- renal nitrogen losses for young Dutch adults also were about 2 g. For this purpose data were available from a previous experimental study in this group. The protein content of their diet was in accordance with the average Dutch diet. Food consumption had been assessed by a 4-day weighing method, and conversion into nitrogen intake had been carried out by analyses of nitrogen in foods, furthermore nitrogen excretion had been determined in 24-hour urine as well as in faeces (20). Table 1 shows that the amount of 2 g a day is applicable to Dutch circumstances. Both the difference between daily nitrogen intake and urine nitrogen excretion, and the sum of faecal and dermal nitrogen losses are 2 g.

Table 1. Nitrogen intake and nitrogen excretion via urine, faeces and skin during 24 hours in young adults (aged 18-28 years). Data from Van Raaij (20).

	Mean	s.e.	Method	N
	g	g		
N-intake (N_I)	13.9	0.5	4-day weighed record Nitrogen analyses in foods consumed	64
Urine N-excretion(N_E)	11.9	0.4	Kjeldahl	64
$N_I - N_E$	2.0	0.45		64
Faecal N-excretion	1.6	0.1	Kjeldahl	68
Dermal N-excretion	0.4	0.01	Estimated as 0.005 g/kg body weight (21)	69
Faecal and dermal N-excretion	2.0	0.1		68

Statistical methods. In order to assess the concurrent validity the mean of the differences between individual pairs of measurements and 95 per cent confidence limits were calculated. The mean difference reflects the systematic departure between the estimation of nitrogen intake as assessed by the dietary history and as assessed by the nitrogen excretion in urine.

To evaluate the reproducibility, the standard deviation of individual differences and the intraclass correlation coefficients between the first and the second estimation, as advocated by Lee (22), were calculated.

Table 2. Comparison of N-intake in grams per day as determined by the dietary history method (N_I) and as estimated from urine N-excretion per 24 hours including 2 g for extra-renal N losses (N_E) in young adults.

	Total group (n=44) g	Men (n=22) g	Women (n=22) g
N-intake (N_I)	13.3* (0.51)	14.6 (0.77)	11.9 (0.55)
N-intake (N_E) estimated from:			
urine N excretion	11.3 (0.46)	12.4 (0.60)	10.1 (0.63)
and extra-renal losses	2.0	2.0	2.0
$N_I - N_E$	0.0 (0.50)	0.2 (0.94)	-0.2 (0.57)
Confidence limits $N_I - N_E$	-1.1 and 1.1	-1.6 and 2.0	-1.5 and 1.1

* Mean; standard error between brackets

RESULTS

Population. Out of the 47 persons who agreed to participate, 44 (22 men and 22 women) were able to complete the whole task: two dietary history interviews

and collecting 24-hour urine twice. Three women completed the dietary history interviews, but were not able to collect the urine.

Concurrent Validity. Table 2 shows the results of a comparison between the daily nitrogen intake for a weighted average of week-days as estimated by the first dietary history interview and as estimated from the 24-hour urine nitrogen excretion. The mean difference was 0.0 g with 95% confidence limits of $\pm$ 1.1 g. This result seems to support the hypothesis that there is no difference between excretion and intake for the aggregated group values. On the other hand, it should be born in mind that there is considerable variation in individual differences between estimated intake and excretion.

The sex-specific mean difference between intake and excretion was 0.2 g and -0.2 g with confidence limits of -1.6 to 2.0 and -1.5 to 1.1 for men and women respectively. The 95 per cent confidence limits of this mean difference are rather wide, especially for the men. In fact, the number of subjects in the subcategories men and women is too small to draw firm conclusions.

Reproducibility. Table 3 shows the results of both dietary history interviews over a weighted average of week-days, a workday, a Saturday, and a Sunday. The assessed nutrient intake resulting from the second interview does not differ significantly from that of the first interview on an aggregate level. However, whereas validity concerns systematic deviations between two methods, reproducibility concerns random fluctuations in repeated measurements by the same method on various occasions. The intraclass correlation coefficient quantifies the extent of overall agreement on an individual level between the two interviews. The high correlation coefficients indicate agreement between the

Table 3. Reproducibility of a dietary history interview on an aggregate level (mean) and on an individual level (SD of difference) over a weighted average of week-days, a workday, a Saturday, and a Sunday (n=47).

	Energy (kcal)	Protein (g)	Fat (g)	Sat.Fat (g)	Linoleic acid(g)	Carbohydrate (g)	Dietary fiber(g)	Alcohol (g)
weighted week-day								
first interview (mean)	2352	82	101	45	12	256	24	12
second interview (mean)	2327	79	103	46	14	248	23	12
SD of differences	434	14	26	9	7	46	6	8
intraclass correlation	0.86	0.80	0.81	0.89	0.67	0.87	0.75	0.91
Workday								
first interview (mean)	2321	84	101	45	12	255	26	8
second interview (mean)	2247	78	100	46	13	243	24	8
SD of differences	442	16	27	8	8	51	7	8
intraclass correlation	0.87	0.79	0.85	0.93	0.64	0.86	0.72	0.87
Saturday								
first interview (mean)	2573	82	107	46	14	271	20	28
second interview (mean)	2641	82	112	47	16	280	20	27
SD of differences	1026	35	54	25	9	112	10	21
intraclass correlation	0.54	0.70	0.52	0.46	0.64	0.47	0.50	0.85
Sunday								
first interview (mean)	2286	77	96	43	11	248	20	17
second interview (mean)	2410	79	110	47	15	245	20	17
SD of differences	608	28	44	15	11	62	87	11
intraclass correlation	0.68	0.57	0.53	0.62	0.41	0.76	0.59	0.90

first and the second dietary history interview over a weighted average week-day.
The lowest correlation coefficient was found for linoleic acid (0.67) and the
highest for alcohol (0.91). High correlation coefficients were also found for
energy and nutrient intakes during an average workday. The sex-specific results
of the intraclass correlation coefficient were very similar to those for men and
women pooled.

The intraclass correlation coefficients for Saturday and Sunday are much
lower. Very low correlation coefficients were found for the Saturday intakes of
saturated fat (0.46) and total carbohydrate (0.47); the agreement between the
first and the second interview on Saturday as regards alcohol intake seems to be
much better (0.85), but this is partly due to non-alcohol users. The correlation
coefficients for the two interviews on Sunday are also low, especially as
regards linoleic acid (0.41).

DISCUSSION

The positive results found on the concurrent validity of the dietary history
method correspond with the findings of Isaksson and indicate that a valid
assessment has been made on the intake of foods containing protein. It might be
concluded that it would also be an unbiased estimation for energy, fat and
carbohydrate from these products. However, various foods do not contain any
protein, for example sugar, oils and butter, alcoholic drinks and soft drinks.
This makes it unwarranted to extrapolate the concurrent validity simply towards
other nutrients. As to energy, Isaksson (10) suggests that the contribution from
protein to the total energy may be a fixed proportion in groups of subjects. In
comparable groups of Dutch adults the percentage of energy from protein varies
from 12 to 15 (17, 18, 23), which is indeed a small fluctuation.

In literature the validity of the dietary history method is mostly determined
by comparing this method with a seven-day food record or a 24-hour recall

method. The results of these studies show that the dietary history method in
general produces higher estimates than the two other methods (4, 5, 6, 7). Our
study does not indicate an overestimation of the protein intake. However, in
comparing our results with those of the other studies it should be realized that
in the former the estimated "usual" consumption refers to a fixed rather short
period of time as opposed to a longer period (six months to one year) in the
latter.

Our study demonstrates a good reproducibility of the dietary history method
(Table 3). This confirms earlier findings of studies evaluating the same method
over longer periods of time (24, 25, 26).

Table 4 compares the reproducibility in the daily intake of fat, saturated
fat and animal protein by women in the present study on the one hand and by
Hankin et al. (14) with a dietary history method questionning a usual week on
the other hand. Hankin et al. have tested the reproducibility of a dietary
history questionnaire in a case control study on breast cancer with Caucasian
and Japanese women in Hawaii. Their findings seem to indicate that the dietary
history method is not reproducible for the Caucasian controls. The higher
correlation coefficients in our study reflect a greater consistency in the
intakes measured over one month than over one week.

Table 4. Comparison of the reproducibility of the daily intake of fat, saturated fat and animal protein as determined by a dietary history method with a time of reference of a "usual" week (Hankin et al., 1983) and a dietary history method with a time of reference of a selected month (Van Staveren et al., 1985)[*]

| | Hankin et al., 1983 Caucasian women (n = 33) | | | | | van Staveren et al., 1985 Caucasian women (n = 25) | | | | |
	First interview (mean ± SD)	Second interview (mean ± SD)	Difference mean	SD	Intraclass correlation coefficient	First interview (mean ± SD)	Second interview (mean ± SD)	Difference mean	SD	Intraclass correlation coefficient
Total fat (g)	64.6 ±24.8	52.4 ±23.6	12.2[+]	-	0.41	79.2 ±26.4	80.4 ±28.7	-1.2	19.7	0.75
Saturated fat (g)	22.1 ±9.4	18.0 ±7.7	4.1[+]	-	0.32	36.2 ±13.0	35.9 ±12.9	0.4	5.5	0.91
Animal protein (g)	48.6 ±16.5	40.1 ±14.9	8.5[+]	-	0.12	53.4 ±14.1	47.5 ±13.2	5.9[+]	7.7	0.76

*) Apart from a difference in the reference of time, there are also differences as regards the time lag between the first and the second interview (3 months for Hankin and 1 month for Van Staveren) and the way of measuring the amounts of food consumed. Hankin used pictures of standard-size servings and did a recall over 43 food groups, whereas Van Staveren included all food items and weighed the portions most frequently consumed.

+ Denotes that the mean difference between the first and the second interview is significantly different from zero ($p < 0.05$).

In comparing our results with those of Hankin's study, it should be realized that, in addition to differences in the time of reference, the time lag (one month versus three months) and the technique of measuring the amounts of foods consumed differed. Hankin questionned the subjects on 43 items or food groups, which contributed about 85% of the total fat and animal protein intakes. She estimated the amounts of foods consumed by means of pictures of standard-size servings.

In summary the results of our study indicate that a dietary history with a time of reference of one month may give a valid estimation of the nitrogen and thus protein intake, and reproducible estimations for intakes of energy and macronutrients in adult Caucasians.

ACKNOWLEDGEMENTS

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5. COMPARISON OF CONTEMPORANEOUS AND RETROSPECTIVE ESTIMATES OF FOOD
CONSUMPTION MADE BY A DIETARY HISTORY METHOD.

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SUMMARY

In 1983 the relative validity of a retrospective dietary history method
(DH'R) was assessed against a current dietary history method taken seven years
previously in 1976 (DH'76) and a second current dietary history taken in 1983
(DH'83). In total 44 men and 58 women, aged 38-62 years participated in the
study.

For energy intake and for most nutrients, the relative difference between
DH'R and DH'76 was below 15 per cent and for six of the 11 nutrients reported
below ten per cent. When the three main macronutrients (protein, fat and
carbohydrate) were expressed as a proportion of energy intake, the relative
difference was also below ten per cent. The difference between energy and
nutrient intake reported contemporaneously and retrospectively appears to be
comparable with or slightly more than the reported change in food consumption
between 1976 and 1983. Similar results were found for food groups. An
appropriate method for assessing food intake in the distant past also may be a
current dietary history supplemented with information on the frequencies of
food consumed in the period for which the intake information is required. The
data obtained retrospectively correlate rather well with the results of the

current dietary history taken in 1983 suggesting an effect of contemporaneous food habits on retrospective reporting.

KEYWORDS: diet; epidemiologic methods; interviews; retrospective studies.

In research on the etiology of cancer related to food intake, it is often essential to have information on the dietary patterns of cases and controls some time before the onset of symptoms because of the long latency period of most types of cancer. Therefore, it is necessary to assess the food consumption in retrospect.

The dietary history method may be the most adequate method for this purpose. This method yields information from an individual about his or her usual food intake over a specific period of time (1) and is applicable for studying usual dietary patterns in the past (2-6).

In an earlier study we reported on a comparison of a retrospective dietary history method with a seven-day record taken four years previously (7). As was then suggested part of the reported difference between the two dietary assessments may have been due to the different methods used. In this study a retrospective dietary interview in 1983 is compared with a dietary history taken in 1976, seven years previously. In addition, the current daily intake in 1983 was measured by a current dietary history. By doing so we hoped to establish whether present intake influences responses in the retrospective dietary history method.

MATERIAL AND METHODS

Sample selection

In the spring of 1976 the Department of Human Nutrition carried out an assessment of usual food consumption during the winter period October 1975 to

March 1976 (DH'76) among residents of Harderwijk (population about 31,000), the
Netherlands. This group (mean age 43 years) consisted of 74 men and 88 women
(8). Of the original study participants, 146 (90%) were relocated in 1983 and
asked if they would take part in this further study.

Data collection

For those agreeing to participate in the current study, two interview
appointments were scheduled for the spring of 1983. At the first interview, a
dietary history (DH'R) was taken concerning the same period as was examined
seven years before: the winter period October 1975 to March 1976 and with
respect to workdays only (Mondays to Fridays). Six weeks later (range 2-10
weeks) a second interview was carried out concerning the winter period October
1982 to March 1983 (DH'83).

The first interview (DH'R) began with the collection of sociodemographic
data (date of birth, educational level, marital status, family size),
anthropometric data (height, weight), information on such habits as food
purchasing, food preparation and dieting, and some questions about the
situation in the household in 1976 (e.g. working schedule of the man, school
hours of the children and passtimes affecting the time of meals). Such
questions were designed to facilitate the recollection of food habits at that
time. To assess dietary consumption, respondents were asked about their usual
dietary pattern in the past following a method adapted from that of Burke (9),
including a cross-check list in chronological order throughout the day, and
finally, the weighing of the following items (scale: Sartorius 1020, d = 1
gram): margarine on bread, sandwich spreads, sugar and/or milk in coffee and
tea, the contents of a cup, glass or mug, of a soup plate and of a gravy spoon.
Other portion sizes were estimated in standard household measurement. In the
second interview, (DH'83) the usual dietary pattern at the present time was
assessed. In addition, information was sought about perceived changes in

dietary patterns over the last few years. Each interview took approximately one hour. All interviews were carried out by four postgraduate students in nutrition (PB, AFMK, GAFCvP and HJAS) who had received training in this method.

Calculation of food and nutrient intake

Dietary histories were coded by the interviewer at the first opportunity. A computer file of the 1982 Dutch food composition table was used for conversion into nutrients (10). The 1976 data then were recoded in terms compatible with the 1982 food composition table. Foods were grouped on the basis of their nutrient value and their place in the Dutch menu pattern.

Statistical methods

Data from the three dietary histories (DH'76, DH'R and DH'83) were compared in respect of the amount of energy and nutrients and of frequently consumed food groups. Means, standard deviations and Pearson correlation coefficients were calculated for energy and nutrients. Individual differences between each pair of measurements were also considered, and their means (with 95% confidence limits) and standard deviations were computed. The difference between two pair-dependent correlation coefficients was tested according to Hotelling (11). The distribution of consumption of food groups was skewed, therefore the food groups median intakes and Spearman rank correlation coefficients were calculated. Also for the pair differences considered, median and spread were computed, the latter calculated as the difference between the third quartile (75th percentile) and first quartile (25th percentile) of the distribution of differences. In epidemiologic research it is usually sufficient to locate individuals in broad categories of the variables of interest. Therefore the subjects were classified into tertiles of low, medium and high intake for energy and nutrients as reported by DH'76 and DH'R; the agreement between these two measures of dietary intake was assessed by the statistic kappa (12).

RESULTS

Of the 146 persons contacted, 102 were willing to participate in the present
study. These were 44 men and 58 women ranging in age from 38 to 62 years of age
with a mean age of 47 years.

Eleven respondents found to be on a diet in 1976 were excluded since they
were not considered to be eligible for this study. The subjects were on a diet
only temporarily, while retrospectice studies refer to food habits over the
long-term. Some of these respondents reported with exactness what they had
consumed in 1976, whilst others did not recall the precise period during which
they were dieting and consequently reported a very different food intake.

As no data for DH'83 were recorded for three participants, data are
available from 91 participants for DH'76 and DH'R but only from 88 participants
for DH'83. Selected characteristics of the participants are presented in
Table 1.

Table 1. Selected characteristics of the participants in the study comparing
contemporaneous and retrospective estimates of food consumption by a dietary
history method.

	Males (n = 41)		Females (n = 50)	
	Mean	SD	Mean	SD
Age (yr)	49.7	6.6	47.1	6.2
Body weight (kg)	79.2	10.1	68.6	8.6
Body height (cm)	177	6.7	166	6.3
Body mass index	25.3	2.7	24.8	3.5
Level of education	Proportion (%)		Proportion (%)	
low	56		70	
middle	42		26	
high	2		4	

*
Body mass index is the weight expressed in kg divided by the square of the
height expressed in metres.

Comparison in respect of nutrients and energy

As shown in Table 2 for all nutrients studied, except cholesterol and alcohol, the mean values determined by the retrospective dietary history (DH'R) were on average higher than those determined by the current dietary history taken in 1976 (DH'76). The mean differences and their 95 per cent confidence limits for daily intake in 1976 as measured by these two methods are also shown in Table 2. For most of the nutrients except protein and alcohol, the confidence limits do not include a difference of zero. When expressed as a percentage of total energy, differences were small and only 1.1, 0.7 and 0.2 for protein, fat and carbohydrate respectively. As these differences did not differ significantly from zero, the retrospective method gives a good indication of the proportions of these macronutrients in the diet.

When classified in tertiles (low, medium and high) of intake, the proportion remaining in the same tertile averages about 55 per cent, while the proportion that falls in the opposite tertile is of the order of eight per cent for most nutrients, although for polyunsaturated fatty acids, this proportion is 14 per cent.

In Table 3 differences between intakes of energy and nutrients reported at the three interviews (DH'83, DH'76, DH'R) are compared. The difference between DH'83 and DH'76 describes the actual change in food intake while the difference between DH'R and DH'83 represents the reported change in food intake. In general the actual changes in food consumption are smaller than the reported change. When considering the mean of differences, agreement between DH'R and DH'76 would be expected to be better than the agreement between DH'83 and DH'76, but the differences between DH'R and DH'76 are generally higher than either of the two other estimates. Thus the results show that the systematic error between DH'R and DH'76 is greater than that between DH'83 and DH'76, indicating that DH'83 provides a better estimate on the group level of DH'76 than DH'R. However, the standard deviations of individual differences between

Table 2. Comparison of the daily intake of energy and nutrients in 1976, assessed by a dietary history method in 1976 (DH'76) and by a retrospective dietary history method in 1983 (DH'R).

	Intake		Mean of differences (95% confidence limits)	Relative difference (%)*	Pearson correlation coefficient (95% confidence limits)	Proportion in same tertile (%)	Proportion in opposite tertile (%)	Kappa
	DH'76 mean ± SD	DH'R mean ± SD						
Energy								
Total (kcal)	2177 ± 586	2431 ± 690	254 (136;373)	11.7	0.61 (0.46;0.73)	55	7	0.32
Relative contribution (en%)								
Protein	14.0 ± 2.0	12.9 ± 2.6	-1.1 (-6.0;3.7)	-7.9	0.45 (0.27;0.60)	43	13	0.14
Fat	44.5 ± 7.3	45.1 ± 8.0	0.7 (-13.8;15.2)	1.6	0.53 (0.36;0.66)	55	13	0.32
Carbohydrates	41.0 ± 7.1	40.8 ± 7.6	-0.2 (-14.1;13.6)	-0.5	0.54 (0.38;0.67)	55	8	0.32
Nutrients								
Protein (g)								
Total	75.1 ± 19.3	76.4 ± 20.3	1.2 (-2.6;5.5)	1.6	0.57 (0.41;0.70)	56	8	0.34
Vegetable	22.8 ± 7.4	23.9 ± 7.9	1.1 (-0.4;2.5)	4.8	0.57 (0.41;0.70)	54	10	0.31
Animal	52.4 ± 15.9	52.5 ± 16.5	0.1 (-3.1;3.3)	0.2	0.54 (0.38;0.67)	54	4	0.32
Fat (g)								
Total	108.1 ± 35.0	123.0 ± 46.9	14.9 (6.0;23.8)	13.7	0.48 (0.30;0.62)	49	7	0.24
Saturated	42.0 ± 12.7	47.7 ± 16.3	5.8 (2.7;8.9)	13.8	0.49 (0.32;0.64)	47	8	0.21

Table 2. Continuation.

	Intake		Mean of differences (95% confidence limits)	Relative difference (%)*	Pearson correlation coefficient (95% confidence limits)	Proportion in same tertile (%)	Proportion in opposite tertile (%)	Kappa
	DH'76 mean ± SD	DH'R mean ± SD						
Polyunsaturated	13.9 ± 5.5	19.4 ± 11.0	5.5 (3.5;7.5)	39.6	0.46 (0.28;0.61)	51	14	0.25
Cholesterol (mg)	367.0 ±151.5	334.8 ±154.9	-32.3 (-63.9;-0.6)	-8.8	0.51 (0.34;0.65)	48	4	0.22
Carbohydrates (g) Total	222.5 ± 70.2	246.8 ± 80.6	24.2 (12.1;36.3)	10.9	0.71 (0.59;0.80)	64	7	0.46
Mono- and disaccharides	114.4 ± 45.2	121.1 ± 54.6	6.7 (-0.8;14.2)	5.9	0.75 (0.64;0.83)	58	4	0.37
Polysaccharides	107.5 ± 40.5	127.7 ± 44.1	20.2 (12.9;27.6)	18.8	0.65 (0.51;0.75)	57	9	0.36
Alcohol (g)+	14.9 ± 14.6	14.9 ± 21.4	-0.1 (-4.2;4.1)	-0.5	0.69 (0.51;0.81)	55	8	0.32

* Difference as a proportion of DH '76 intake.
+ Data for alcohol is based on 53 participants.

Table 3. Comparison of the daily intake of energy and nutrients in 1976 (DH'76) assessed by a dietary history method in 1976 (DH'76) and a retrospective dietary history method in 1983 (DH'R) and of the daily intake of energy and nutrients in 1983 assessed by a current dietary history (DH'83). The results of a previous study are also included for comparison.[*]

	Mean of differences[+]				Standard deviation of differences				Pearson correlation co-efficient		
	DH'R-DH'76	DH'83-DH'76	DH'R-DH'83	DH'R-RM'77	DH'R-DH'76	DH'83-DH'76	DH'R-DH'83	DH'R-RM'77	DH'R-DH'76	DH'83-DH'76	DH'R-DH'83
Energy											
Total (kcal)	254	29	222	124	568	473	552	606	0.61	0.67	0.65
Relative contribution (en%)											
Protein	-1.1	0.0	-1.1		2.5	2.1	2.4		0.45	0.56	0.54
Fat	0.7	-1.6	1.9		7.4	7.8	6.5		0.53	0.45	0.65
Carbohydrate	-0.2	0.5	-0.4		7.1	5.2	7.0		0.54	0.55	0.77
Protein (g)											
Total	1.2	0.7	1.0	5	18.4	16.9	19.5	21.9	0.57	0.60	0.52
Vegetable	1.1	1.2	0.0	1	7.1	7.0	6.3	6.7	0.57	0.61	0.68
Animal	0.1	-0.6	1.0	3	15.5	14.9	16.4	18.6	0.54	0.55	0.49
Fat (g)											
Total	14.9	-1.4	15.7	1	42.9	34.8	39.0	34.2	0.48	0.55	0.61
Saturated	5.8	0.3	5.2	0	15.0	13.8	14.2	15.5	0.49	0.55	0.61
Polyunsaturated	5.5	2.9	2.7	1	9.8	8.7	11.8	7.1	0.46	0.39	0.32
Cholesterol (mg)	-32.3	-42.5	11.3	13	152.5	170.4	117.2	173.2	0.51	0.44	0.75
Carbohydrate (g)											
Total	24.2	-4.3	20.2	22	58.1	57.4	53.4	72.9	0.71	0.68	0.77
Mono- and disaccharides	6.7	-8.0	14.5	11	36.2	40.0	36.2	50.8	0.75	0.63	0.76
Polysaccharides	20.2	15.1	5.8	12	35.5	29.0	32.9	31.1	0.65	0.75	0.70

*In the previous study (Van Leeuwen et al, 7) food intake of 79 subjects in 1977 was assessed by a seven-day record method (RM'77) and a retrospective dietary history method in 1981 (DH'R).

+The number of subjects included in DH'76, DH'R and DH'83 are 91, 91 and 88 subjects.

DH'83 and DH'76 are as high as those of individual differences between either
of these estimates and DH'R. This indicates that the random error is of the
same level. Consequently the ranking of individuals based on the two methods
will be liable to the same amount of error. Further in Table 3, the pairwise
Pearson correlation coefficients for the three estimates are shown. The
correlation between DH'R and DH'76 seems to be somewhat weaker than the
correlation between DH'83 and DH'76 for energy and proteins. With regard to fat
and carbohydrate, DH'R and DH'76 correlate less well than DH'R and DH'83.
However, all these differences are not statistically significant except that
for carbohydrate. In general, the correlations for DH'R and DH'83 seem to be
the strongest, which indicates the influence of contemporary habits on
retrospective reporting.

Comparison in respect of food groups

    In Table 4 the current intake of selected food groups in 1983 (DH'83), that
reported in 1976 (DH'76) and the retrospective reporting of intake in 1976
(DH'R) are compared. Median of differences between retrospective (DH'R) and
current dietary interviewing (DH'76) is negative for the food groups bread,
meat and vegetables, and positive for dairy products and potatoes. The median
of differences is smallest for the group bread and dairy products and highest
for vegetables. The spread of differences is large for all groups, but the
value for dairy products is very high. The Spearman rank correlation
coefficient is reasonably strong for the groups bread and potatoes,
intermediate for dairy products, low for meat and very low for vegetables. The
median of differences between the two currently assessed dietary histories
(DH'76 and DH'83) is similar to the median of differences between DH'R and
DH'76; the ranges and Spearman rank correlation coefficients also do not show
striking differences. These results indicate that the group of respondents had
changed their diet and had correctly reported how much of these foods they had

Table 4. Comparison of the daily intake of five food groups in 1976 assessed by a dietary history method in 1976 (DH'76) and a retrospective dietary history method in 1983 (DH'R) and of the daily intake of the same food groups in 1983 assessed by a current dietary history (DH'83). The results from a previous study are also included for comparison*.

Food Group	Median intake(g)+			Median of differences(g)‡				Spearman rank correlation coefficient			
	DH'76	DH'R	DH'83	DH'R–DH'76	DH'83–DH'76	DH'R–DH'83	DH'R–RM'77*	DH'R/DH'76	DH'83/DH'76	DH'R/DH'83	DH'R/RM'77*
Bread and crackers	150	132	126	-6 (66)	-6 (43)	0 (48)	9 (28)	0.76	0.83	0.80	0.68
Dairy products (excl. cheese and butter)	416	400	360	11 (169)	-20 (217)	26 (220)	51 (106)	0.55	0.58	0.58	0.35
Meat, poultry and fish	146	141	101	-36 (58)	-26 (67)	4 (69)	-12 (71)	0.39	0.41	0.15	0.47
Vegetables (excl. potatoes)	365	225	100	-100 (86)	-86 (96)	-16 (106)	33 (84)	0.16	0.32	0.17	0.34
Potatoes	150	198	160	40 (108)	20 (80)	16 (90)	26 (88)	0.63	0.79	0.67	0.62

*In the previous study (Van Leeuwen et al., 7), food intake of 74 subjects in 1977 was assessed in 1977 by a seven-day record method (RM'77) and in 1981 by a retrospective dietary history method (DH'R).

+The number of subjects included in DH'76, DH'R and DH'83 are 91, 91 and 88 respectively.

‡The values in parentheses represent the spread which is calculated as the difference between the third quartile (75th percentile) and the first quartile (25th percentile)

need in epidemiologic research for valid methods to assess dietary intake in the past. Several investigations, including that reported in this paper have indicated that past dietary patterns can be ascertained retrospectively with some degree of success. The evidence, however, indicates that current dietary patterns give a good or a somewhat better estimate of past dietary patterns than does a retrospective assessment.

A reasonable approach to assessing past dietary patterns may be to combine a current dietary history, (or one referring to the recent past), with information on the frequency of consumption of particular foods in the distant past. Information on food frequency alone is insufficient because it does not provide data on amounts of foods or of nutrients. Such an approach, although presenting new challenges concerning how best to combine this information, may yield the most accurate picture of diet in the distant past.

ACKNOWLEDGEMENTS

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6. SEASONAL VARIATION IN FOOD INTAKE, PATTERN OF PHYSICAL ACTIVITY AND CHANGE IN BODY WEIGHT IN A GROUP OF YOUNG ADULT DUTCH WOMEN CONSUMING SELF-SELECTED DIETS[1-2]

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SUMMARY

The effect of season on the energy balance was examined in 114 young adult Dutch women consuming self-selected diets. Energy intake and pattern of physical activity were assessed monthly fourteen times with the 24-hour recall method. After this period of 14 months in the second year the same estimates were made with intervals of 2-3 months to check if the seasonal variations observed were not accidental. The study did not demonstrate seasonal variations in the mean energy intake of the group under study. A statistically significant effect of the season was observed in the intake of fat, dietary fiber and mono- and disaccharides. For mono- and disaccharides the seasonal effect could not be confirmed in the second year. Small seasonal fluctuations were observed in body weight and time spent on various physical activities. On the one hand, these fluctuations were too small to indicate physiological significance, on the other hand they are wide enough to be taken into account in the design of many longitudinal studies on the relation between diet and disease.

In order to check for test effects a group of women initially matched with
the study group for age, body weight, body height and socio-economic class was
investigated twice: at the time of the first and the thirteenth observation of
the study group.

Selection of the sample

From the registry of the Municipality of Renkum, a small industrial town
about 60 miles from Amsterdam, a random sample of women in the age of 29-32
years was selected. Women rather than men were selected, because in the
Netherlands most women do not have a full-time job out of doors. Therefore,
their food pattern is less limited by work schedules and more likely to be
affected by the season. A practical consideration was that women at home
purchase and prepare the food and are thus easier to interview on their diet
than men. From the 182 persons contacted 140 agreed to take part (77%). Women
who were pregnant, physically handicapped or who consumed a prescribed diet
were excluded from the study. The control group lived in a town situated at 6 m
from Renkum and was selected from a group of women who recently participated in
another type of study (19).

Socio-demographic data

During the first interview, socio-demographic data, information on food
habits, history of body weight and information on smoking habits and sports
were collected by questionnaire. Changes in the situations were registered on a
structured questionnaire during all nineteen visits of the dietitian.

Anthropometry

Body weight without clothes was measured by the participant themselves every
day after the visit of the dietitian before breakfast and after the bladder had
been emptied. For this purpose high quality Seca balances with an exactitude to

the nearest 0.5 kg were supplied by and regularly calibrated at the department. Height was measured by the dietitians with a microtoise to the nearest 0.5 cm.

Food consumption and conversion into energy and nutrients

Food consumption was estimated with the 24-hour recall method (20). The participants were not informed about the day of interview until the evening before. If the dietitian did not succeed in making the appointment for the next day, she would try again the same day in the next week. At the end of the interview the dietitian checked the amounts of foods frequently consumed by weighing them on a Soehnle 8600 balance to the nearest 2 g; other foods were estimated in household measurements. For the conversion of foods into energy and nutrients the 1981 release of the national Dutch nutrient data base "UCV" was used (21).

Physical activities

The time spent in physical activities was also estimated with the 24-hour recall method. The activities were classified in eight categories with a different average demand of energy (22, 23). The categories are as follows:
- lying down and sleeping;
- sitting unloaded (reading);
- sitting loaded (type writing);
- standing unloaded;
- standing loaded (light domestic work);
- walking unloaded;
- walking loaded (cycling slowly);
- walking heavily loaded (sports).

The activities were administered in units of time of five minutes. The energy expenditure per activity category was not measured, so the mean time

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spent per activity category was not converted into daily energy expenditure.

Urinary nitrogen analysis

Mean daily protein intake as assessed by the fourteen 24-hour recalls was
validated against the protein intake as assessed by 24-hour urine nitrogen
excretion. Therefore, the subjects collected their urine for a 24-hour period
following each of the first 14 interviews. The total urinary nitrogen was
essayed by the Kjeldahl method. The validation of the 24-hour food recalls has
been described elsewhere (24).

Climatological data

Data on the local weather conditions during the days of observation were
obtained from the Department of Physics and Meteorology of the Agricultural
University in Wageningen.
The mean daily temperature in degrees Centigrade in the four seasons were:

	1982		1983	
	mean	SD	mean	SD
winter	1	4	1	4
spring	8	2	10	2
summer	17	4	17	3
autumn	12	3	15	2

To evaluate potential seasonal variations in food consumption and nutrient
intake, measurements in the winter months (December, January and February) were
contrasted with two summer measurements (June and July).

Statistical analysis

Differences in energy and nutrient intake between seasons were examined
firstly by comparing the winter with the summer. Effects of season were tested
in an analysis of variance, accounting for the between-person effect and the
day-of-the-week effect. Since adjustment of dietary data for the latter effect
was taken as prohibitive it was decided to adjust for three periods, viz.:
weekend (Saturday and Sunday), Friday, and Monday through Thursday. Recalls of
subjects who were temporarily ill or on an extreme slimming diet were excluded
from analysis. These recalls, which accounted for less than one per cent of the
total number of 2066 24-hour recalls of all participants, were evenly
distributed over the year.

Seasonal variation in body weight was tested by fitting a sinusoid curve
with a period of one year after adjustment for individual level and a common
time trend.

RESULTS

Subjects

Out of the 140 persons who agreed in participation 129 completed the recalls
and questionnaires during the first 14 months and 123 also collected 24-hour
urine at least 11 times. Reasons to stop were pregnancy (10) and disease (1).
The data of 15 participants were considered not to be trustworthy because there
was a wide discrepancy between the stated energy intake and pattern of physical
activity on one hand and fluctuations in body weight on the other hand.
Furthermore there was a mean difference of more than 20 grams between the
stated daily protein intake and the mean daily protein intake as derived from
the nitrogen excretion in fourteen 24-hour urine collections. The results on
the first 14 months presented in this paper concern the data of the 114
remaining apparently healthy women. After 14 months 17 subjects wished to stop

their participation so the results of the last five observations were obtained from 97 women.

Table 1 gives the following initial characteristics of the participants and the control group: body weight, body height, body mass index and level of education. The data of the two groups were very similar and in agreement with earlier findings in a random sample of this age group (25).

Table 1.

Initial characteristics of the young adult Dutch women participating in the study (n=114) and a control group (n=126).

	Participants		Control group	
	Mean	SD	Mean	SD
Body weight (kg)	60.7	7.0	61.3	7.6
Body height (cm)	167.1	5.6	166.7	6.7
Body mass index (kg/m^2)	21.7	2.2	22.0	2.2

Level of education	per cent	per cent
low	38	33
medium	52	56
high	10	11

At the beginning of the study 56 of the 114 participants had a job (49%), but most of them (80%) were part-time (20 hours or less per week). Almost all participants (95%) took care of the food purchases and preparation. The average family size was 4.3. Most meals were consumed at home: 89 participants reported to eat out of doors seldom (less than once a week) and 25 women stated to eat out of doors one to three times a week. At the end of the study these data had hardly changed.

Table 2. Daily energy and nutrient intake (mean, SD) in young adult Dutch women as assessed with the 24-hour recall, comparing participants (n=110*) and control group (n=126).

	Participants				Controlgroup			
	September				September			
	1981		1982		1981		1982	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Energy (kcal)	2007	570	2048	632	1971	572	1991	705
Protein (energy %)	14	5.4	14	3.6	14	4.3	14	3.7
Fat (energy %)	38	9.7	37	7.7	37	7.7	36	8.7
Poly unsaturated								
fatty acid (energy %)	6	2.6	6	2.1	6	2.3	6	2.5
Carbohydrates (energy %)	44	9.4	46+	8.5	46	7.9	46	9.5
Mono- and disaccharides								
(energy %)	22	7.1	23+	7.6	24	7.1	25	8.3
Dietary fiber (g)	20.1	7.5	21.3	8.7	21.0	7.4	21.0	7.4
Alcohol (energy %)	4	5.6	4	5.2	4	5.9	4	5.5

* From 4 participants there were no data obtained over either the first or the 13th month due to illness.

+ Statistically weakly significant (p<0.10) difference between September 1981 and September 1982.

Intake of energy, macronutrients and food (groups)

In Table 2 the dietary intake data of the first month (September 1981) and of the thirteenth month (September 1982) are shown for both participants and controls in order to check whether monthly dietary recalls have caused a change in dietary habits. Except for the intake of carbohydrates the data for both groups are very similar. In September 1982 the intake of mono- and disaccharides (and therefore also total carbohydrates) of the participants is higher than in 1981 (p<0.10). This increase in the intake of mono- and disaccharides is, however similar to the small increase in intake as observed in the controlgroup. Therefore, it is unlikely that the change in intake of carbohydrates can be attributed to a test effect.

The mean daily intake is in agreement with the USA and Dutch Dietary Allowances for women of this age group with an average body weight of 60 kg and light physical activities (26, 27). The data reflect a diet typical for an industrialized country, with a high intake of fat and mono- and disaccharides and a low intake of dietary fiber.

In this study no seasonal effect on the mean daily energy intake was found. Table 3 shows that there was a seasonal effect on the proportion of energy supplied by some of the macronutrients. In the summer relatively less fat was eaten (37.2 per cent of energy versus 39.4 per cent in the winter) and more carbohydrates especially mono- and disaccharides (24.4 per cent and 22.4 per cent of the energy in the summer and the winter respectively). The daily dietary fiber intake in the winter (20.3 g) and the autumm (21.2 g) was higher than that in the summer (19.1 g). In the second year the same seasonal trends in intakes were found as in the first year except for the intake of carbohydrates. In that year smaller effects of the season on the intake of mono- and disaccharides were observed.

Table 3. Mean daily intake of energy and macronutrients during four different seasons in 1982 and 1983 and during a whole year (December 1981 - November 1982) estimated with a repeated 24-hour recall method with young adult Dutch women. In 1982 three observations per person (n=114) were made in the winter, the spring and the autumn as against only two observations per person in the summer. In 1983 only one observation per person (n=97) per season was carried out.

	Winter			Spring		Summer		Autumn		Whole year
	'81-'82	'83	'83	'82	'83	'82	'83	'82	'83	'81 - '82
	Dec,Jan. Febr.	Jan.	Dec.	March,Apr. May	April	June,July	June	Sept,Oct. Nov.	Sept.	
Energy (kcal)	2072	2072	2068	2124	2042	2070	2013	2098	2037	2084 ± 361 ‡
Protein (energy %)	13.5	13.3	12.7	13.9	14.2	13.2	13.8	13.1	13.3	13.4 ± 1.9
Fat, total *+ (energy %)	39.4	37.8	40.0	39.2	38.3	37.2	37.8	38.1	37.5	38.8 ± 4.4
Saturated fat. acids (energy %)	16.1	15.9	16.5	16.3	15.8	15.4	16.0	15.8	15.3	16.0 ± 2.0
Linoleic acid (energy %)	5.0	4.8	5.0	4.8	4.9	5.0	4.9	4.8	4.9	4.9 ± 1.4
Carbohydrate, total* (energy %)	43.0	44.5	43.3	43.2	43.8	44.2	44.7	44.2	45.3	43.4 ± 5.3
Mono- and dissacchari- des (energy %) *	22.4	23.7	22.7	22.5	21.9	24.4	23.3	23.0	24.2	22.9 ± 4.6
Dietary fiber (g)*+	20.3	19.9	20.6	20.2	19.9	19.1	19.6	21.2	21.0	20.2 ± 5.2
Alcohol (energy %)	5.7	4.4	3.9	5.3	3.8	8.2	3.6	6.1	3.8	4.8 ± 4.9

* denotes statistically significant ($p < 0.05$) in 1982
+ denotes statistically significant ($p < 0.05$) in 1983
‡ mean ± standard deviation

Table 4. Mean daily intake of food groups (grams) of young adult Dutch women during four different seasons in 1982 and 1983 and during a whole year (December 1981-November 1982). In 1982 three 24-hour recalls were conducted per person per season (n=114); as against one recall per person per season in 1983 (n=97).

	Winter			Spring		Summer		Autumn		Whole year
	'81-'82 Dec,Jan. Febr.	'83 Jan.	'83 Dec.	'82 March,Apr. May	'83 April	'82 June,July	'83 June	'82 Sept,Oct. Nov.	'83 Sept.	'81 - '82
Bread, toast	108	110	103	109	114	106	109	108	107	106 ± 38 #
Potatoes, rice, macaroni	127	127	140	133	143	118	130	138	143	128 ± 53
Butter, margarine*, oils, dressings	30	31	32	34	33	33	35	33	35	32 ± 12
Meat, fish, eggs	113	108	99	121	104	107	104	113	101	114 ± 37
Milk, milkproducts	382	364	355	393	384	388	407	357	372	378 ± 244
Vegetables*+	112	110	113	141	127	157	158	132	146	132 ± 72
Fruits	117	130	105	112	102	124	104	154	163	125 ± 76
Sugar and sweets	94	94	100	97	96	95	77	98	90	96 ± 39
Soft drinks*+	96	119	84	126	106	141	150	114	117	116 ± 98
Alcoholic drinks*	108	113	104	109	110	≈168	125	130	90	123 ± 136

* Statistically significant (p< 0.05) in '82

+ Statistically significant (p< 0.05) in '83

mean ± standard deviation

Table 4 shows that the relatively higher intake of mono- and disaccharides in the summer of 1982 was caused mainly by a higher intake of soft drinks and alcoholic drinks. The difference between the mean intake in the summer and in the winter for soft drinks and alcoholic drinks was 45 g and 60 g respectively. The higher intake of dietary fiber in the autumn was due to an increased intake of fruit, 30 g and 59 g more in 1982 and 1983 respectively, and of wheat products, potatoes and rice, 20 g and 13 g more than in the summer of 1982 and 1983 respectively. The higher consumption of vegetables in the summer (25 g and 12 g in 1982 and 1983 respectively) did not counter-balance the dietary fiber intake.

The relatively higher intake of fat during the winter of both years was due to a higher intake of animal products rich in fat. This was not compensated by the use of slightly more fat and oils for the preparation of foods during the two summers.

Fluctuations in body weight and pattern of physical activities

Figure 2 shows that a small seasonal fluctuation with a one year period is observed over and above a gradual   increase in body weight. The mean body weight was 60.8 kg (SD 7.0) at the beginning of the study in August 1981 and 61.2 kg (SD 6.5) after 14 months. In January 1983 17 subjects ceased to participate; the body weight of the remaining participants (n=97) was then 61.4 kg (SD 6.3); a year later body weight was 61.2 kg (SD 6.5) for this group. In 1982 as well as in 1983 mean body weight tended to increase in the winter and to decrease before the summer. With the 91 participants of whom all body weight measurements were reported we found a yearly increase of 0.4 kg and a sinusoid fluctuation with an amplitude of 0.2 kg, having its maximum in January and its minimum in July.

Figure 2
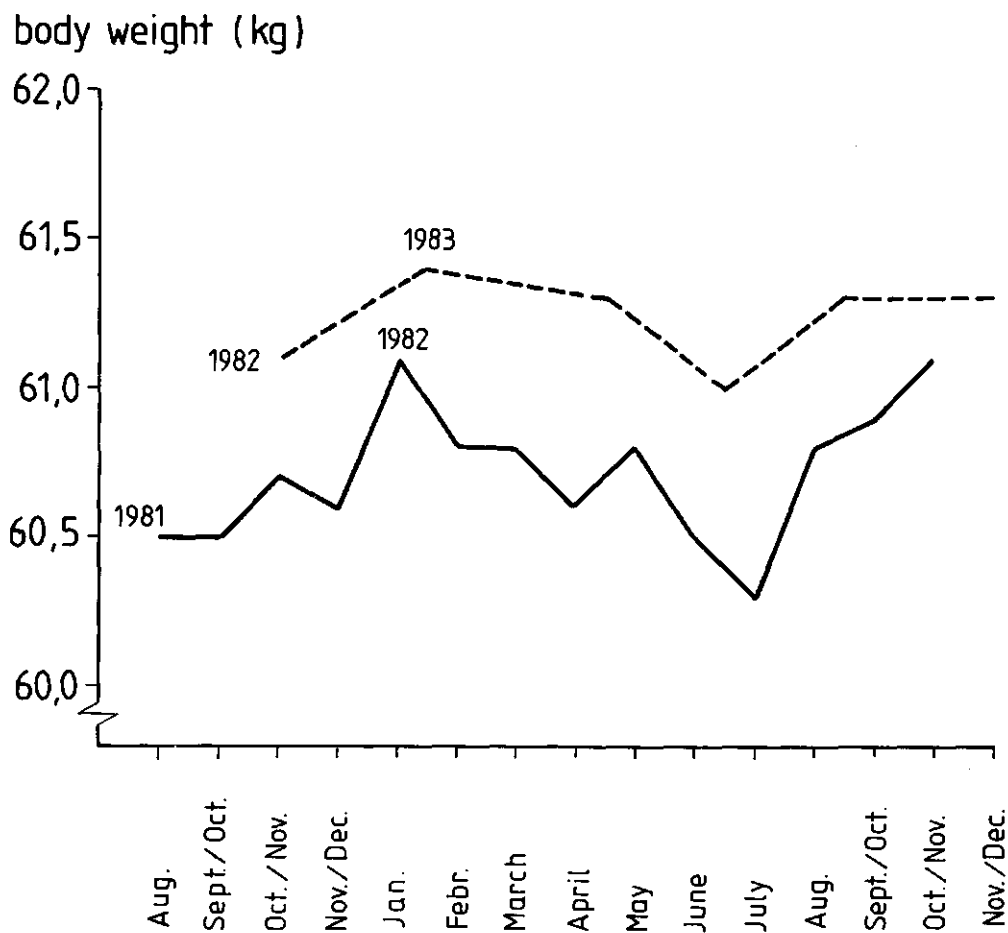
Fluctuations in body weight of young adult Dutch women as assessed monthly from August 1981 through October/November 1982. The following year five assessments were made with an interval of 2-3 months (n=91); only subjects are included of whom 19 observations were obtained.

Table 5. Mean time in minutes spent daily in eight categories of physical activities during four different seasons in 1982 and 1983 estimated with a repeated 24-hour recall method in young adult Dutch women. In 1982 three observations per person per season (n=114) were made, except in the summer when only two observations were registred. In 1983 only one observation per person (n=97) was carried out.

	Winter			Spring		Summer		Autumn	
	'81-'82	'83	'83	'82	'83	'82	'83	'82	'83
	Dec,Jan,Febr	Jan	Dec	March,Apr,May	April	June,July	June	Sept,Okt,Nov	Sept
lying down	501	497	493	494	485	483	490	492	486
sitting unloaded	386	428	407	403	392	419	408	396	407
sitting loaded	113	91	94	81	91	66	68	84	69
standing unloaded	43	48	47	52	63	50	61	56	67
standing loaded	217	233	242	212	230	225	232	235	251
walking unloaded	145	119	121	162	142	154	139	138	123
walking loaded	33	31	32	34	36	39	36	33	31
walking heavily loaded	2	2	5	3	2	4	4	6	6

Table 5 shows that most of the time was spent on light physical activities: roughly eight hours sleeping, eight hours sitting, five hours standing and three hours walking and other more strenuous activities. During the spring and the summer on the average slightly more time was spent on walking and sports than in the winter and the autumn (17 minutes more per day). In the summer less time was spent on sitting (about 15 minutes less) than in the winter. In 1983 the same trends were observed. These differences in time spent in the various activity categories during the seasons were too small to have a noteworthy effect on energy intake and body weight.

DISCUSSION

In order to assess the usual food intake of man it is necessary to know whether the season has any effect on the energy balance. From studies made in developing countries it is well known that the season is one of the most important sources of variance in food intake and changes in body weight (28, 29). Recent studies in the USA on the long-term dietary intakes of adults consuming self-selected diets have not shown statistically significant effects of the season in the intake of energy and macronutrients (8, 10, 11). Neither did the present study find seasonal effect on the intake of energy, but there was a statistically significant difference in the percentage of energy derived from fat and carbohydrates (Table 3). In the winter of 1982 and that of 1983 the mean daily intake of fat was 6 grams and 8 grams more respectively than in the summer of that year which is equivalent to an amount of fat in a small sausage of 25-30 grams. In the summer of 1982 the mean daily intake of mono- and disaccharides was 10 grams more than in the winter, which is equivalent to the amount of sugar in half a glass of soft drinks. This latter difference was not found in 1983, which is probably due to the smaller number of days with warm summer weather included in the survey that year. It remains doubtful,

however, if the observed differences in the intake of fat and sugar between summer and winter have physiological significance.

The same holds for the mean differences between seasons in the dietary fiber intake. In both years the greatest differences were found between summer and autumn and accounting for 2.1 g and 1.4 g per day in 1982 and 1983 respectively. This effect of the season on dietary fiber intake is statistically significant, but the differences observed do not seem to be very important physiologically. For dietary fiber as well as for fat intake the effect of the season is sufficiently remarkable to be taken into account in the designs of many longitudinal studies assessing changes in intake.

The annual fluctuations in body weight were small (Fig. 2). The observed increase in body weight in the winter and decrease in body weight before the summer is in agreement with findings in another study of our department (30), a higher prevalence of obesity in winter (6) and a higher efficiency of slimming treatment conducted during spring and summer (17). The data on the time spent in various activity categories showed that our subjects were physically slightly more active in the spring and the summer than in the winter and the autumn. This corresponds well with the results of studies on circannual rhythms in physical fitness in man (31, 32). In the present study, however, the average time spent in physically strenuous work was very little.

In conclusion, the present study did not reveal seasonal variations in the mean energy intake of the group under study. There were small seasonal fluctuations in the relative intake of some of the macronutrients, in body weight and in the time spent in the various activity categories. On the one hand, these fluctuations were not great enough to indicate any physiological significance, on the other hand they are great enough to take into account in the design of many longitudinal studies and sometimes cross-sectional studies on the relation between diet and disease.

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7. VALIDITY OF THE 24-HOUR RECALL METHOD REPEATED MONTHLY 14 TIMES FOR THE ASSESSMENT OF THE USUAL ENERGY AND PROTEIN INTAKE OF YOUNG ADULT DUTCH WOMEN [1-2].

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SUMMARY

The validity of a monthly, fourteen times repeated 24-hour food recall method was studied with 123 young adult Dutch women. The validity was examined by comparing the mean daily energy intake with changes in body weight over a period of 14 months and by comparing the mean daily protein intake with the protein intake as assessed from the nitrogen excretion in 14 collections of 24-hour urine. The data confirm earlier findings that the 24-hour recall gives a valid estimate of the mean energy intake and protein intake of groups. By categorizing the group approximately into quintiles of the energy intake it appeared that those who reported a very low energy intake tend to underestimate and those who reported a very high energy intake tend to overestimate their food consumption. With 20 subjects (16 per cent) the mean difference in protein intake as estimated from the fourteen 24-hour recalls and as derived from the nitrogen excretion in 24-hour urine exceeded 20 grams. Sixteen of these 20 subjects either reported a very low energy intake (n=7) or a very high energy intake (n=9). These results show that some subjects consistently overreported,

and some others consistently underreported their food intake. Consequently it
seems unevitable that subgroups selected within a study population on the basis
of a very high or a very low reported intake of some specific nutrient, are
contaminated with subjects which have, infact, a less extreme usual intake.

INTRODUCTION

Recall methods are dietary survey methods which aim at measuring the actual
food intake of an individual during the immediately preceding period, usually
24 or 48 hours, or the preceding day by means of an interview (1). The 24-hour
recall method is often preferred to other methods, because it usually has high
response rates. The cooperation required from the respondents gives them only
little trouble. Numerous comparative studies have been made on the 24-hour
recall methods and their applicability to various study situations and
population groups. In addition, several reviews in which dietary survey methods
are evaluated have been published during the last 2 decades (2-11). The results
obtained so far suggest that a single 24-hour recall is not an appropriate tool
for assessing the usual diet of an individual due to a high day-to-day
within-individual variation in energy and nutrient intake. However, the value
of the 24-hour recall method in estimating the average intake levels of groups
seems reasonably well established.

So far, there is no information on the validity of repeated 24-hour food
consumption recalls assessing the usual diet of individuals. In the present
study this validity was examined by comparing the mean values of 14 monthly
obtained recalls on energy intake and physical activity with the fluctuations
in body weight of 123 young adult women. Furthermore, the mean protein intake
as assessed by the 14 food consumption recalls was compared with the mean
protein intake as assessed by the nitrogen excretion in fourteen 24-hour urine

collections. In four subjects with a very high mean energy intake and five

subjects with a very low energy intake resting metabolic rate was determined to

examine if their extreme value of energy intake was due to a disturbed resting

metabolic rate.

METHODS

The design of the study and the methods used to select samples, to collect

socio-demographic data, to estimate food consumption and pattern of physical

activity and to make anthropometric measurements have been described

extensively elsewhere (12). Therefore, the discussion of these items will be

brief.

Selection of samples

A random sample of women in the age of 29-32 years was selected from the

registry of the Municipality of Renkum. Out of the 140 persons who agreed to

participate 123 apparently healthy women completed the whole task.

Energy and protein intake

Food consumption was assessed monthly with fourteen 24-hour recalls (1). The

recalls were administered by trained dietitians in the period from September

1981 through October 1982. Per subject two interviews for every day of the week

were obtained in an arbitrary order. Amounts of foods frequently consumed were

checked by the dietitian by weighing them on a Soehnle 8600 balance, other

foods were estimated in household measurements. For the conversion of foods

into energy and nitrogen the 1981 release of the national Dutch nutrient data

base "UCV" was used (13).

Physical activities

Physical activity was also estimated with a 24-hour recall method. The
activities were classified in eight categories with a different average demand
for energy (14, 15). The time spent on these activities was not converted into
energy expenditure, because the intensity of the activity (or the energy
actually spent on it) could not be estimated.

Questionnaire

Socio-demographic data and food habits were administered on a structured
questionnaire.

Anthropometry

Body weight without clothes was estimated to the nearest 0.5 kg on Seca
bathroom scales by the participants themselves the day after the visit of the
dietitian before breakfast.

Height was measured with a microtoise to the nearest 0.5 cm.

Resting Metabolic Rate (RMR)

The RMR was measured in a subsample by indirect calorimetry under
standardized conditions after an overnight fast of 12-14 hours. The subjects
were taken to the laboratory by car, and after a 30 minute rest in supine
position at a room temperature of 20-22 $^{\circ}$C, two samples of expired air were
collected in a Douglas-bag for 10 minutes. The amount and composition of the
samples were analysed by a paramagnetic oxygen analyser (Servomex 570^{A}) and an
infrared carbon-dioxide analyser (P.K. Morgan LTD). If the difference in result
between the two samples was more than two per cent, a third sample was taken
for another 10 minute period. The mean value of the two (nearest)
determinations was used in the analysis.

Analysis of urine nitrogen excretion

In the week after every dietary interview 24-hour urine was collected. According to Isaksson (16) comparison of urinary nitrogen determinations with dietary intake data showed that the excretion data react with some time lag and with less variation on a varying actual nitrogen intake. The collection of urine started in the morning after the bladder had been emptied and before breakfast, and ended the next morning again after the bladder was emptied and before breakfast. Two-and-a-half-litre containers were supplied for the urine with 5 ml 80 per cent acetic acid to bind ammonia. The 24-hour volume was determined by weighing, and a sample was frozen at $-20\,^\circ C$. After the study all samples were analysed on nitrogen in a random order by means of a Kjeltec Auto 1030 Analyser, using a mixture of Se and K_2SO_4 as catalyst according to the Kjeldahl method. The daily protein intake from 24-hour urine nitrogen excretion was estimated as:

Protein intake in 24 hours = 6.25 (N intake in 24 hours)

where N intake was derived from N excretion by the formula of Isaksson (17):

N intake in 24 hours = N excretion in 24-hour urine + 2 g

The last two grams are added for dermal and faecal nitrogen losses. We have shown earlier that this addition of 2 grams is also adequate for Dutch circumstances (18).

Data analysis

In order to assess the validity of the energy intake the study population was categorized approximately into quintiles of the reported energy intake.

Differences in body weight,in changes in body weight and in body mass index among the five categories of energy intake were tested with the Newman-Keuls test (19). To study the validity of the assessment of protein intake, results from the 24-hour recalls and those from the 24-hour urine nitrogen excretion were compared for each individual, and the mean (with 95 per cent confidence limits) of the individual differences was calculated in each of the five quintiles.

RESULTS ·

The mean daily energy intake thoughout the year of the 123 women participating in this study was 2056 kcal (Table 1). During the 14 months the mean gain in body weight was 0.6 kg indicating that the group as a whole had a slightly positive energy balance. The observed energy intake, body weight and body mass index (kg/m^2) agree with earlier findings for women in this age group in the Netherlands (20) and in the USA (21). The minimum daily energy intake (mean of 14 recalls) was 846 kcal and the maximum was 3289 kcal, which indicates a high spread in reported intake among individuals.

After distribution of the study population into quintiles of energy consumption it appeared that the data obtained from those who reported a very low energy intake and those who reported a very high energy intake were inconsistent with the (lack of) changes in their body weight (Table 1). The mean energy intake of 1461 kcal calculated for the group reporting a very low energy intake hardly allows for the resting metabolic rate of this group; a negative energy balance with a decrease in body weight would have been expected instead of no change in body weight.

Table 1. Mean daily energy intake, body weight, body height, body mass index (BMI) and change in body weight over a period of 14 months of young adult Dutch women with different levels of energy intake.

Energy intake	N	Energy intake* kcal/day	Body weight kg	Body height cm	BMI kg/m^2	Change in body weight+ kg
Very low < 1675 kcal	24	1461	67.3	168	24.0	0.0
Low 1675-2000 kcal	25	1856	62.3	166	22.7	0.1
Average 2001-2155 kcal	25	2089	59.6	166	21.6	1.2
High 2156-2345 kcal	24	2238	58.9	166	21.2	0.9
Very high > 2345 kcal	25	2619	60.4	169	21.3	0.8
Total group	123					
Mean		2056	61.7	167	22.1	0.6
Stand. dev.		412	8.5	6.0	2.7	2.2

* Estimated by 14 monthly 24-hour recalls

+ Difference between the last and the first 3 measurements.

On the other hand the calculated daily energy intake for the group reporting a very high energy intake was 2619 kcal, (thus 1150 kcal more than in the group of very small consumers) and the mean gain in weight was only 0.8 kg. This inconsistency could not be explained by their physical activities. Table 2 shows that on the average the whole group spent most of their time on light physical activities and that the pattern of physical activity of the subgroups of women with a different level of energy intake differed only slightly.

Table 2. Mean time in minutes spent daily on various physical activities by the total group of young adult Dutch women and by the subgroups with different levels of energy intake.

Energy intake	N	lying down	sitting unloaded	sitting loaded	standing unloaded	standing loaded	walking unloaded	walking loaded	walking heavily loaded
Very low < 1675 kcal	24	503	414	85	47	224	135	29	3
Low 1676-2000 kcal	25	486	398	98	49	231	144	31	3
Average 2001-2155 kcal	25	496	375	97	46	217	162	43	4
High 2156-2345 kcal	24	489	379	100	48	225	168	29	2
Very high > 2345 kcal	25	487	418	76	46	205	163	39	6
Total group:	123								
Mean		492	396	92	48	220	155	34	3
Stand. dev.		36	68	53	17	60	45	20	6

The group with a very low energy intake spent on the average 41 minutes less on all walking activities than the group with a very high intake; for walking unloaded, walking loaded and walking heavily loaded this was 28 minutes, 10 minutes and 3 minutes respectively. The extra daily energy required for these 41 minutes of more strenuous activities will not exceed 100 kcal if the rate of work is the same in both, the group reporting a very low and a very high energy intake, taking into account body weight. On the average, the women with a very low energy intake were heavier than those of the other groups (Table 1). The difference in weight between this group and the groups with an average- and a high energy intake was significant ($p < 0.05$); the difference in body mass index between this group and the average-, high- and very high energy intake groups was also significant. The differences in weight changes between the groups were not statistically significant.

Another independent indicator of nutrient intake is 24-hour urine nitrogen excretion from which the protein intake for groups can be estimated (16, 18, 22). Based on earlier studies (16, 23, 24) the food consumption data were considered valid if the mean value of the daily protein intake as estimated with the fourteen 24-hour recalls was within plus or minus 10 g of the mean protein intake as derived from the 24-hour urine nitrogen excretion. Table 3 shows that for the whole study population the result was within this limit (2.7 g), but not for the group with a very low energy intake (-11.1 g) and a very high energy intake (+13.7 g). The data indicate that subjects in the group with a very low energy intake underestimate (on average) their protein intake and those in the group with a very high energy intake overestimate their protein consumption. In this study we did not find a relation between level of energy intake and level of education.

Table 3. Protein intake as estimated by fourteen 24-hour recalls and as derived from the mean nitrogen excretion in fourteen 24-hour urine collections with young adult Dutch women with different levels of energy intake.

Energy intake	N	Protein intake (g) estimated from:				Protein intake - excretion (g)	
		24-hour recalls		urine N excretion			
		mean	SD	mean	SD	mean	95% conf. limits
Very low							
< 1675 kcal	24	52.8	9.4	63.9	17.2	-11.1	-19.5; -2.7
Low							
1676 - 2000 kcal	25	66.6	10.2	65.9	14.6	0.7	- 4.8; 6.2
Average							
2001 - 2155 kcal	25	68.6	10.2	65.9	14.0	2.7	- 1.6; 7.0
High							
2156 - 2345 kcal	24	72.9	9.5	65.9	11.2	7.0	4.2; 9.9
Very high							
> 2345 kcal	25	79.3	10.9	65.7	13.0	13.7	7.8; 19.6
Total group	123	68.1	13.3	65.5	13.9	2.7	- 0.1; 5.5

In four subjects who reported a very high energy intake and five subjects who reported a very low energy intake we examined whether the inconsistency between the mean energy intake and the fluctuations in body weight was caused by a disturbed resting metabolic rate. Table 4 shows that the body mass index of the four "big" eaters was within normal limits. The subjects B and D had a body mass index of less than 20, which is generally indicated as lean (25). Subject D had put on more than 5 kg weight after the fourteen months. For all subjects who reported a very high energy intake the resting metabolic rate was within normal limits. On the average, none of them undertook the more strenuous physical activities (walking unloaded, loaded, and heavily loaded) longer than four hours a day. The most strenuous activity in this category (walking heavily loaded, e.g. sports) was carried out no longer than a quarter of an hour a day. The data demonstrate that the subjects A,B and C had seriously overreported their energy intake. The mean daily energy intake for subject B does not seem to be high, but calculated per kg body weight (60 kcal/kg) it is very high. The difference in protein intake as estimated by the 24-hour recalls and as derived from urine nitrogen excretion also indicates overreporting of protein intake for the subjects A, B and C, but less so for subject D.

The data of the subjects who reported a very low energy intake are also inconsistent, but in the opposite direction. The individuals in this group were heavier than the individuals who reported a very high energy intake and one subject had a body mass index of more than 37, indicating severe obesity. The mean resting metabolic rate of this group was significantly higher than in the group who reported a very high energy intake ($p < 0.05$), but in agreement with their larger body mass. As can be seen in Table 4 the reported mean daily energy intake of all "small eaters" was not even enough to cover their resting metabolic rate and should thus have resulted in a loss of body weight instead of the observed gain in weight in four of the five subjects.

Table 4. Body weight, body height, body mass index (BMI), change in body weight over a period of 14 months and resting metabolic rate (RMR) of four young adult Dutch women with a high energy intake, "big eaters", and five women with a low energy intake "small eaters". The mean daily energy and protein intake was assessed monthly by fourteen 24-hours recalls and the mean daily protein intake was also derived from 24-hour urine nitrogen excretion (mean of 11 - 14 collections).

| | Body weight | Body height | BMI | Change in body weight | RMR | Energy intake | | Protein intake | | |
| | | | | | | mean | SD | 24-hour recalls (I) | urine N excretion (E) | I/E x 100% |
	kg	cm	kg/m^2	kg	kcal/24-h	kcal		g	g	%
"Big Eaters"										
A	53.1	162	20.2	0.8	1450	3288	780	91	48	190
B	40.9	150	18.2	0.0	1076	2396	740	82	65	126
C	64.2	179	20.1	2.8	1536	3359	1360	98	58	168
D	48.4	161	18.7	5.3	1373	2704	795	52	46	113
Mean	51.6	163	19.3	2.2	1359	2937	-	81	54	150
"Small Eaters"										
E	80.0	174	26.5	-0.3	1859	1035	330	43	102	42
F	65.1	168	23.2	3.8	1502	1282	369	53	74	72
G	62.8	174	20.7	0.3	1500	845	196	29	93	31
H	66.9	166	24.1	4.0	1563	1162	456	60	81	74
K	109.6	170	37.7	2.0	1866	1611	402	49	89	55
Mean	76.9	170	26.4	2.0	1658	1188	-	47	88	53

The large discrepancy in this group in protein intake as estimated from the mean of fourteen 24-hour recalls and as derived from the mean of 24-hour urine nitrogen excretion was also in the opposite direction of those who reported a very high energy intake. The observed differences were very great for the subjects E and G.

A cause for the inconsistency in the results of the "small" as well as the "big" eaters might have been that the fourteen 24-hour recalls were not sufficiently representative to estimate the usual energy and protein intake of these individuals. The questionnaire indicated, however, that only for subject G a selection of days with a low energy intake might have been the cause of underestimation of the usual energy and protein intake.

DISCUSSION

Validation of a method is the demonstration that a method measures what it is intended to measure. Accordingly, in order to validate a given dietary intake assessment, the true dietary intake must be known or ascertainable. There is, however, no method assessing the diet of free-living persons consuming self-selected diets with absolute accuracy. Therefore, the purpose of validation studies on the 24-hour recall method is to determine whether this method is interchangeable with a method of greater acceptance (e.g. the weighed record method or the dietary history method) or whether its results can be compared with the results of physiological and biochemical indicators of the nutritional status. In this study we have concentrated on the latter; the results confirm earlier findings (26-29) that a 24-hour recall method may give valid data on dietary intakes on a group level.

The earlier validation studies demonstrate that individuals tend to overestimate high food intakes when a single 24-hour recall method is used

(30-32). In our study a monthly fourteen times repeated 24-hour recall method was used. The results show that subjects reporting a very low energy intake ("small" eaters) underreport and subjects reporting a very high energy intake ("big" eaters) overreport their food consumption. This has been shown by categorizing the study population into quintiles of the energy intake. The very low energy intake group reported a mean energy intake which hardly allowed for their resting metabolic rate; on the average the group had not lost body weight after 14 months. In contrast, the very high energy intake group reported on the average 1150 kcal per day more but the energy balance of this group was only slightly positive (the gain in weight after 14 months was 0.8 kg). Many reasons might explain these differences in energy balance, but the data on the pattern of physical activity and the results of the determination of the resting metabolic rate in a small subsample did not show great differences in energy expenditure between the two groups. Although it is very hard to predict loss or gain in weight from underfeeding and overfeeding even in studies under standardized conditions (33, 34), the data on protein intake found in the present study confirm the conclusion from energy intake results, which indicate underreporting by "very small" eaters and overreporting by "big" eaters. Worthy of note in Table 3 is the similarity in intake of protein as derived from the 24-hour urine nitrogen excretion for the five energy intake categories; meanwhile the data based on the 24-hour food recalls suggest that an increase in energy intake implies an increase in protein intake.

Assuming a constant percentage of energy derived from protein this suggests that the "true" between-person variation in protein-intake is very small and consequently that there are really no "small" or "big" eaters in this group. However, the standard deviation of the mean daily protein intake as derived from the 24-hour urine nitrogen excretion shows, that within groups there is a large variation in intake. In an earlier paper (35) we have published data on the between-person and on the within-person variance in the intake of energy

and some nutrients of participants in this study. For the total study group we found, that the between-person variation (s.d.) in daily protein intake as estimated with the recall method was 3.7 g and the within-person variation was 21.8 g. For the daily protein intake as derived from 24-hour urine nitrogen excretion the between-person and the within-person variation were 4.3 g and 13.0 g respectively. Thus the between-person variation is almost similar according to either assessment, but the within-person variation in mean daily protein intake as estimated with the 24-hour recall method is almost twice the within-person variation in daily protein intake as derived from the 24-hour urine nitrogen excretion. This means that the standard error of an individual mean daily intake of e.g. 66 g protein as derived from 24-hour urine nitrogen excretion is $13/(14)^{1/2}$ = 3.5 g and as estimated with the fourteen times repeated 24-hour recalls is $21.8/(14)^{1/2}$ = 5.9 g.

Figure 1 shows a plot of the mean daily protein intake as assessed by either of the two methods. As could be expected from the preceding results the relation between the two estimates is disturbed by data from subjects who either seriously underreported or seriously overreported their food intake. In considering these results, it should be realized that in this study 24-hour urine nitrogen excretion was taken as the reference method. However, as described by Rand et al. (36), there are three potential sources of error and variation in this method: 1) the methods and approach used for determining urine nitrogen, 2) the inherent regulatory mechanism as it responds to various individual stresses and 3) the inherent responses of nitrogen metabolism to the external world, involving general stimuli such as temperature, humidity and the use of anticonceptiva. Errors described under 1) range from problems involved in obtaining complete 24-hour urine collections to analytical errors in determinations of nitrogen in urine samples. In our study the only check on completeness of urine collections was the request to the subjects to make a note if some urine was spilt.
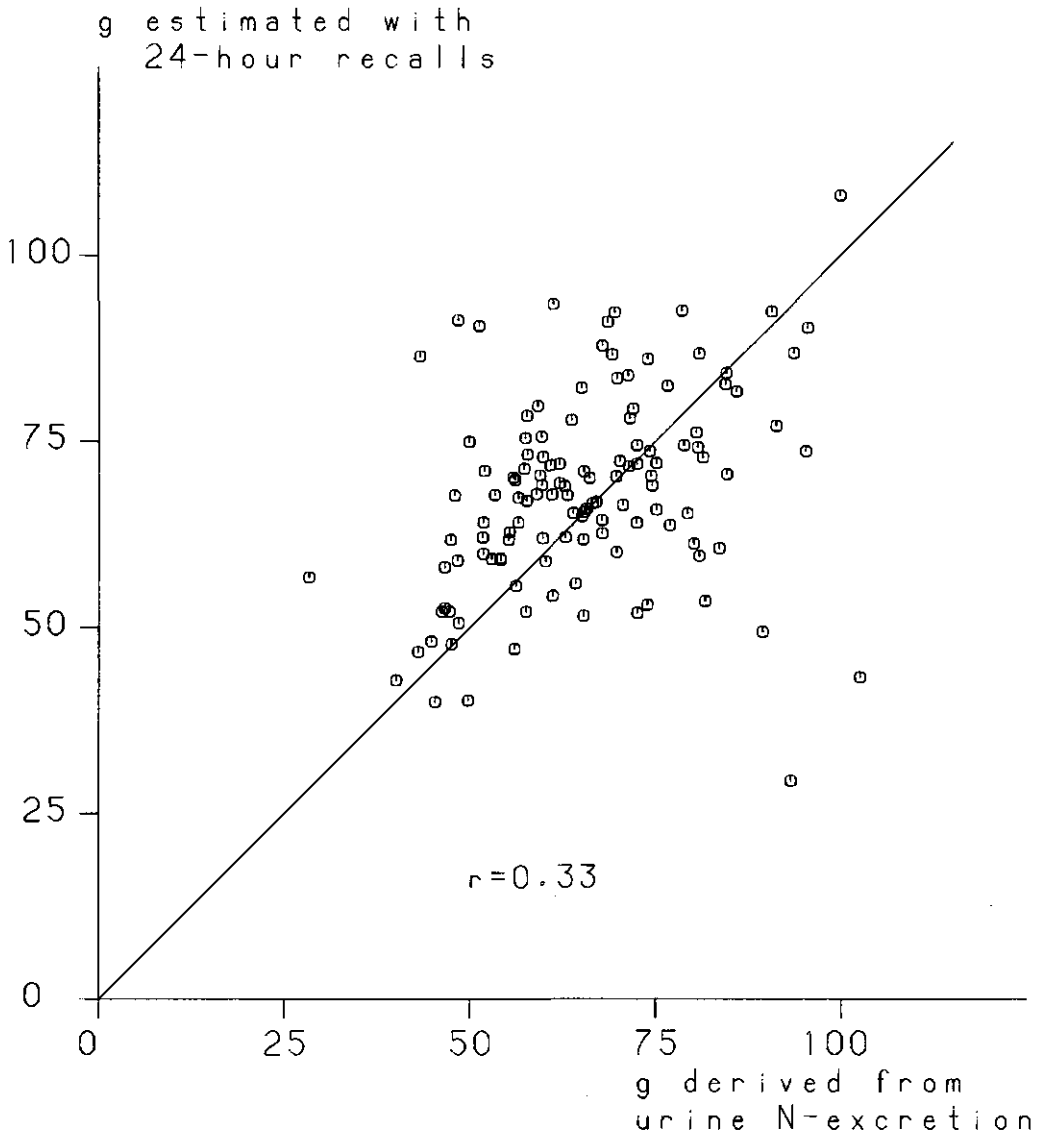
Figure 1.

The daily protein intake of 123 young adult Dutch women; intake as estimated

with fourteen monthly repeated 24-hour food recalls (down) and intake as

derived from nitrogen excretion in 11-14 collections of 24-hour urine (across).

Futhermore, we have checked if the volumes of the 24-hour collections were all
within the limits expected in view of the water intake as calculated from foods
and drinks. In this study in particular the timing of collection of urine
samples was a problem, since it was practically impossible to collect urine
exactly the day after the 24-hour food recall. By including control urine
samples in the analytical procedures and with replicate analyses of samples, we
found that the analytical error accounts for about one per cent of the total
variance. It is difficult to separate methodological errors from "true"
biological variation (described under 2 and 3). According to the study of Rand
et al. (36), the most important source of variation is the response of body
nitrogen metabolism to individual perturbations (described under 2). These
sources of error and variation attenuate the relationship between protein
intake as derived from the 24-hour urine nitrogen excretion and as estimated
with the food consumption data.

It is generally accepted, that urine nitrogen excretion can hardly be used
on an individual level as a biological marker to validate daily protein intake
as estimated with food consumption data, even for an average over several days.
Data of short-term studies (16, 23, 24) as well as long-term studies (36) under
controled conditions show that it is not very likely that these sources of
error and variation would account for departures more than 20 per cent of the
level of protein intake as derived from 24-hour urine nitrogen excretion. In
our study this means, that the difference between the two mean estimates for
one person should not exceed 20 grams. Such a difference, however, was found,
with 20 persons (16 per cent). Sixteen of them (80 per cent) were in the cate-
gories reporting an extremely high (n=7) or extremely low (n=9) energy intake.
This latter result is very important and shows that it is almost impossible to
distinguish within a study population, solely on the basis of food consumption
data, groups with a high health risk, if this risk is marked by either a high
or a low intake of a certain nutrient. In conducting food consumption studies

in free-living individuals with the purpose to relate food consumption data with an indicator of the health status it is advocated to oversample and to check the data with measurements independent of the subject's memory for foods consumed. In this way untrustworthy records or recalls can be eliminated. Twenty-four hour urine nitrogen excretion and changes in body weight (37) might be used as independent measures in adults.

In conclusion: in an excellent review on the validity of methods assessing food consumption Block (8) stated that in epidemiological studies it is not always necessary to determine in grams or milligrams what people do eat of certain nutrients. It would, however, be of great value if on the basis of data of food consumption studies, individuals can be classified accurately in "small", "medium", and "big" eaters. Sixteen per cent of the subjects participating in this study consistently overreported or underreported their food intake, making it impossible to categorize the study population correctly in "small" or "big" eaters. This is disappointing and throws doubt on assumptions made from earlier studies. Further studies should be done to indicate whether the problems of overreporting or underreporting encountered in this study are especially associated with the 24-hour recall method. It might be important to be able to characterize persons who either overreport or underreport their food consumption and why they do so.

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8. VALIDITY OF THE FATTY ACID COMPOSITION OF SUBCUTANEOUS FAT TISSUE

MICROBIOPSIES AS AN ESTIMATE OF THE LONG-TERM AVERAGE FATTY ACID COMPOSITION OF

THE DIET OF SEPARATE INDIVIDUALS [1,2].

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SUMMARY

The relationship between the fatty acid composition of subcutaneous adipose

tissue and diet was estimated in 59 young adult women. Food consumption was

estimated by taking the mean of nineteen 24-hour recalls administered over a

period of two and a half years. Highly significant correlations were found

between linoleic acid content of fat tissue and diet (r = 0.70) and also

between the linoleic acid-to-saturated fatty acid (linoleic/S) ratio of fat

tissue and diet (r = 0.62). This confirms the hypothesis that on an individual

level the fatty acid composition of the adipose tissue is a valid index for the

habitual dietary fatty acid composition of free-living adults.

When using one 24-hour recall instead of the average of 19 recalls, the

correlation coefficient between the linoleic/S ratio of the diet and that of

the adipose tissue was substantially decreased. This demonstrates the weakening

effect of the large day-to-day variation in within-person intake on the

correlation between a short-term assessment of the nutrient intake of an

individual and a biochemical indicator of long-term nutritional status.

INTRODUCTION

Many problems are encountered in determining food intake by means of survey methods (1, 2). Therefore, there is a great interest in objective biochemical indicators of nutrient intake. It has been known for a long time (3, 4, 5) that the mean fatty acid composition of the subcutaneous adipose tissue of groups of subjects reflects the mean fatty acid composition of the diet of the group. The question remained, however, whether data on adipose tissue composition would give any useful information on the composition of dietary fatty acids of free-living individuals. In an earlier study (6) we examined this question by comparing the fatty acid composition from microbiopsies of buttock adipose tissue with the dietary fatty acid composition as determined by a two-day record method. A two-day record method may provide valid data on the mean composition of the diet of groups of individuals, but yields imprecise information on the fatty acid intake of individuals, due to a large day-to-day variation (7-12). In this earlier study (6) the weakening effect of the day-to-day within-person variance on the correlation coefficient between dietary fatty acid composition and adipose tissue fatty acid composition was estimated using the ratio of the day-to-day within-person variance and the between-person variance as published previously (7, 8, 12). The result indicated that the correlation coefficient between the long-term average dietary P/S ratio and the adipose tissue P/S ratio might be as high as 0.85 instead of the observed 0.49. Therefore, we suggested that the fatty acid composition of an individual's fat tissue could be a valid index for the habitual fatty acid composition of the diet of free-living individuals.

In this study we have tested this hypothesis by taking fat tissue biopsies from 59 young Dutch women after a two and a half year period in which their food intake was estimated 19 times by a 24-hour recall method.

METHODS

Selection of subjects

Women (aged 32-35 years) taking part in a study on seasonal variation in the
energy balance were asked by mail to participate in this study. In the letter
the purpose and method of taking a fat biopsy were explained; a reply coupon
and a short medical questionnaire were included. The medical questionnaires
were screened by a physician. From the 96 subjects contacted 49 agreed
immediately, and another 20 subjects agreed after a telephone call or after a
home visit during which additional explanation was given. The remaining 27
refused to cooperate.

From the 69 women who were willing to participate three subjects were not
eligible for the study because they were pregnant or had moved away. The data
of seven subjects were discarded, since comparison of their stated nitrogen
intake with their urinary nitrogen excretion and of their stated energy intake
and physical activity with their changes in body weight suggested that their
intake data were not trustworthy. The results presented in this paper refer to
the remaining 59 apparently healthy women for whom the 24-hour food recalls
were considered valid. Table 1 shows some characteristics of these women by the
end of the study.

Table 1. Age, body weight, body height and body mass index of the 59
young adult Dutch women.

Variables	Mean	SD
Age (yr)	34.9	1.7
Body weight (kg)	60.4	6.1
Body height (cm)	167.3	5.8
Body mass index (kg/m^2)	21.6	1.7

The study was approved by the ethical committee of the Department of Human Nutrition.

Data on food consumption and nutrient intake

Food consumption was assessed 19 times by means of 24-hour recalls. The interviews were conducted by trained dietitians during home visits in the period from August 1981 till December 1983. The first 14 interviews were carried out at monthly intervals and the last five interviews at intervals of 2-3 months. Per subject at least two interviews were obtained for each day of the week. The portion sizes of the foods most frequently used were checked by the dietitian by weighing on a Soehnle 8600 balance; other foods were estimated in household measurements. The food consumption data were converted into nutrient intakes using the 1981 edition of the computerized Dutch nutrient data bank (13). This data base made it possible to calculate the saturated, monounsaturated and polyunsaturated fatty acid content and the linoleic acid content of the diet, linoleic acid referring almost exclusively to the cis, cis isomer. On the average five per cent of the total amount of fatty acids fell under the category "degree of saturation unknown". The set-up of the data base is such that the sum of the fatty acid categories equals the total (crude) fat; the non-fatty acid part of food lipids has not been taken into account. For statistical calculations fatty acids were expressed in grammes per 100 g fat.

Physical activity

Physical activity was also assessed 19 times by 24-hour recalls. The activities were classified into seven categories by level of energy expenditure (14).

Anthropometric measurements

Body weight without clothes was measured to the nearest 0.5 kg by the
participants themselves the day after every dietary interview before breakfast
and after the bladder had been emptied, using high quality bathroom scales
provided and calibrated by us. The dietitians measured their heights to the
nearest 0.5 cm with a microtoise.

Adipose tissue collection and fatty acid analysis

Three months after the food consumption study had been finished subcutaneous
adipose tissue samples were collected during a home visit. The samples were
taken from the buttock as described by Beynen and Katan (15), using an
evacuated blood sampling tube and a 1.5 mm needle. It has been shown (15) that
this method is rapid and safe and that subjects judge it to be no more painful
or unpleasant than a routine blood sampling from an arm vein.

Methyl esters of the component fatty acids (16) were analysed by gas-liquid
chromatography using a 1.8 meter glass column filled with 10% Silar 5CP on
100-120 mesh Chromosorb WHP packing (Chrompack, Cat. No. 00910, Middelburg, The
Netherlands) with helium as a carrier gas. The oven temperature was 180 $^{\circ}$C and
was programmed to rise to 215 $^{\circ}$C in 28 minutes. This yielded a good separation
of fatty acids from C8:0 to C24:1. In addition, cis- and trans-isomers of
unsaturated C16 and C18 fatty acids were quantitated separately on a 6 m column
containing 15% OV-275. Data are presented and statistical calculations were
made in terms of g/100 g fatty acid methyl esters. Monounsaturated fatty acids
were defined as the sum of cis and trans isomers of C14:1, C16:1,
C18:1 and C20:1; polyunsaturated fatty acids as the sum of all di- and
polyenoic fatty acids; and linoleic acid as cis,cis C18:2 (n-6).
With a view to quality control, two samples of a commercial frying fat were

analysed in each run. The coefficient of variation for this material over a
two-months' period was 0.5 % for major peaks and 1.5 % for minor peaks (< 2
g/100 g fatty acid methyl esters).

Urinary nitrogen analysis

The subjects collected their urine for a 24-hour period in the week
following each of the first 14 interviews, and total urinary nitrogen was
determined by the Kjeldahl method.

Statistical methods

Pearson correlation coefficients were calculated between the fatty acid
composition of the diet and the corresponding variables of the adipose tissue.

The attenuation of correlation coefficients due to day-to-day within-person
variation was calculated according to the formula (7, 8, 12, 17):

$$r = r_u \, (1 + R^2 / k)^{-1/2}$$

r_u : "true" correlation coefficient

r : observed correlation coefficient

k : number of independent recalls per subject

R : ratio of intra-individual coefficient of
    variation over inter-individual coefficient
    of variation in dietary fatty acids.

Analyses of variance were performed with both logarithmically transformed
and untransformed data. The results of the transformed data did not differ
basically from those of the untransformed data. In this report we present

coefficients of variation resulting from the analysis with the transformed data as this is the appropriate way of modelling proportionality between intra-individual variation and individual mean level (see appendix).

A regression analysis was conducted to examine whether the fatty acid composition of the diet can be predicted from the fatty acid composition of the adipose tissue.

RESULTS

The composition of the diet determined by taking the average of the nineteen 24-hour recalls is presented in Table 2.

Table 2. Composition of the diet as determined by the 24-hour recall method repeated 19 times in 2.5 years in 59 young adult Dutch women, and the ratio of the within-subject variation over the between-subject variation in nutrient intake. Comparison with data by Beaton (12).

| | Mean ± SD* | Coeffficient of variation | | | |
| | | Within subjects | Between subjects | Ratio within/between | |
				This study	Beaton et al.
Energy (kcal/day)	2132+617	0.25	0.16	1.6	1.2
Protein (% of energy)	13+5	0.27	0.09	3.0	2.0
Fat, total (% of energy)	38+8	0.20	0.11	1.8	1.6
Sat. fatty acids (% of energy)	16+4	0.23	0.13	1.8	1.4
Monounsat. fatty acids (% of energy)	15+4	0.24	0.13	1.9	1.8
Polyunsat. fatty acids (% of energy)	6+2	0.36	0.19	1.9	3.3
Linoleic acid (% of energy)	5+2	0.42	0.23	1.8	-
P/S ratio+	0.40+0.20	0.42	0.22	1.9	2.8
M/P ratio+	2.78+1.16	0.34	0.19	1.8	-
Carbohydrate, total (% of energy)	44+9	0.16	0.13	1.2	1.3
Mono- and disaccharides (% of energy)	23+7	0.26	0.21	1.2	-
Alcohol (% of energy)	5+2	†	†	†	†

* The 19 recalls were averaged per subject; the mean and SD of these 59 averages are given.
+ S, M and P: saturated-, mono- and polyunsaturated fatty acids.
† No analysis of variance was made, because the distribution was skewed.

The dietary pattern is typical for a Western population and is similar to that found in earlier studies on the food consumption of young Dutch adults (18).

The ratio of the intra-individual coefficient of variation over the inter-individual coefficient of variation given in this table makes it possible to estimate the attenuation of the correlation coefficients between the dietary fatty acid composition and the fatty acid composition of the adipose tissue. A high ratio for the fatty acid intake would cause underestimation of the correlation coefficients if only one 24-hour recall per subject was used. As can be seen in Table 2, the ratio was highest for the energy percentage from protein; this was caused by the very low between-subject coefficient of variation. In general, the ratios found in this study are comparable to the findings of Beaton et al. (12), who used six 24-hour recalls. Exceptions are the ratios for the energy percentages from protein and polyunsaturated fatty acids and for the P/S ratio. The higher values for the latter two variables in Beaton's study are due to a higher within-subject variation.

The average fatty acid composition of the adipose tissue agreed well with the findings in our earlier study (6) and with data from the USA (19) as is shown in Table 3. Dietary polyunsaturated fatty acids consist mainly of linoleic acid, which cannot be synthesized de novo by man. The results from our study confirm earlier findings (5) that long-term (relative) linoleic acid intake is well reflected in the proportion of this acid in the adipose tissue (Table 3). This was less so for the percentages of monounsaturated fatty acids (M) and saturated fatty acids (S) in the adipose tissue. This is not surprising, as the body synthesizes these fatty acids from various precursors and can also convert them into each other.

Table 4 shows the observed Pearson correlation coefficients and the calculated "true" or unattenuated correlation between the fatty acid composition of the adipose tissue and the diet in this study and in the normal healthy controls in our previous study (6). The attenuation factor of

Table 3. Proportion of fatty acids (g/100 g fatty acids) in the diet and in the adipose tissue of 59 young adult Dutch women (mean ± SD). Data on the adipose tissue of 51 young adult Caucasian men in the USA (19) are given for comparison.

Fatty acids	Dietary fat	Adipose tissue	
	Dutch women	Dutch women	USA men
	(g/100 g fat)	(g/100 g fatty acid methyl esters)	
Saturated	41.2 ± 2.6	25.2 ± 2.0	29.1
Monounsaturated	37.9 ± 2.0	54.3 ± 2.5	57.9
Polyunsaturated	15.4 ± 2.7	18.1 ± 2.2	
Linoleic	12.9 ± 2.8	14.3 ± 2.1	12.8
Unknown	5.5	2.4	

Table 4. Observed and unattenuated* correlation coefficients between the fatty acid composition of the diet and of the adipose tissue. Data are given for the control group of our previous study (6; men and women, n=162), and for the present group of young adult Dutch women (n = 59).

Fatty acid	Correlation coefficient			
	Previous study (average of a 2-day record)		Present study (average of nineteen 24-hour recalls)	
	observed	unattenuated*	observed	unattenuated*
P/S ratio +	0.38	0.65	0.57	0.63
M/P ratio +	0.38	0.61	0.63	0.69
P +	0.40	0.64	0.68	0.75
Linoleic/S ratio +			0.62	0.68
M/linoleic ratio +			0.63	0.69
Linoleic acid			0.70	0.77

* The value expected if the mean intake during an infinite number of survey days is assumed. It was calculated by the formula presented in the Methods section.

+ P = polyunsaturated fatty acids, Linoleic = linoleic acid, M = monounsaturated fatty acids, S = saturated fatty acids.

$(1 + R^2/k)^{-1/2}$ for the P/S ratio was about 0.91 for the present study as
opposed to 0.62 for the previous study, in which only 2 days were recorded per
person. The unattenuated correlation coefficients predicted from the present
data are similar to those calculated in our previous study.

A separate analysis was conducted for subjects with large fluctuations in
body weight, because Dayton et al. (20) have shown that these fluctuations
disturb the relationship between the fatty acid profile of adipose tissue and
the average fatty acid composition of the diet. The data of women with a change
in body weight by more than 3 kg from the first to the last 3 measurements
(mean absolute weight change 5.4 $\pm$ 1.5 kg in two and a half years) were
compared with those of women with a more stable body weight. Table 5 and Figure
1 show that this change in weight indeed weakens the correlation of the dietary
fatty acid composition and the fatty acid composition of the adipose tissue,
although the correlation coefficients are still rather high even for the group
with large changes in body weight.

DISCUSSION

Dietary surveys are usually conducted to characterize the food and nutrient
intake of populations with emphasis on group means rather than on the results
of the individuals in the group. Already in 1952 Chalmer (21) stated that
unless repeated surveys are made of the same individuals, inter-individual
variation will be overestimated and intra-individual variation will be
underestimated. As a consequence, the dietary intakes of individuals found in
surveys covering one or only a few days fail to correlate with other
characteristics of these individuals even if there is ample evidence that those
characteristics are affected by the diet (7-9, 12, 17).

In the present study we have used the mean of nineteen 24-hour recalls
obtained over a two and a half year period as a reference method to test the

Table 5. Effect of changes in body weight on the correlation coefficient
between the fatty acid composition of the diet and the fatty acid
composition of the adipose tissue. "Changed" denotes subjects (n = 27)
who had lost or gained more than 3 kg in 2.5 years. "Stable" denotes
the others (n = 32).

Fatty acid variable	Weight category	Correlation coefficient r	95% confidence limits for r	One-tailed P-value[†]
Linoleic/S ratio[+]	"changed"	0.54	0.23 - 0.76	
	"stable"	0.75	0.54 - 0.87	0.09
M/Linoleic ratio[+]	"changed"	0.54	0.21 - 0.64	
	"stable"	0.77	0.57 - 0.88	0.07
Linoleic[+]	"changed"	0.62	0.32 - 0.81	
	"stable"	0.82	0.66 - 0.91	0.06

* Calculated as the difference between the means of the first three and the
last three measurements.

+ Linoleic = linoleic acid, M = monounsaturated fatty acids, S = saturated
fatty acids.

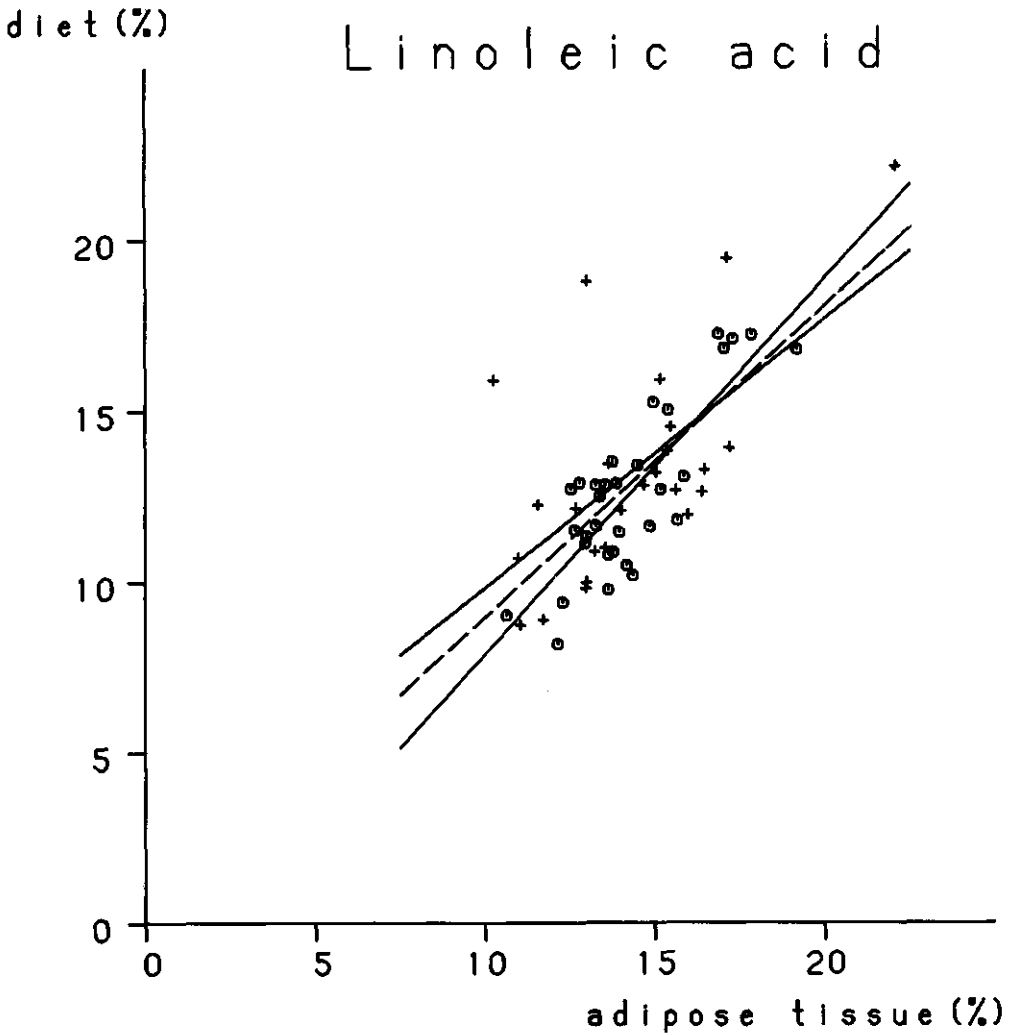† For difference between values of "stable" and "changed" groups.

Linoleic acid

Figure 1.

Linear regression (y = -0.14 + 0.91x) of linoleic acid (g/100 g fat) in the diet, assessed with a 24-hour recall method repeated nineteen times during two and a half years, on the corresponding value in adipose tissue.

+ denotes women (n = 27) who lost or gained more than 3 kg during the survey period (y = 1.96 + 0.79);

o denotes women (n = 32) with a more stable body weight, (y = -3.12 + 1.10)x.

hypothesis that the fatty acid composition of an individual's subcutaneous buttock fat tissue is a valid index of the long-term fatty acid composition of the diet. The half-life time of adipose tissue in humans in energy balance is approximately 600 days (4, 22) and thus its composition should reflect the dietary fatty acid intake over the preceding two and a half years. The results shown in Table 4 confirm that, at least for apparently healthy young adult women, the fatty acid composition of an individual's subcutaneous (buttock) fat tissue is a valid index of the long-term fatty acid composition of the diet. The lowest observed Pearson correlation coefficient was 0.57 for the P/S ratios and the highest was 0.70 for the cis-cis linoleic acid values. The correlation was 0.62 for the linoleic/S ratio, which means that almost 40 per cent of the variation between individuals in this ratio in fat tissue is accounted for by variation in apparent dietary intake. If the number of recalls per person would be further increased, the correlation coefficient would finally approximate a value as high as 0.68 (Table 4). On the other hand, with only one 24-hour recall per person the degrading factor would be 0.48 and, theoretically, the correlation coefficient for the linoleic/S ratio in adipose tissue and diet would approximate a value of 0.32. We found values ranging from 0.14 to 0.50 with a median of 0.28 on considering the nineteen 24-hour recalls separately. We could not find any systematic time or seasonal effect on the size of the correlation coefficient.

Thus this study demonstrates the weakening effect of a large day-to-day variation in intake on the correlation coefficient between a short-term assessment of the nutrient intake of an individual, and a biochemical indicator of the long-term nutritional status.

Yet, even with nineteen 24-hour recalls about half of the variance in the fatty acid composition of the adipose tissue could not be explained by the intake data. This may be due partly to differences in fatty acid metabolism beween subjects, and for a greater part to errors made in recalling the types

and amounts of foods eaten, identification of ingredients in ready-to-eat foods, and shortcomings of the food composition table used to calculate the fatty acid contents of the foods (23).

The linear regression of the percentage of polyunsaturated fatty acid in the diet on the corresponding variable in the adipose tissue was compared with data from an ecological study based on 14 population means, published by Beynen et al. (5). The slope of the regression line in the ecological study was b = 1.2, but if population groups with sizes smaller than n = 10 were discarded the slope equalled 1.1. Thus between populations a difference of 1 g/100 g fatty acids in adipose tissue polyunsaturated fatty acid content predicts a difference in intake of 1.1 g/100 g of fat. In the present study the slope of the regression line for the 59 individuals was b = 0.9. Excluding subjects with great changes in weight, the slope equalled 1.1. This means that the slope of the regression line for group means in the population-based study was similar to that for individuals in the present study. This indicates that the expected differences of the percentage of polyunsaturated fatty acid in the diet for given differences of the corresponding variable in the adipose tissue is the same for individuals with a stable body weight as it is on an aggregate level. This suggests that we are dealing with a fairly general physiological mechanism.

The question arises whether individuals in other categories of the population would demonstrate the same linear regression. In adults the effects of age and sex on the fatty acid composition of the adipose tissue is negligible (24, 25). However, in addition to large fluctuations in body weight, some pathological factors might affect the linear regression of the fatty acid composition of the diet on the corresponding variable in the adipose tissue (26).

We have shown that the fatty acid composition of body fat tissue biopsies is a valid indicator of the long-term dietary fat composition of healthy

individuals, especially for subjects who did not experience large gains or losses in body weight during the preceding two to three years. This biochemical indicator may be of value for investigations into the relationship between nutrition and cancer, studies on dietary compliance, and studies evaluating the long-term effects of nutrition education programmes.

ACKNOWLEDGEMENTS

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Appendix

When intra-individual variation is known to be related to mean individual level, it is often considered appropriate to express variability as a coefficient of variation (CV) instead of in terms of the standard deviation (SD) itself.

In this case it is implicitly understood that the assumption of homoscedasticity in the analysis of variance model, i.e. equal intra-individual variances for each subject, is violated.

A logarithmic transformation allows for a proportional increase in the SD with mean level of measurement, i.e. it accomplishes the desirable property of homogeneity of variances of the transformed variables.

When employing the natural logarithm, the coefficient of variation of the untransformed variable is approximately equal to the square root of the residual variance of the transformed variable.

9. DISCUSSION

This thesis reports on the validity and reproducibility of methods assessing food consumption in groups of free-living Dutch adults consuming self-selected diets. Only methods producing quantitative estimates of energy and nutrient intake have been examined. Qualitative approaches such as food frequency methods are not described in this thesis. The aim of this chapter is a wider discussion of the information presented in the preceding chapters.

There are many sources of error in food consumption studies as Table 4 in Chapter 2 clearly shows and results from studies relating diet and health in free-living populations have thrown doubt on the usefulness obtained by the different methods. Several authors have pointed out that the methods indeed often fail to produce accurate results for each individual, but that this inaccuracy has two origins, viz.firstly the discrepancy between what the investigator wants to estimate and what the technique actually estimates, and secondly the observation per se. For epidemiological studies it is not always necessary to produce accurate results for each individual, but methods yielding valid data on groups of individuals would be of great value. To be able to obtain such valid data on a group level it is of the utmost importance to specify before-hand which kind of data the study should supply. In Chapter 2, Table 6, the data required for three purposes have been formulated, viz.,
A. Average energy and nutrient intake data of a group, to make a group
   to group comparison   In such a survey a representative sample of the
   population under study as well as a representative period of obser-
   vation are required.

B. The distribution of usual energy and nutrient intake data within a
   population to detect groups of individuals at risk, if the risk is
   marked by a high or low intake of a certain nutrient.
C. The usual energy and nutrient intake of individuals throughout time
   to make a correlation and regression analysis relating independent and
   dependent variables in order to make inferences on an aggregate level.

We will discuss how far the methods described in this thesis can supply
the data desired to fulfill these three purpose.

Ad Purpose A:

The preferred approach for this purpose is to estimate the energy and
nutrient intake of one day per person in a large group with an adequate
representation of all days of the week. A certain required precision for
the mean intake (e.g. a standard error of 10 per cent or less of the mean
value) does necessarily not fix the sample size and the number of days
per person, but can be attained by a number of equivalent combinations.
In Chapter 3 is demonstrated which combinations are of a similar
precision and how these depend on the total variation and on the ratio
of the within-person variations to the between-person variation. Although
the importance of the ratio of the within-person variation to the between-
person variation has been known for a long time (1, 2, 3, 4), most
investigators seem to take this ratio into account in their study design
only recently.

A weighed record method has been considered since long as the golden
standard and valid group estimates may be obtained with this method (5,
6, 7). Based on comparison of protein intake with urine nitrogen excretion
it might be concluded that valid group estimates on protein intake may
also be obtained with the dietary history method estimating the usual

food consumption of the previous month (Chapter 4) and with the single and the repeated 24-hour recall method (Chapter 7). Study designs and interviews, however, should be made carefully, because it appears that systematic underestimation of energy and nutrient intake often occurs with record as well as recall methods (8).

In epidemiological research on the relationships of nutrition and cancer there is a growing interest in valid methods assessing dietary intake in the distant past. Chapter 5 indicates that for group to group comparisons past dietary patterns can be ascertained retrospectively with some degree of succes. It appeared, however, that current dietary patterns in 1983 affected reporting about past dietary patterns.

Ad Purpose B and C:

For the purposes as mentioned under B and C it is necessary to assess the usual energy and nutrient intake of individuals, although the data are interpreted on an aggregate level. Here too, sample size and number of observations required depend on the precision desired and the ratio of the within-person to the between-person variation.

The dietary history method has been developed by Burke (9) to estimate the usual food consumption of individuals with one interview and sometimes completed with a three-day record method. The usual food consumption refers to the past year, six months or season. According to Burke (9) this method can only be applied in groups of individuals with a rather constant dietary pattern. Since Burke developed this method in 1947 food consumption patterns have become much more complicated. At this moment it is difficult to interview individuals in industrialized countries about their usual food consumption over one year. Therefore we have restricted the time of reference in our dietary history interviews to one month (Chapter 4). Even then it is practically impossible to

to validate the results of the dietary history method on an individual level. In Chapter 4 the high mean standard deviations of mean differences between individual pairs of the first and the second dietary history interview indicate that the reproducibility on an individual level in this study was poor especially for fat, fatty acids, dietary fiber and alcohol.

It has been suggested that recalls or records of a single day's food intake randomly selected to represent all days of the week and administered over an interval long enough to discover cyclic changes, will result in valid estimates of the usual intake of individuals. Such a design with 19 times repeated 24-hour recalls administered over 2 1/2 years has been described in Chapter 6 and 7 for 114 and 123 adult women respectively . This design should yield valid information for purposes as mentioned under B and C.

To estimate the percentage of the population at risk (purpose mentioned under B) tertile analysis might be applied to classify subjects into small, medium and big consumers of energy and nutrients. Categorical analyses of this type have their drawbacks, as has been described in Chapter 5. If there is, however, no linear relationship between energy or nutrient intake and other characteristics of the subjects under study (e.g. a health indicator), this analysis is a good first try. Using the data presented in Chapter 7 we have compared the results of such a tertile analysis on the mean daily protein intake, as assessed with the first fourteen 24-hour recalls, with the mean daily protein intake, as assessed with nitrogen excretion in fourteen collections of 24-hour urine. The results showed, that 55 per cent of the individuals was classified in the same tertile, but 11 per cent of the subjects was classified in opposite consumption categories.

If a difference between the assessment with the 24-hour recalls and
the assessment with the 24-hour urine nitrogen excretion of no more than
20 g of protein is considered as sufficiently accurate for the purposes
as mentioned under C, the outcome of our study is that the data on
protein intake of 84 per cent of the subjects may be considered valid.
However, a difference of 20 grams in the daily protein intake between the
two estimates is a large discrepancy. The results of this validation on
protein intake confirmed the validation on energy intake: most of the
subjects who either underreported or overreported their protein intake
by 20 grams or more either reported a very low or a very high energy
intake. Thus, depending on the criteria used, 11-16 per cent of the
subjects were not able to provide valid 24-hour food recalls. Most of
these in-valid recalls concerned participants, who reported either a very
high or a very low energy intake. This result indicates that it is very
difficult to determine within a group under study, solely on the basis of
food consumption data, the percentage of subjects with a high or a low
health risk, if the risk is marked by a high or a low intake of a certain
nutrient (purpose B). To relate intake data of certain nutrients with
indicators of the health status (purpose C) it has been suggested to
oversample and to check data with an independent biochemical indicator
of the diet. This makes it possible to discard data which are not
considered trustworthy.

The question has been formulated whether the degree of biasing found in
our long-term study is especially related to the 24-hour recall method.
There are but a few studies available assessing individual daily food
consumption and covering a period as long as one year or more. Miles et al.
(10) determined the intake of energy and nutrients of 16 women and 13 men
Consuming self-selected diets daily, with a weighed record method, over a
one year period. During four seven-day balance periods, corresponding to
the four seasons of the year, duplicates of diets consumed and urine and

faeces excreted were collected for analysis and for calculation of available energy and nitrogen balance. During the four balance periods, the food intakes and thus the energy and protein intake of the subjects decreased as documented by seven-day food records immediately before and after the balance period. The observed decreases in intakes make it difficult to extrapolate the results of the balance periods to the results covering the whole year and consequently to compare the results with our long-term food intake data, which were discussed above. No other validation studies of long-term dietary intakes of individuals are known. Such studies are useful as reference studies to evaluate the importance of seasonal effects in energy and nutrient intake. Furthermore they would serve to provide the usual food intake data of individuals against which other methods assessing long-term nutrient intake may be validated (Chapter 8).

The data in Chapter 6 revealed that seasonal variations in the intake of energy and of some of the nutrients were small in our study group. Miles et al. also found seasonal variation but only in the intake of some of the micro-nutrients (10).

In Chapter 8 we have described a validation study of a biochemical indicator of the intake of a nutrient. In this study we have demonstrated that microbiopsies of subcutaneous fat tissue are a valid indicator of the long--term fatty acid composition of the diet. As has been discussed in this Chapter it is hard to obtain valid estimates on the fatty acid composition of the diet by recording or recalling alone. If the sole purpose of the study is to collect data on the fatty acid intake of individuals the biopsy method may replace the food record or recall method. If information on the intake of energy and other nutrients is needed as well as information on the sources of fat, then the biopsy method as described in Chapter 8 may supply valuable information in addition to either a recall or a record method. As yet only few biochemical indicators yielding information on the long-term intake of nutrients are known.

Further attempts to perfect methods are desirable in order to decrease response errors (Table 4, Chapter 2) and consequently the within-person variation. Moreover adequately formulated research designs comparing - if possible - population groups with extremely diverse diets (e.g. in international multicentre studies) will be very helpful to find out the relationships between nutrition and health or disease. It is not possible to show a clear-cut relationship between diet and health from food consumption studies alone. Ultimately in most cases, the aim is to show a dose-response relationship between a diet and a health indicator. This can only be attained on the basis of consistency of the evidence from various kinds of investigations: i.e. next to surveys in several free-living population groups consuming self--selected diets, metabolic experiments in humans as well as animals are required.

In conclusion: the methods for assessing food consumption described in this thesis appear to be relatively valid for estimating the mean intakes of energy and the described nutrients in groups of people (Purpose A). If only data on food consumption are available, however, it is difficult to categorize unbiased within the study-population groups with a low or a high intake of a certain nutrient (Purpose B). This is so even, if based on the required precision and the ratio of the within-person to the between-person variation, enough records or recalls are obtained per participant in a sample of sufficient size. If energy and nutrient intake data are to be related to health indicators (Purpose C) it is advocated to oversample and to check the intake data with an independent biochemical or physiological indicator of the intake of a nutrient. This makes it possible to discard data that are considered not to be trustworthy. The remaining data, considered valid, and collected within an adequately formulated research design will be very useful in finding out the relation between nutrition, health and disease.

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10. SUMMARY

This thesis reports on the validity and the reproduciblity of methods assessing food consumption in groups of free-living Dutch adults consuming self-selected diets. The validity of a method, that is the demonstration that a method measures what it is intended to measure, can only be assessed by comparing it with an independent method of indisputable accuracy. There is no such absolute method because of the nature of the data to be collected. Instead, it may be possible to establish either the relative validity or the concurrent validity. The relative validity evaluates the method in terms of another generally accepted method, designed to measure the same concept. The concurrent validity compares the results of a method with a biological marker. Validity studies refer to information bias and systematic response errors.

A method is commonly called reliable or reproducible if it gives the same results when used repeatedly in the same situation. The problem in food consumption surveys is that the situation is never absolutely identical. Reproducibility refer to the biological within-person variation (a true day-to-day variation) as well as to random response errors, because these two sources of variation can hardly be separated.

Many objectives can be served in conducting food consumption studies. It is essential to distinguish between food consumption surveys mainly used for national food planning and administration and surveys in which the emphasis is primarily on the relation between nutrition and health. Distinction is necessary because each objective demands a different type of information. In this thesis only methods assessing food consumption used in studies on the relationship between diet and health have been examined.

Chapter 2 describes the state of the art of methods assessing food consumption. There are many sources of error in these types of studies as Table 4 in Chapter 2 clearly shows. For epidemiological studies, however, it is not

always necessary to produce accurate results for each individual, but methods yielding valid data on groups of individuals would be of great value. To be able to obtain such valid data on a group level it is of the utmost importance to specify beforehand which data the study should supply. In Chapter 2, Table 6, the data required for three purposes have been formulated, viz.:

A. Average energy and nutrient intake data of a group, to make group-to-group comparisons. In such a survey a representative sample of the population under study as well as a representative period of observation are required.
B. The distribution of usual energy and nutrient intake data within a population, to detect groups of individuals at risk, if the risk is marked by a high or a low intake of a certain nutrient.
C. The usual energy and nutrient intake of groups of individuals throughout time to make a correlation and regression analysis relating independent and dependent variables in order to make inferences on an aggregate level.

For all three purposes data have to be collected on an individual level, but they are analysed and interpreted on an aggregated level. Chapters 3 to 8 describe the evaluation of methods used for the above-mentioned purposes in groups of Dutch adults. In all methods sizes of portions of the foods most frequently consumed have been checked by weighing by the interviewer. Other portions have been estimated in standard household measurements. The amounts of foods consumed have been converted into energy and nutrients using the national nutrient data base "UCV".
In Chapter 3 the seven-day record method has been described assessing the energy and dietary fiber intake of 100 adults (44 men and 56 women). In the analysis the emphasis was on the within-person and the between-person variation in the intake of energy and dietary fiber. Information on these components of variance is desired to determine in study designs the number of persons and the

number of records per person required to assess with a certain precision the group mean in the intakes of nutrients. The findings in this study show that the precision for the measurement of dietary fiber intake obtained by using one-day food records from twice the number of individuals is comparable to that obtained from a seven-day food record. For the measurement of energy intake, only 1.5 times the number of individuals is required for the one-day record method to obtain the same precision as with the seven-day record method. However, a one-day record method does not yield information on the usual food consumption of an individual. To be able to distinguish within the study population groups of individuals with a very high or a very low intake of a certain nutrient more food records per person are needed. The number of records required depends on the ratio of the within-person variation to the between-person variation.

Chapter 4 describes the validity and the reproducibility of a dietary history method assessing the usual food consumption during one month. Forty-four young adults (aged 19-32 years) participated in this study. The concurrent validity of the method was assessed by means of the 24-hour urine nitrogen excretion. The mean difference between nitrogen intake and nitrogen excretion was 0.0 g with a 95 per cent confidence limit of $\pm$ 1.1 g. These limits for the mean difference between excretion and intake indicate a valid assessment of the protein intake of this group.

The reproducibility was evaluated in the same group through a test-retest design. The intra-class correlation coefficients were high over a weighted average of week-days and for an average workday as regards the intakes of energy and selected nutrients. As to the Saturday and Sunday intakes, the correlation coefficients were lower for the energy intakes and most of the nutrients (except alcohol) indicating a poorer reproducibility for week-end assessments.

Chapter 5 describes a dietary history method assessing the food consumption in retrospect. In 1983 the relative validity of the retrospective dietary history method (DH'R) was assessed against a current dietary history taken seven years earlier, in 1976 (DH'76), and a second current dietary history taken in 1983 (DH'83). In total 44 men and 58 women, aged 38-62 years, participated in the study. For the intake of energy and most of the nutrients the relative difference between DH'R and DH'76 was below 15 per cent. The difference between energy and nutrient intake reported contemporaneously and retrospectively appears to be comparable with or slightly more than the reported change in food consumption between 1976 and 1983. Similar results were found for food groups. The results indicate that for group-to-group comparisons past dietary patterns can be ascertained retrospectively with some degree of success. Such data can be useful in case-control studies examining the relationship between diet and cancer.

Seasonal variation in the intakes of energy and nutrients may affect the validity as well as the reproducibility of results in studies examining food consumption.
In Chapter 6 the effects of the season on the energy balance of 114 young adult women are described. Energy intake and pattern of physical activity were assessed monthly fourteen times with the 24-hour recall method. The day following each interview before breakfast body weight without clothes was measured by the participants themselves. After these 14 months, in the second year the same estimates were made with intervals of 2-3 months to check if the observed seasonal variations were not a casual effect.
The study did not demonstrate seasonal variation in the mean energy intake of the group under study. A statistically significant effect of the season was observed in the intake of fat, dietary fiber and mono- and disaccharides. For mono- and disaccharides this seasonal effect could not be confirmed the second

richtlijnen te kunnen samenstellen voor een goede voeding. Deze verschil-
lende doelstellingen hebben geleid tot zeer verschillende methoden. In
dit proefschrift zijn alleen methoden geëvalueerd, die gebruikt worden
in onderzoek naar de relatie voeding, gezondheid en ziekte.

In hoofdstuk 2 wordt de stand van zaken met betrekking tot de kwaliteit
van het voedselconsumptieonderzoek toegelicht. Er zijn veel bronnen van
fouten en variatie. In epidemiologisch onderzoek bij mensen onder niet
gecontroleerde omstandigheden is het echter niet direct noodzakelijk om
op individueel niveau in grammen of milligrammen nauwkeurig op te geven
wat mensen aan voedingsstoffen opnemen. Op groepsniveau moeten de waar-
nemingen echter voldoende nauwkeurig zijn om te kunnen voldoen aan één
van de volgende doelstellingen:
A. het vergelijken van de voedselconsumptie van diverse bevolkingsgroepen;
B. het maken van onderscheid binnen onderzoekspopulaties in groepen met
   en zonder een bepaald gezondheidsrisico, wanneer dit risico bepaald
   wordt door een hoge of lage opneming van een bepaalde voedingsstof;
C. het leggen van relaties tussen de opneming van energie en voedings-
   stoffen enerzijds en biochemische of fysiologische indicatoren van de
   gezondheidstoestand anderzijds.
Ten behoeve van deze doelstellingen worden resultaten op geaggregeerd
niveau geanalyseerd en geïnterpreteerd; niettemin dienen de gegevens op
individueel niveau verzameld te worden. In hoofdstuk 3 tot en met 8 zijn
een aantal individueel gerichte methoden die de voedselconsumptie bij
volwassenen meten nader onderzocht. Bij alle onderzochte methoden is de
hoeveelheid voedingsmiddel, die men opgaf te eten, geschat door de meest
gebruikte porties (achteraf) te wegen. Deze hoeveelheid voedingsmiddel
is omgezet in energie en voedingsstoffen met behulp van de voor de
computer geschikt gemaakt uitgebreide Nederlandse voedingsmiddelentabel
("U.C.V.").

In hoofdstuk 3 wordt de zeven-daagse opschrijfmethode ("record")
beschreven als instrument om de opneming van energie en voedingsvezel te
meten bij 100 volwassenen (44 mannen en 56 vrouwen). Bij de analyse is
de nadruk gelegd op de binnen- en tussenpersoons variatie in de opneming
van energie en voedingsvezel. Deze componenten van variatie zijn belang-
rijk bij het bepalen van het aantal personen en het aantal dagen per
persoon, dat nodig is om met een van tevoren vastgestelde betrouwbaar-
heid (b.v. een "standard error" van tien procent of minder van de gemid-
delde waarde) de gemiddelde opneming van energie en voedingsvezel te
kunnen meten. Het bleek in dit onderzoek bijvoorbeeld, dat voor het vast-
stellen van de gemiddelde opneming van voedingsvezel op groepsniveau met
behulp van een één-daagse "record" methode twee keer zoveel mensen nodig
zijn als met de zeven-daagse "record" methode, wanneer dezelfde graad
van betrouwbaarheid wordt nagestreefd. Een waarneming van één dag per
persoon is echter alleen geschikt voor het vaststellen van groepsgemiddel-
den. De dag-tot-dag variatie in de opneming van energie en voedingsstoffen
per persoon is meestal erg groot en voor het onderscheiden van risico-
groepen binnen de onderzoekspopulatie zijn meer dagen per persoon nodig.
Het aantal "records" dat nodig is per persoon is afhankelijk van de
binnen-persoons variatie en de verhouding tussen de binnen-persoons en
tussen-persoons variatie.

Ten behoeve van dit laatstgenoemde doel kan ook een "dietary history"
methode gebruikt worden. Een "dietary history" methode achterhaalt door
middel van één interview de gebruikelijke voeding van een persoon over een
bepaald tijdsbestek. Burke heeft deze methode in 1947 ontwikkeld en
destijds werd gevraagd naar de gebruikelijke voedselconsumptie van het
afgelopen jaar of half jaar. Inmiddels is de variatie in het voedsel-
patroon in geïndustrialiseerde landen sterk toegenomen en is deze methode

steeds moeilijker toe te passen. Hoofdstuk 4 beschrijft een onderzoek
naar de validiteit en reproduceerbaarheid van een "dietary history"
methode, die vraagt naar de gebruikelijke voeding van de afgelopen maand.
De validiteit is onderzocht door de gemiddelde dagelijkse eiwitconsumptie
te vergelijken met de gemiddelde stikstofexcretie in 24-uurs urine bij
44 volwassenen. Op groepsniveau bleek de overeenstemming heel goed te zijn.
Het is praktisch gezien bijna onmogelijk om de "dietary history" op
individueel niveau te valideren. Dit zou vereisen, dat bijvoorbeeld in
dit onderzoek de deelnemers "prospectief" meerdere malen urine hadden
moeten verzamelen gedurende de maand waarover later met behulp van de
"dietary history" navraag gedaan werd. De reproduceerbaarheid werd
geëvalueerd in een test-retest onderzoeksontwerp bij 47 volwassenen. Op
groepsniveau bleken de gegevens eveneens goed reproduceerbaar te zijn,
maar standaarddeviaties van de gemiddelden van de individuele verschillen
gaven aan, dat op individueel niveau de reproduceerbaarheid niet goed is
voor de meting van de opneming van energie en de meeste voedingsstoffen.

De "dietary history" methode kan behalve naar de voeding van het
recente verleden (de huidige voeding) ook vragen naar de voeding in het
verre verleden. In hoofdstuk 5 worden de resultaten van een dergelijke
"retrospective dietary history" methode, die in 1983 vroeg naar de
voedselconsumptie in 1976, vergeleken met de resultaten van een "dietary
history" methode afgenomen in 1976 bij dezelfde groep mensen. Met behulp
van deze laatste methode werd destijds naar het huidige voedselconsumptie-
patroon gevraagd. Bovendien is in 1983 bij deze groep mensen nogmaals
naar de huidige voedselconsumptie gevraagd met een "dietary history"
methode. De "retrospective dietary history" methode wordt dus vergeleken
met twee "dietary history" methoden die naar het huidige voedselpatroon

vroegen: de één in 1976, de ander in 1983. Er waren respectievelijk
91 en 88 volwassenen bij betrokken. In alle 3 de onderzoekingen is gevraagd
naar de voeding in de winter (oktober tot maart). De vergelijking van de
resultaten van de "retrospective dietary history" met de resultaten van de
"dietary history", die in 1976 vroeg naar de huidige voedselconsumptie
geeft aan dat het relatieve verschil voor energie en bijna alle berekende
voedingsstoffen kleiner was dan 15 procent. Uit de vergelijking van de
resultaten van de retrospectieve methode met de "dietary history" methode,
die in 1983 vroeg naar het huidige voedselpatroon, blijkt echter dat het
huidige voedselpatroon invloed heeft op de antwoorden die bij de retro-
spectieve methode worden gegeven.

In hoofdstuk 6 worden de seizoenseffecten beschreven op het voedsel-
consumptiepatroon, de lichamelijke activiteiten en het lichaams-
gewicht van 114 jonge volwassen vrouwen. Het onderzoek is uitgevoerd
met een negentien keer herhaalde 24-uur "recall" methode over zowel
de voeding als de lichamelijke activiteit gedurende tweeëneenhalf
jaar (augustus 1981 - december 1983). De eerste veertien metingen werden
maandelijks verricht. Naast voeding en lichamelijke activiteit werd ook
het lichaamsgewicht vastgesteld en 24-uurs urine verzameld. De laatste
vijf keer is geen urine meer verzameld en waren de intervallen tussen
de metingen 2 tot 3 maanden. De vrouwen verrichtten overwegend lichte
lichamelijke activiteiten. Ongeveer de helft van de vrouwen werkte
buitenshuis, maar 80 procent van deze werkende vrouwen werkte 20 uur of
minder buitenshuis per week. De resultaten van het onderzoek tonen aan,
dat er geen seizoenseffect is op de energieopneming, maar dat er een
kleine seizoensvariatie te bespeuren valt in de opneming van vet, kool-
hydraten en voedingsvezel en in het lichaamsgewicht. Deze variaties zijn
gering en hebben fysiologisch nauwelijks enige betekenis. In longitudinaal
onderzoek echter, waarbij veranderingen in voedselconsumptie en/of lichaams-

gewicht onderzocht worden, is het aan te bevelen met deze seizoenseffecten rekening te houden.

Hoofdstuk 7 handelt over hezelfde onderzoek als hoofdstuk 6, maar in dit hoofdstuk wordt de validiteit van de (eerste) veertien keer herhaalde 24-uurs "recall" methode beschreven. De validiteit is bepaald door de energieopneming te vergelijken met veranderingen in lichaamsgewicht en door de gemiddelde eiwitopneming zoals bepaald door de 24-uurs "recalls" te vergelijken met de gemiddelde eiwitopneming bepaald op basis van N-uitscheiding in 24-uurs urine. Uit het onderzoek blijkt, dat mensen die zeggen weinig te eten, dikwijls onderrapporteren en mensen die zeggen veel te eten dikwijls overrapporteren. Afhankelijk van de kriteria, die aangelegd worden, zijn de gegevens van 11-20 procent van de vrouwen onbetrouwbaar. Het grootste deel van deze onbetrouwbare gegevens (80 procent) komt van mensen uit de extreme groepen, dus van mensen die een zeer hoge of zeer lage energieopneming hebben gerapporteerd (potentiële risicogroepen). Het resultaat van dit onderzoek geeft aan hoe moeilijk het is om binnen populaties op betrouwbare wijze risicogroepen vast te stellen.

Hoofdstuk 8 beschrijft in hoeverre op individueel niveau de vetzuursamenstelling van een micro-biopt uit het onderhuids vet een valide indicatie kan geven van de vetzuursamenstelling van de voeding. Negenenvijftig vrouwen uit de seizoensstudie (hoofdstuk 6), waarvan de rapportage over de voeding valide bleek te zijn (hoofdstuk 7) namen deel aan dit onderzoek. De hoge correlatie coëfficiënt van 0,7 die werd gevonden tussen linolzuur in het voedingsvet en in het onderhuids vetweefsel toont aan dat de vetzuursamenstelling van het onderhuids vetweefsel een valide indicatie kan geven van de vetzuursamenstelling van de voeding.

Uit het onderzoek gepubliceerd in dit proefschrift kan geconcludeerd worden dat met alle toegepaste methoden bij volwassenen in Nederland de gemiddelde dagelijkse opneming van energie en een aantal beschreven voedingsstoffen op groepsniveau valide kan worden vastgesteld. Het is echter bijzonder moeilijk om binnen onderzoekspopulaties risicogroepen vast te stellen, als dat risico bepaald wordt door heel veel of heel weinig van een bepaalde voedingsstof te gebruiken. Om relaties vast te kunnen stellen tussen opneming van energie en voedingsstoffen enerzijds en een indicator van de gezondheidstoestand anderzijds wordt aanbevolen een veel grotere steekproef te nemen dan op grond van binnen- en tussen-peroons variaties voldoende betrouwbaar geacht wordt. Gebaseerd op gegevens van dit onderzoek zou het aantal mensen in de steekproef dan met 10 tot 20 procent verhoogd moeten worden. Wanneer in het onderzoek tevens een onafhankelijke biochemische of fysiologische indicator van de voeding wordt meegenomen kunnen onbetrouwbare gegevens bij verdere analyse uitgesloten worden. Dit zal de validiteit van de uiteindelijke resultaten zeer ten goede komen en als zodanig een waardevolle bijdrage kunnen leveren aan onze kennis omtrent de relatie voeding, gezondheid en ziekte.

APPENDIX

Terms used to qualify measurements and their association with two
types of error*.

Concept	:	bias	variability
Type of error	:	non-random	random

Used in this thesis :	validity:	reproducibility
	relative validity	
	concurrent validity	
Synonyms	: unbiasedness	precision
		reliability
		repeatability
		accuracy*

*The terms mentioned in this table refer to only one of the two types
of error. In addition, the term accuracy is used when referring to
both types of error.

CURRICULUM VITAE

Wija van Staveren werd op 2 juli 1939 geboren te Breukelen-Nijenrode. Zij behaalde in 1957 het M.M.S. diploma te Eindhoven en in 1961 het diploma diëtist te Amsterdam. Van 1962 tot 1972 was zij werkzaam bij het Centraal Instituut voor Voedingsonderzoek TNO te Zeist. In deze periode verbleef zij 2 jaar in Suriname in het kader van een kindervoedingproject gesubsidieerd door WOTRO.

Vanaf 1972 is zij verbonden aan de Vakgroep Humane Voeding van de Landbouw-hogeschool te Wageningen. Door deze Hogeschool werd zij in de gelegenheid gesteld om in het cursusjaar 1973-1974 een "Master of Science degree in Human Nutrition" te behalen aan het Queen Elisabeth College van de London University. Nadien heeft zij de tijd beschikbaar voor onderzoek, besteed aan voedselcon-sumptieonderzoek. Dit proefschrift is daar onder andere een resultaat van.

Wija van Staveren is co-auteur van het voedingsleerboek "De voeding van elke dag", als mede van de handleiding "Manual for social surveys on food habits and consumption in developing countries".