NUTRITION IN ADOLESCENCE

A LONGITUDINAL STUDY IN DIETARY PATTERNS FROM TEENAGER TO ADULT

VOEDING BIJ JONGEREN

EEN LONGITUDINALE STUDIE NAAR HET VOEDINGSPATROON VAN DE TIENER- TOT AAN DE VOLWASSENLEEFTIJD.

Promotoren: dr. J.G.A.J. Hautvast, hoogleraar in de leer van de voeding en de voedselbereiding

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PROEFSCHRIFT

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Stellingen

behorende bij het proefschrift van G. Bertheke Post *Nutrition in Adolescence: A Longitudinal study in dietary patterns from teenager to adult.*

Wageningen, 15 maart 1989.

1. Meisjes en jongens van 12 tot 21 jaar eten in vergelijking met de richtlijnen Goede Voeding te veel vet en suiker; 'zoals de ouden zongen piepen de jongen'. (dit proefschrift)

2. De snacks van zowel meisjes als jongens bevatten minder vet, meer zoet, minder mineralen en vitamines dan de rest van de voeding. De resultaten geven geen enkele voeding aan het idee dat snacks uitsluitend lege energie zouden bevatten. (dit proefschrift)

3. Bij veel tieners leidt een eerste kennismaking met alkoholische drank vaak tot een overmatig gebruik; een ontmoedigingsbeleid in deze leeftijdsfase lijkt bij uitstek op zijn plaats. (dit proefschrift)

4. Dat Nederlanders als kaaskoppen worden gekarakteriseerd is wellicht juist, wanneer men kijkt naar het aandeel van kaas in de calciumvoorziening van een groep tieners. (dit proefschrift)

5. Vroeg rijpende meisjes hebben meer neiging tot vetzucht dan laat rijpende meisjes, het idee 'vroeg rijp vroeg rot' lijkt derhalve niet helemaal misplaatst. (dit proefschrift)

6. Bij bepaling van het voedingsbeleid in 'ontwikkelde landen' moeten de konsekwenties voor de 'ontwikkelingslanden' zwaar meegewogen worden.

7. Hoe geringer de kwaliteit van het in de horeca gebruikelijke kindermenu des te meer valt het in de smaak.

8. De Nederlanders maken zich drukker over het uitgebalanceerde voedingspakket van hun huisdieren, dan over hun eigen voedingspatroon.

9. De door de regering afgekondigde maatregel licht alkoholische dranken uit de supermarkt te verwijderen, moet uit gezondheidkundig oogpunt onmiddellijk gevolgd worden door de verwijdering van sigaretten uit diezelfde supermarkt.

10. Het percentage meisjes en jongens in de 40-er jaren waarbij 'de melk overkookte' was aanzienlijk groter dan het percentage dat in de 80-er jaren de aanbevolen hoeveelheid melk drinkt.

11. Het gezegde dat tieners uit 'hun krachten groeien' wordt door wetenschappelijk onderzoek ontkracht.
(Kemper HCG, Verschuur R. Longitudinal study of maximal aerobic power in teenagers. Ann Hum Biol, 1987; 14-5:435 – 444.
Beunen GP et al. Adolescent Growth and Motor Performance. HKP Sport Monograph Series, 1988)

12. Het advies 'eet meer fruit' van de Minister van Landbouw moet gepaard gaan met een gerichte strenge kontrole door de Keuringsdienst van Waren van al het fruit dat op de Nederlandse markt gebracht wordt.

13. Toevoeging van zout is ongezond: dit geldt zowel voor onze voeding als voor ons oppervlaktewater.

14. Snackbars, en zeker rijdende, zouden uit de buurt van scholen verwijderd moeten worden.

15. De statistiek is net als een bikini: het verklaart veel, maar verhult het belangrijkste.

16. Het blijft nog steeds gezonder te scharrelen als een varken, dan te eten van een scharrelvarken.

Voor mijn moeder
Voor Han

Contents **Page**

NUTRITION IN ADOLESCENCE, A LONGITUDINAL STUDY IN DIETARY PATTERNS FROM TEENAGER TO ADULT

Thesis, Department of Human Nutrition, Agricultural University, Wageningen, The Netherlands, 15 March 1989.

G.B.Post

ABSTRACT
This thesis reports the longitudinal changes in dietary intake of a group of Dutch adolescents, 103 girls and 97 boys from about 12 to 21 years of age (part of 'The Amsterdam Growth and Health Study'). The subjects were pupils of a secondary school, and measured five times. A dietary history method was used to assess the food intake. Special reference was made of differences between schooldays and weekend days. In girls the observed total energy intake was almost constant over the whole age range (9.5 mJ), whereas in boys the nutrient intake gradually increased with age from about 11 mJ/day at age 12, to 14 mJ/day at age 21. On weekend days the energy intake of girls and boys in all age-groups was consistently higher. Compared to the recommendations of the Netherlands Nutrition Council, the food intake of these teenagers contained too much saturated fat, and not enough poly-saccharides. In general, the mineral and vitamin intake was comparable to the recommendations. Only in girls the intake of iron was borderline. In both sexes some overconsumption of energy was likely, because during the period of study an increased percentage of body fat was found. Snacks supplied about 20-25 % of the total daily energy intake in both sexes (on weekend days about 30 %). The alcohol consumption increased strongly with age, from 1 g/day at age 13 in both sexes, to 7 g/day in girls and 18 g/day in boys at the young adult age. The teenage food pattern was compared with a Dutch meal-planning-disk. It is indicated that the nutrient definitions, given in this model, are too general. The food consumption was divided in a relatively high and low quality diet. Girls with a relatively high quality diet showed lower body fat mass and better physical performance (e.g. higher aerobic power). In boys no relationship could be demonstrated. Early maturing (skeletal age) girls and boys consumed less energy, but also showed a lower habitual physical activity and were fatter than late maturers.
It is concluded that the dietary pattern of these observed youngsters was not different from the Dutch population in general.

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List of Abbreviations

ANOVA	analysis of variance
BW	body weight
C1	cluster 1
C2	cluster 2
Ca	calcium
CVD	cardio-vascular diseases
cm	centimeters
d	day
dietary history	cross-check dietary history interview
EMs	early maturers
en%	energy percentage
g	gram
F	female
FAO	Food and Agricultural Organization
Fe	iron
24-hour recall	24-hour recall method
HQ	relatively high quality diet
IGN	Ignatius College, observed control school
kcal	kilocalories
kg	kilogram
LMs	late maturers
LQ	relatively low quality diet
M	male
MET	metabolic equivalent
mg	milligram
mJ	mega Joule
ml	milliliters
mm	millimeters
N	number
NEVO-table	Dutch food and nutrition table
NFCS	Nationwide Food Consumption Survey
NHANES	National Health and Nutrition Examination Surveys
PHV	peak height velocity
PIUS	PIUS X, longitudinal observed school
PUFA	poly-unsaturated fatty acids
RDA	recommended dietary allowances
s.e.	standard error
s.d.	standard deviation
SPSS	Statistical Package of the Social Sciences
UCV	Uniform Coding Committee
$\dot{V}O_2max$	maximal aerobic power
WHO	World Health Organization

CHAPTER 1

General Introduction

Introduction

This thesis describes the nutritional part of a research, that was done in a group of Dutch adolescents, girls and boys from the age 12 to 21, in order to establish the growth, health and fitness in this population and their relation with lifestyles such as habitual physical activity and nutrition (1). To emphasize the role of adolescent's nutrition in achieving optimum health and preventing disease, a basic understanding of their growth and development as well as their eating practices is necessary. Adolescence is typically characterized by some profound changes during a relative brief period, such as; rapid physical growth and maturation, the capability to reproduce, the beginning of emancipation from parents, the initiation of work for wages, the right to vote, the development of a new class of consumers, and dozens of other significant life changes (2).
The Dutch physician Coronel already in 1872 underlined the importance of a well-balanced food intake for a healthy body (3). Since that time much nutritional research has been done, but the majority is mainly concerned with the relation of certain components in nutrition and a specific disease.

The knowledge of the relationships between food consumption, nutritional status, and general health status of adolescents is limited. One of the most important factors involved, is the influence of the amount and composition of the diet on growth, health and fitness of the individuals in this age category. Insufficient information is available on the actual composition of the diet and the food preferences of adolescents, needed to describe the pattern of dietary intake.

The nutritional situation is affected by environmental factors, such as social changes, increasing numbers of dual-income families, and one-parent families. There is growing evidence that young people habitually skip meals and satisfy their appetite by eating certain food items which could lead to a seriously unbalanced diet. Adolescence is a period in human life, when the organism is sensitive to all environmental factors of a positive as well as a negative nature. Although the family and its members serve as the major provider of nutrition, many other individuals (peers), agencies (food industries), and institutions (school/sportclubs) play a significant role.

In principle the nutritional status depends on the balance of input (energy and nutrient intake) and output (energy expenditure, growth and development) (4). Energy imbalance during adolescence can result in ill health. For instance, lack of physical activity can play an important role in the development of obesity. Physical activity and sports have achieved increasing acceptence as being important to health in modern societies. Increased mechanization has also resulted in a fall in physical activity among the adolescent age group, and disorders from overnutrition are replacing those of undernutrition. Nowadays, some diseases of civilization, e.g. obesity, atherosclerosis, and diabetes may be aggrevated or caused partially by eating too much of the wrong food, and may be partly conceived as a 'pediatric problem' (5). The energy intake, which is stimulated by food in abundance, large varieties and its attractiveness, has lost the direct relation to the energy need. On the other hand, periodic food fads, like slimming phobias, can stimulate the risk of diseases, such as anorexia nervosa.

Malnutrition in various forms, induced by dietary practices or by environmental conditions, is a serious problem throughout the world. It is well recognized that on the one hand a certain period of depletion of body stores or on the other hand overnourishment precedes the manifestation of clinical and biochemical signs and symptoms of the impaired nutritional status. When the supply of an essential nutrient becomes limited, or visa versa, the homeostatic regulation of circulating levels will be disturbed, than this will have its health impact.

Nutrition patterns and healthy consequences should therefore be studied during the adolescent age group. Beal (6) strongly recommends for such studies a longitudinal survey design, using adequate methods. With such studies it may become possible to:

a. determine whether poor health is the result of an inadequate or inappropriate diet,
b. identify the specific nature of any nutrition problem underlying such health impairment,
c. provide information on which to base dietary care for health improvement,
d. evaluate the effectiveness of interventions that may be undertaken to improve health.

Longitudinal Nutrition Surveys in Adolescents

A variety of surveys of food habits have been performed in the past. Most of the large studies, however, have a cross-sectional design, such as the four major nutritional status surveys in the U.S.A. carried out between 1968 and 1980 like: the Ten-State Nutrition survey (7), the Nationwide Food Consumption Survey (NFCS) (8) and the National Health and Nutrition Examination Surveys (NHANES I and II) (9,10). Those surveys have defined the average daily or weekly levels of foods and nutrients consumed by individuals or population groups. The Finnish study of children and adolescents (11), the epidemiological study of health-risk-related dietary habits of 4 to 13 year old children in Sweden (12,13), and the British studies of schoolchildren between 1968 and 1971 (14), also have a cross-sectional design.

From 1958 to 1968 the first longitudinal nutrition survey of children in the Netherlands was executed by Schaik et al (15). The food consumption of children from 8 to 18 years old was studied and related to their nutritional status. From the original population sample 50 percent dropped out. The overall eating patterns do not seem to change very much over time. Burke et al (16) described a longitudinal study over a 17-year period of the caloric and protein intake of 134 children 1 to 18 years old, and showed the distributions of intakes at yearly age

intervals. In a longitudinal growth study, Beal (17) related the caloric intake to body weight in eight children from the age 0 to 10 years old. She stated that an understanding of the relationship between dietary intake and measurements of physical growth and physiological changes in children can best be attained by continuous observation of the same children over many years, but nothing is mentioned about the number of subjects. Huenemann et al (18) and Hampton et al (19) carried out a four year longitudinal study in a teenage population of a public high school. The overall purpose was to determine and identify factors which might be related to body composition of teenagers from their 14th till their 17th year of age. Huenemann et al described their knowlegde, attitudes and interest about food and eating habits, with practical implications for program planning in weight control, whereas Hampton et al examined the variability of nutrient intake with the recommended allowances as standards. Hackett et al (20) studied a group of adolescent schoolchildren in a longitudinal design, to describe the relationship between dietary habits and the development of dental caries. Over the two year period the energy intake of boys increased by 13 percent compared with an increase of only 7 percent in girls. The mean energy intakes were slightly below the 1979 recommended allowances. The data collected were found to be of a high reliability. The vitamin B-6 status of adolescent girls in two states of the USA was assessed longitudinally from 1981 to 1983, by Driskell et al (21). Approximately half of the girls reported consuming less than 0.02 mg vitamin B-6 per gram protein during both years. Almost half of the girls also had coenzym stimulation values indicative of a marginal or deficient status.
All these studies indicate that a very high reliability of food intake measurements will be required in order to relate diet to growth and other factors, such as body composition, maturity and physical activity.

Other longitudinal studies are primarily aimed at growth and development of teenagers, like the study of Placeta (22). Although he stated that 'it is necessary to pay increased attention to all the means which could influence the physical and functional state of youngsters when the most extensive and important changes take place', nutrition was not taken into consideration. Karlberg and Taranger (23) described the somatic development of Swedish children in a prospective longitudinal study. Many facets were studied of the growth and development of children, such as physical, social and psychological measurements, but no attention was given to food consumption. In the Saskatchewan Growth and Development study (24), with objectives to construct growth curves, and to relate the influence of physical activity on growth as well as the relation between various physical and motorial responses and socioeconomic levels, intelligence and personality. Again, nothing is mentioned in respect of nutrition.

The Amsterdam Growth and Health study presented in this thesis is therefore rather unique, amongst longitudinal surveys, because nutrition has been included as an important environmental factor for investigation in relationship to various aspects of growth, development and health of the children involved.

Aim of the Study

The nutritional status of individuals will be designed by the genetic potential and will be influenced by social and other environmental factors. Improved stature and early maturation in adolescents indicate that there has been an improvement in their standards of living and nutrition (25).

Food habits are handed on from generation to generation, and different people, even in the same environment, develop quite different habits. Only very slowly changes occur in food habits, partly caused by a changing economy, social class aspirations, foreign travel and commercial advertising. Although the home and school environment plays a major role in determining a child's attitude to, and consumption of individual foods, there is an increasing tendency for teenagers to select their own meals or food items outside home and school. The most popular of such foods are not always conducive to a nutritionally well-balanced diet.

Dietary habits which affect food preferences, energy consumption and nutrient intakes, are generally developed in early childhood and particularly during adolescence (26). At adolescence it will be a result of large appetite, which increases together with the pubertal growth spurt (27).
The enormous variability in the rate and timing of the adolescent growth spurt, new concepts of nutrient interactions and the human adaptability to nutrient deficiences and excesses, make it difficult to define nutrient allowances for optimal health in this age category.

The present research project is designed to relate the usual food intake to growth, development, and physical activity during the adolescent period. The methodological considerations in the design of a longitudinal survey are described in Chapter 2.
A reliable estimate of the individual food intake made it necessary to assess the reproducibility and feasibility of a food questionnaire to be used repeatedly in a teenage population (Chapter 3).

The main goals of the present study are:
1. To obtain information on the daily nutrient intake of a group of girls and boys measured longitudinally from the age 12 to 21 (Chapter 5 and 7).
2. To compare the quality and quantity of the actual food consumption of this population with the recommended daily intake of the Dutch Nutrition Board and a food consumption education model presented in the Netherlands (Chapter 4, 5 and 6).
3. To analyse to what extent the nutrient intake is associated with the development of the body composition, physical performance and activity (Chapter 8), and with the rate of biological maturation (Chapter 9).

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CHAPTER 2

Design, Subjects and Methods of the Longitudinal Study

Introduction

The design, subjects and methods presented in this chapter concern a longitudinal study in a Dutch population measured from age 13 to age 21. Parts of it are described ealier in chapter 2,3 and 6 of Growth, Health and Fitness of Teenagers (1).

This longitudinal study was set up in two stages:

- The study 'Growth and Health of Teenagers' (1), in which a group of teenagers was examined four times on a yearly basis, between 1976 and 1980, during their secondary school period.
- Five years later, in 1985, the same group was measured for a fifth time, when they had left school. This follow-up of the study is called: 'From Teenager to Adult' (2).

Study design

In studies of growth, development and changes of lifestyles, three classical designs have been used to a great extent, namely the cross-sectional, the time-lag and the longitudinal design (Figure 2.1). In a cross-sectional design different age groups (cohorts) are measured in the same period. In a time-lag design the same age group, but of different cohorts, are studied in different periods. In a longitudinal design the same cohort, but at different ages, is measured in different periods.

Concerning growth and development studies, each measurement taken on a subject at a particular moment is influenced by the following factors: age of the subject, birth cohort to which the subject belongs, and time of measurement. None of the designs allows the three effects to be isolated on the subjects (3).

In the literature, descriptions can be found of several designs which try to face problems like the time of measurement effect, cohort effect and testing effect (4-6). Effects that always may occur in longitudinal measurements.

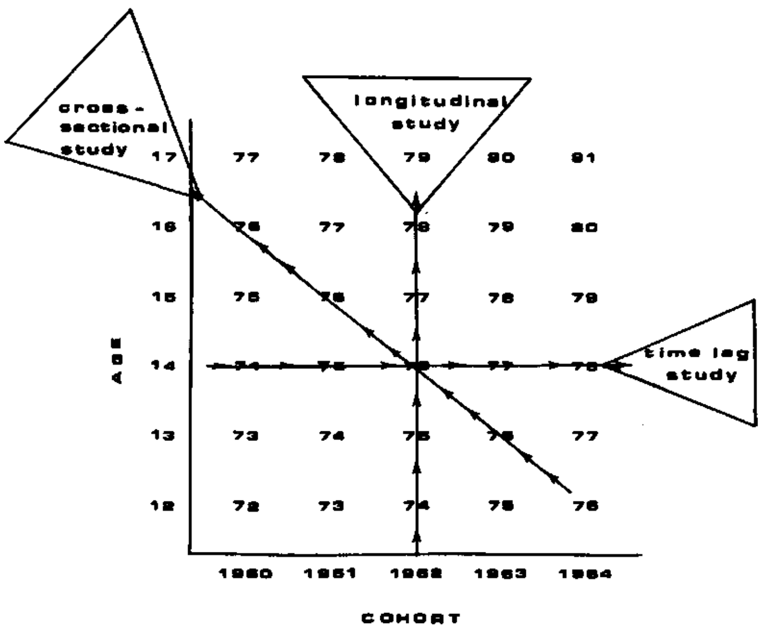

Figure 2.1. Three classical study designs: cross-sectional, longitudinal and time-lag. Years of measurement are dependent of age (Y-axis) and cohort (X-axis).

Multiple Longitudinal design of 'Growth and Health of Teenagers'

The design of the present study is based on Schaie's 'most efficient design'. In order to avoid confusion and to describe more clearly the kind of design used in this study, the term 'multiple longitudinal' is preferred, which implies the idea of repeated measurements on more than one birth cohort (7).

In this case, the measurements were taken during four successive years, from 1976 to 1979. The measurements were started with children from the first and second form of a secondary school in Amsterdam. The average age in these two groups was 13 years (± 0.6) and 14 years (± 0.6) respectively in 1976 (Figure 2.2). Because these two groups were not exactly birth cohorts, we called them clusters (C1 and C2). During the course of the study the composition of these clusters remained unchanged. Pupils who stayed in a class for another year remained members of their original cluster.

Although there were only four periods of measurement in this study, information was gathered from five age groups, because two longitudinal studies ran parallel to each other with a lag of one year in age. This approach made it possible to estimate a five-year teenager development pattern in a period of four years (8).

Additionally, because there is an overlap in age, the two clusters can be compared with each other at three ages (Figure 2.3). A systematic difference between the two clusters at these three ages will be called 'cluster effect'. At the same time it is possible to distinguish one of the interfering factors in a longitudinal study, namely the factor 'time of measurement' (9). For example: fourteen year old children are measured in 1976 (C2) as well as in 1977 (C1). If no cluster effect is found, it is possible to blame the time of measurement for a possible difference between the two groups of children.

Another problem that emerges in repeated measurements is a testing or learning effect. Many variables, physical as well as psychological, and lifestyle parameters such as food habit-interviews, require a certain motivation or habituation of the subject when being measured. This introduces differences between periods of measuring that are solely due to changes in attitude towards the measurement procedure itself. Such

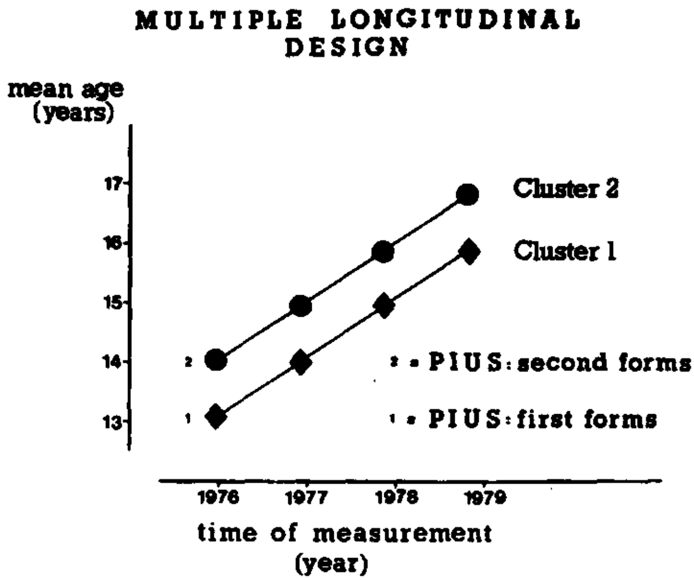

Figure 2.2. Design of the multiple longitudinal study with pupils of the first and second form (cluster 1 and 2) of a secondary school (PIUS), and the eight groups of observations.

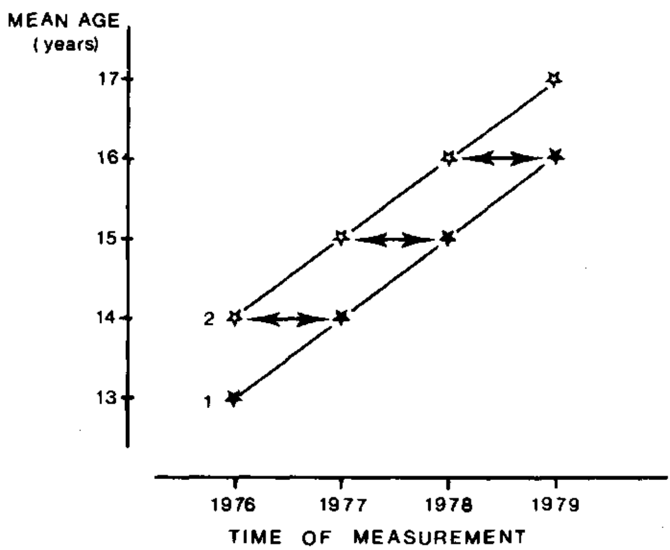

Figure 2.3. Cluster effects can be tested by comparing the same age groups at different times of measurement (arrows).

testing effects may be positive (i.e. when habituation or learning is important) or negative (i.e. when motivation decreases). Repeated measurements may therefore have a disturbing influence on the quantity measured and diminish the external validity of the results. Systematic testing effects can be estimated if the design includes a control group in which no repeated measurements are made. The design of this study provides for this: At a second school, comparable with the first one, an identical arrangement in clusters was made, but during the four years of the study every testing period another quarter of the pupils was measured (Figure 2.4).

These measurements were comparable with those of the first school, except that they were no repeated measurements, but came from independent samples. In this design, when comparing data from both schools, systematic divergence of mean values in the course of the study is an indication for a testing effect. Both time of measurement effect and testing effect, if they are established for a certain characteristic, will seriously influence the interpretation of individual and mean growth curves.

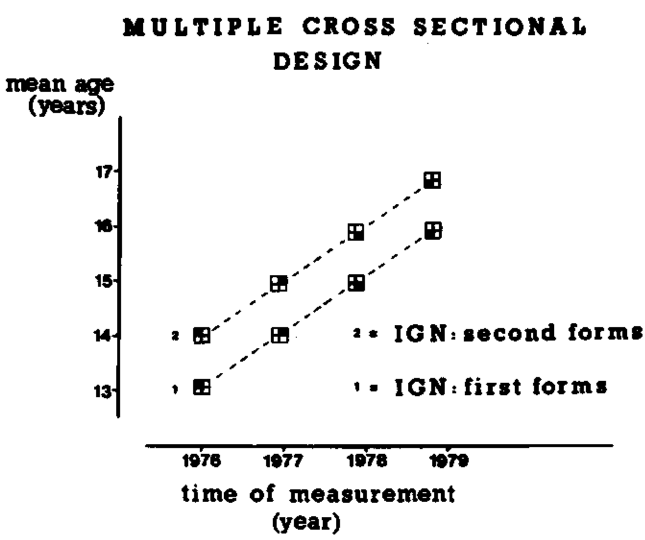

Figure 2.4. Design of the multiple cross-sectional study with pupils of the first and second form (cluster 1 and 2) of a secondary school (IGN), with eight groups of <u>independent</u> observations.

Interfering Factors in the Measurement of Nutrient Intake

Time of Measurement effect and Cluster effect

The design of the study gives a trifactorial model which makes it possible to estimate age, cluster and time of measurement effect. The trifactorial model is quite simple; however, because of the fact that the measurements are a mixture of dependent and independent observations, there was no readymade computer program available to estimate and to test cluster and time of measurement effects. The computation of these effects is extensively described by Storm-van Essen et al (10).

Testing and Learning effect

It is assumed that the pupils from the 'longitudinal school' show a development of the nutrient intake which, on an average, is identical to that of the children from the control school. The repeated dietary interview each year by the longitudinal group could cause a learning or test effect. Two possible reasons are:

- the interview itself influences the consumption of the pupils, because they become more aware of the kind and the quantity of their own food intake;
- there is a bigger chance that pupils give more or less pleasing answers concerning healthy food products.

The observations of the groups of the control school are independent of each other, because of the fact that every year another quarter of the pupils has been measured. If a difference occurs between the physical and/or psycho-social development of the pupils of both schools during the period of measurement, it is taken that this is caused by the influence of repeated measurements.

To estimate and test the learning effects a multivariate analysis of variance for nonorthogonal designs is used (11).

Drop-Outs

During the longitudinal study a number of pupils withdrew from the longitudinal sample. The main reason was that they left school. Because of the chance of selective drop-out, this group is compared to the group of pupils which stayed in the sample for four years. This comparison is made on the base of measurements of their daily diet from the first year (1976) and used univariate or multivariate tests.

Age Curves and the Meaning of the Tails of these Curves

The two clusters (C1 and C2) in the present design consist of four birth cohorts: '61 to '64.The birth cohort '61 consisted of only one girl and four boys and is therefore not taken into consideration any further.
As can be seen in figure 2.5 the average age curve of the three remaining cohorts is estimated most precisely in the middle, for the ages 14 and 15, where the observations of all three birth cohorts are included. The tails of the curve (age 12 and 17), however, are estimates which are only based on a small group of children from one cohort. Afterwards it was noticed that it is possible that the youngest or oldest cohort differs from the other in a physical, psychological or sociological aspect, without finding a cluster effect. Therefore, graphical plots are made of the mean values of each cohort and inspected with respect to any typical deviations at the tails that could influence the developmental curves substantially. If no cluster/cohort effect, nor time of measurement or testing effects were found, the longitudinal data could be arranged in age groups, irrespective of the year of measurement. In this way a developmental pattern over 6 years (from 12 to 17 years) can be covered. An outline of this final data arrangement is given in figure 2.6.

Interperiod Correlations

The purpose of longitudinal studies is to investigate individual changes over time. This becomes difficult when the stochastic measurement error exceeds the change over time. The degree to which this occurs for the food intake measurement may be studied on the basis of interperiod correlation matrices (9). An interperiod correlation is a coefficient of correlation between two periods of measurement for one variable. Van 't Hof et al (12) showed that under fairly realistic conditions the correlation coefficients can be approximated by a linear function of the

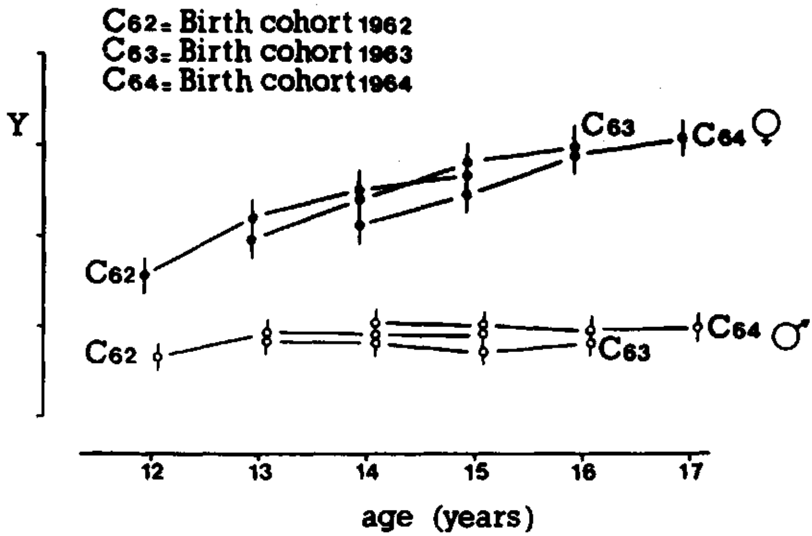

Figure 2.5. The composition of an age curve of a parameter Y based on three birth cohorts.

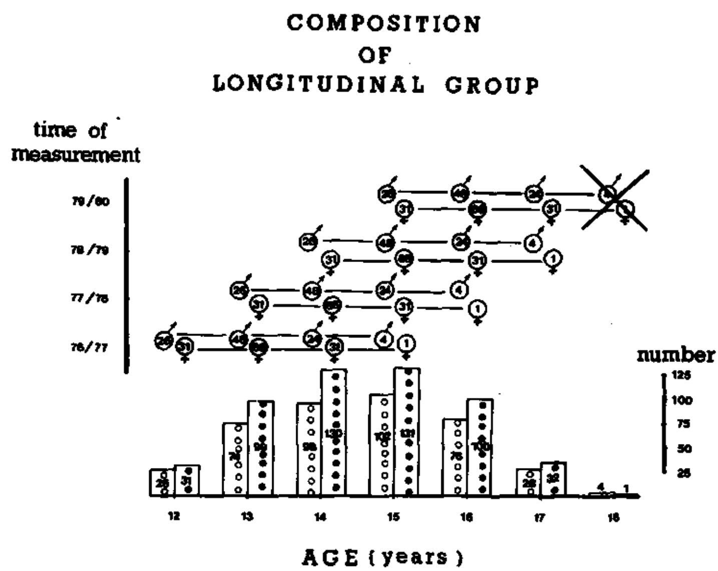

Figure 2.6. The composition of the age groups in the study 'Growth and Health of Teenagers'.
The upper part shows the number of girls and boys measured during the four years. The vertical bars in the lower part summarize the total number of girls and boys that were measured per age group.

time interval (Figure 2.7). The intercept of the straight line is the correlation coefficient between two (independent) measurements, having an intermediate time interval equal to zero, and this may be interpreted as the instantaneous measurement-remeasurement reproducibility. It therefore is an estimate of the intra-individual reliability of the measurement in question. The slope of the line gives an impression of the intra-individual changes over a time-period.

Comparison of the slope and intercept gives an impression of the usefulness of the variable for longitudinal purposes:

- If the intercept is small (e.g. 0.6) and there is not a steep descent, the reproducibility of such a variable is so poor, that individual changes over time are overruled by measurement errors. In that case for each individual the mean value of the variable over time is a more accurate measurement of the level of the variable than each of the single measurements separately.
- If the intercept is about 1.0 and there is a steep descent, such a variable has a high reproducibility, accompanied by large differences in growth between individuals. When no testing effect or time of measurement effect are present, such a variable is very suitable for the study of individual growth patterns.

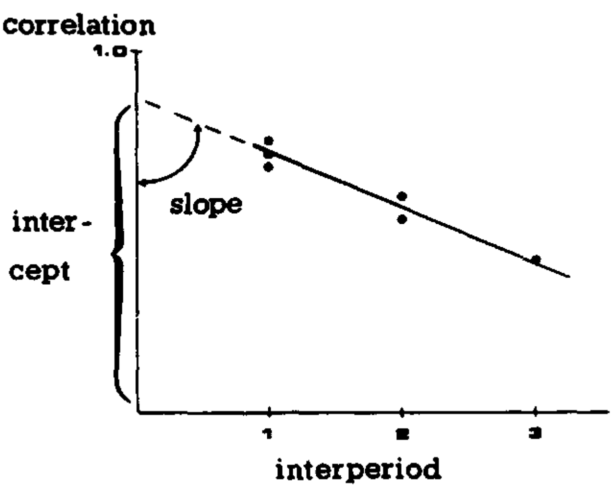

Figure 2.7. Graphical explanation of the interperiod correlation matrix for the interpretation of the measurement-remeasurement reproducibility.

Description of the data

The results of the food intake data of the longitudinal measured group will be reported and discussed, only in case of an existing testing effect the results of the control group will be reported as well.

Subjects

The study was carried out at two secondary schools in the Netherlands: at the Pius X Lyceum in Amsterdam, and at the Ignatius College in Purmerend. The school in Amsterdam was the so called 'longitudinal school', whereas the school in Purmerend acted as the 'control school'. Both are schools for pupils with a level of intelligence above the average for their age (HAVO/VWO).

Subjects were all the pupils enrolled in the first and second form of the two schools in the schoolyear 1976/1977. At the start of the study in August 1976, the **longitudinal group** consisted of 307 pupils, 159 girls and 148 boys (Table 2.1); 233 pupils (131 girls and 102 boys) were still there at the end of the four-year study. The total drop-out was 24 %, mostly because of transfer to other places and/or other types of school. Only 2 % (= 6 pupils) refused to continue participation.

Table 2.1. Number of girls and boys in the longitudinal group and the number of drop-outs.

	Girls	*Boys*	*Total*
At the start of the study in 1976	159	148	307
Drop-outs	28	46	74
Longitudinal group	131	102	233

The **control group**, chosen from the population of the other school, consisted every year of a different 25 % of the selected group of pupils

(Table 2.2). At the end of the study each pupil was measured only once. Some pupils left school during the study, which would have resulted in the control groups becoming too small at the end. Therefore pupils of the same age-group who joined the school after 1976 were added to the group. In 1977 14 girls and boys, and in 1979 26 girls and boys joined the control group.

Table 2.2. Number of girls and boys in the control group.

	Girls	*Boys*	*Total*
School year			
1976/1977	39	37	76
1977/1978	38	29	67
1978/1979	39	35	74
1979/1980	43	32	75
Total	159	133	292

Since the subjects were not selected by age, because all the pupils in the first two forms of each school were measured, they differed in age. September 15 was selected as the reference date for classifying pupils into calendar age groups. For example, all the children who were between 13 years and 6 months and 14 years and 6 months on this date were classified as 14 year olds. All data of the food intake were collected in the winter period, so the age groups were approximately six months older. This will be indicated in the text and tables as 13/14, and in the figures on the abcissa shown as half way the two age groups 13 and 14.

Informed consent for the investigation was given by the school authorities, the parents and the pupils of both schools. There were no refusals.

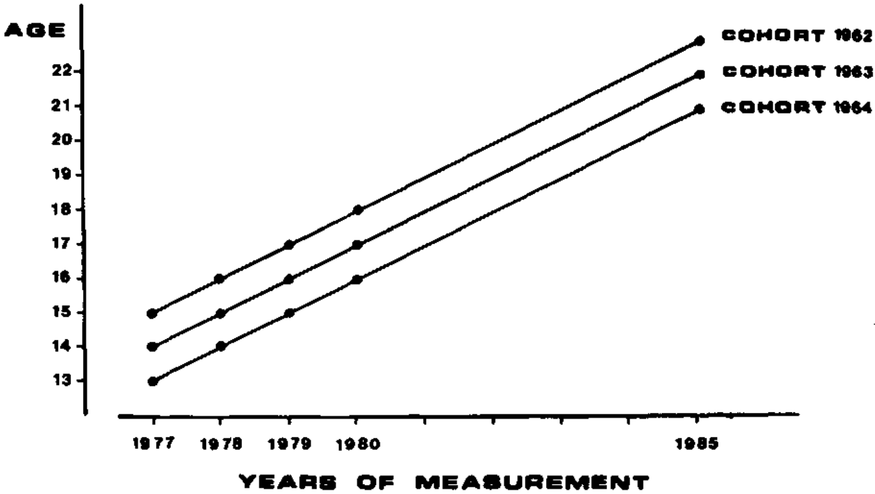

Figure 2.8. The three cohorts studied from 1976 - 1985.

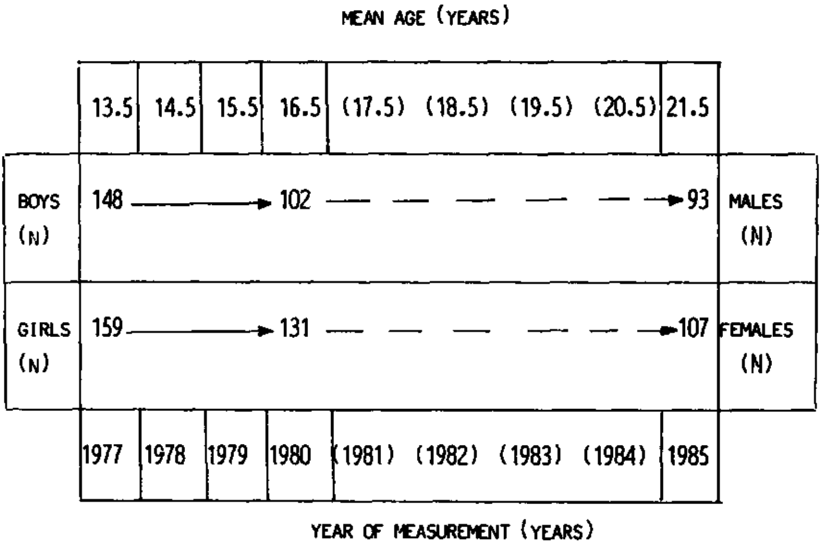

Figure 2.9. The number of girls and boys per mean age studied over the five years of measurement, in the study 'From Teenager to Adult'.

All measurements took place once a year during the months January, February and March, for four consecutive years. The measurements were taken during regular school hours, in a mobile research unit that was placed in front of the school building. Care was taken to ensure that the measurements of the same pupil were done each year within the period at approximately the same time, and by the same observer.

Before entering the study each pupil underwent a general medical examination by a physician of the school health service to obtain an impression of the health status of the subjects.
The socio demographic background information about the pupils was gathered from a questionnaire, that was sent to all parents in the first year of the investigation. The questions concerned professional status, the family income, and the educational level and were compared to a representative sample of the Dutch population (13). The professional status, level of education and income were higher in Purmerend (control groups) than in Amsterdam (longitudinal group), and for both groups they were higher than the average for Dutch families. The group of pupils studied may therefore not be considered to be representative of the teenager population either of Amsterdam or of the Netherlands in general (14).

Continuation of the study: 'From Teenager to Adult'

In 1983 it was decided to extend the study 'Growth and Health of Teenagers' with a fifth measurement in 1985, when the teenage population would have reached the 'young adult age' (Figure 2.8). From the 131 girls and 102 boys who had been studied longitudinally over a period of four years, 103 girls and 97 boys were remeasured five years later (Figure 2.9). The drop-out percentage was about 18 % in girls, and 9 % in boys . Because of the chance of a selective drop-out, this drop-out group was compared to the remaining longitudinal sample. The mean age of the drop-outs (21.7 $\pm$ 0.8) was comparable with the remaining longitudinal group (21.5 $\pm$ 0.8). To get more information of this drop-out group a questionnaire was sent to them about biographic and anthropometric characteristics (2). Age, height, weight and Quetelet index (weight divided by height squared), as a rough indication of fatness in the drop-outs, did not show any differences (Table 2.3). So the remaining group did not appear to be biased on a number of parameters, because of the drop-outs.

Table 2.3. Mean and standard deviation (s.d.) of age and three anthropometric characteristics of the longitudinal group in 1985, and the drop-outs.

		Longitudinal group N=200		*Drop-out group N=26*	
		mean	s.d.	mean	s.d.
Age (years)		21.5	0.8	21.7	0.8
Height (cm)	male	183	6	189	5
	female	170	6	170	6
Weight (kg)	male	71.5	9	73	7
	female	62.5	9	61	9
Quetelet	male	19.5	0.2	19.5	0.7
index (kg/m^2)	female	18.3	0.2	18.0	0.5

The Cross-check Dietary History Method

The Interview

The most important requirements in choosing a suitable method for collecting longitudinal data about individual food habits of teenagers are: (a) the technique should not interfere with the subject's dietary habits; (b) the data collected should be representative of the usual intake, and (c) it should be applicable in field investigations with large groups of normal teenagers.

A modification of the dietary history (15,16,17) was used to ascertain the individual food intake of the teenagers. It lists a series of items, covering the entire range of foods and drinks, making allowance for teenagers (Table 2.4.). Data on foods eaten during regular meals as well as between meals (so-called 'snacks') were collected separately for normal schooldays and for weekend days. Only the food items that were eaten at least twice monthly were recorded. The amounts were reported in household measures and dimensions. Food models were used to illustrate common portion sizes such as glasses, bowls, spoons, and also polystyrene imitations of potatoes, apples and other fruits. In order to estimate the amount of sugar in tea/coffee and butter on bread, a small pair of scales was used to weigh the amounts (Figure 2.10).

Similar food items, e.g. pork/beef and vegetables, were grouped together to shorten the interviews. The length of the interview was 60 - 90 minutes, depending on the kind of subjects. In the following years the interview was conducted in exactly the same manner, by the same interviewer, but took less time in the longitudinal group (approximately 45 minutes).

Since it was assumed that teenagers do not know everything about their food consumption and the way of preparation, a questionnaire was made for the parents about details of several food items, consumed by their child, e.g. skimmed or whole milk, kind and quantity of meat, addition of butter or sauce to vegetables and potatoes (Table 2.5.).

After the interview the pupils took this questionnaire home to their parents. In a covering letter the parents were asked to cooperate by filling up the questionnaire and sending it back. In case of no reply

Table 2.4.: The head lines of the dietary history interview.

DIETARY HISTORY INTERVIEW

Questions mean: A. average number of times used during five schooldays,
B. average number of times used during two weekend days.

Questions about:
1. Breakfast/ lunch food items;
   - kind of bread
   - kind of butter/margarine
   - kind of sandwich filling (cheese, meat, egg, sweets)
   - raw vegetable items
2. Cooked meal/ diner food items;
   - kind of soup
   - kind of meat
   - kind of potatoes or substitutes
   - kind of vegetables/legumes, cooked or raw
   - kind of sauces
   - meal substitutes like pancakes/fondue
3. Fruit;
   - kind of citrus fruit
   - kind of other fruit, cooked or raw
4. Milk products/desserts;
   - kind of milk product
   - kind of additives (cereals, sugar, cream, sweet sauces)
5. Drinks;
   - kind of drinks (milk, choc.milk, coffee, tea)
   - kind of additives (cream, sugar)
   - kind of soft drinks/juices
   - kind of alcoholic drinks (with/without soft drink)
6. Pastries and sweets;
   - kind of cookies/cakes
   - kind of sweets (chocolate, candy bars, liquorices)
7. Snacks;
   - kind of salty items (cookies, chips, cheese, nuts)
   - kind of snackbar items (french fries, sausages, rolls)
   - kind of icecream.

Score: Mean amount (grams) of the five schooldays and the two weekend days.

Figure 2.10. Pupil, demonstrating the amount of sugar in coffee or tea during the dietary history.

Table 2.5.: The 'parents' dietary questionnaire.

DIETARY QUESTIONNAIRE

Questions are directed to the parents, but concerned the consumption of their child.

Questions mean: - the used ingredients;
- the used amount (grams);
- average number of times served in a week/month.

Questions about:
1. Bread
2. Fat used for bread/cooking
3. Meat/fish/cheese as sandwich filling
4. Soup
5. Meat/fish/egg/cheese for diner
6. Stews
7. Sauces/gravy/salad dressing
8. Desserts
9. Kind of milk (whole/low fat, cream)

the parents were telephoned to remind them. Sometimes the nutritionist could be of assistance by telephone in completing the questionnaire.
In 1985, when the longitudinal group was interviewed for a fifth time, no questionnaire was sent anymore to the parents, because most of the subjects lived on their own and were supposed to know everything of their food preparation. Therefore, the dietary history interview form was completed with the questions of the questionnaire.
The dietary history was executed by the author, who is an experienced nutritionist. All interviews in all the years were completed by herself, to increase the reliability of the results (18).

Conversion and Coding of the Food Data

For each individual all amounts were converted into grams for the five schooldays and the two weekend days. The schoolchildren in this study do not have a fixed pattern of meals. In the Netherlands cooked lunches are not served at school, but most pupils bring sandwiches with them for lunch, and have a cooked meal at home in the evening.
Since special attention will be paid to teenage snacking, a calculation is made of the amounts of snacks consumed during the five schooldays and the two weekend days as well. In this study snacks are defined as:
A food item that will be eaten between meals, and belonging to one of the following food groups: (1) sweets, such as candy bars, chocolates, gums, cakes, cookies, biscuits, sweet rolls; (2) soft drinks, lemonade, fruit juices, alcoholic beverages, and (3) snack bar items, such as french fries, dressed rolls, ice cream, milkshake etc..

The coding and calculation of the food characteristics were based on the food-composition table of the Uniform Coding Committee (UCV) (19); now known as the NEVO-table (20). The data are saved in SPSS system files (21).
The following food characteristics were calculated:

(1) **Energy:** as megaJoules(kiloCalories), percentages obtained from protein, fat, carbohydrate and alcohol.
(2) **Protein:** vegetable origin (g), animal origin (g), total of vegetable and animal (g).

(3) **Fat**: poly-unsaturated fatty acids (g), total of saturated and poly-unsaturated fatty acids (g), cholesterol (mg).

(4) **Carbohydrate**: mono- and disaccharides (g), total of mono-, di- and polysaccharides (g), non-digestible polysaccharides (so-called dietary fibre, g).

(5) **Alcohol**: (g).

(6) **Minerals**: calcium (mg), iron (heme and non-heme, mg).

(7) **Vitamins**: retinol (mg), thiamin (mg), and per 4.2 mJ (mg), riboflavin (mg), pyridoxine (mg), and per g. protein (mg), ascorbic acid (mg).

The energy and nutrient intake was calculated per average schoolday (Monday-Friday), as well as per mean weekend day (Saturday-Sunday). The nutrient value of the snacks was calculated separately.

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CHAPTER 3

Reproducibility of Two Methods estimating Foodhabits in Teenagers *

Introduction

In view of a multiple longitudinal study of growth and health of teenagers in the Netherlands (1) it was considered necessary to be informed about the quantitative and the qualitative aspects of food habits of children during their teens (see Chapter 2).

The population that was aimed at in this longitudinal survey would consist of schoolchildren from 12 to 18 years of age, and would be measured during four successive years, to get a detailed picture of their food pattern.

Food consumption has been measured by a variety of methods. These methods differ greatly in the degree of aggregation of the data and the conclusions that may be drawn from them. Various researchers have compared survey data collection methods to determine their effects on reliability and validity of the resulting data (2-10). The quality of the methods depends on their validity (does the method measure what the investigator wants to measure) and reproducibility (does the method give the same results when used repeatedly under the same circumstances). The various methods do have a different concept and their validity depends on the type of information needed by the investigator. No method used up till now is absolutely valid. Therefore the relative validity of methods has been investigated by comparing results of a method with biological markers or with another method already accepted to be valid. Validation studies have indicated, that when using the correct method for the type of information needed, relatively valid answers can be obtained.

(Updated version of an earlier publication in Dutch:
Voeding 1980;41:123-129.)

However, the longitudinal design of the present study required a precise method. Therefore it was thought necessary to compare two relevant food consumption interview methods, in order to select the best one for this young population. Moreover, in 1975 there were very few studies on the reproducibility and the validity of these dietary survey methods when applied to a young population such as teenagers (11-15).

Dietary study methods, constructed for use in adult populations, may be inappropriate in younger age groups.

A study was planned with schoolchildren in two different age groups: 12 - 13 years of age , and 15 - 16 years old.

The main question to be discussed in this chapter is the following: Do the 24-hour recall method and the dietary history method give comparable results on the mean daily food consumption of groups of teenagers, when they are repeated after one month with the same youngsters? And which method will be the most suitable for the longitudinal survey?

Methods

In selecting an appropriate method to estimate the food intake of teenagers the following points have to be considered:

a. The technique must not interfere with the subject's dietary habits.

b. The data collected must be representative of the habitual intake of individuals.

c. The method should be applicable in field investigations, with large groups of subjects.

d. Most of the teenagers are not yet quite aware of their eating and drinking habits, the problem of memory (16).

e. Teenagers are not completely free in their food-choice, because parents will, for a great deal, decide what kind of foods will be served as meals at home.

f. Teenagers that have pocket money can also buy extra foods such as snacks.

g. The nutritional status is the result of a long-term pattern of usual intake, and not of food items that are eaten rarely.

h. The observation time has to be limited to three months, in order to avoid possible seasonal variations (17,18).
i. The problem of inter-interviewer variations in the longitudinal study.

With these points in mind it was clear that collecting nutrient data by methods requiring weighing and laboratory analysis of food items were impracticable for the longitudinal survey in teenagers.
Two approaches feasible within the design in order to obtain dietary information are: the recall methods and the record methods (19).
The record methods can provide detailed information about the actual food intake over the day. Such a method however will only give accurate measurements if records are available on more than one day, and the participants should be highly motivated to take notice of what they eat or drink during the whole day (16,19,20,21). These methods, however, demand a high degree of cooperation of the subjects. Since this cooperation will not often be present in young people such as teenagers and because we were dealing with a longitudinal study in which the method has to be repeated four times, the record methods were considered not feasible in this study.
So, the recall methods remain, but also these methods have their strengths and weaknesses.
Advantages of the recall methods are:
- The participants will not be burdened by the method, because the information can be obtained within a one hour interview.
- The respondent's diet will not be influenced very much by the interview.

Disadvantages are:
- The memory of the subjects is involved, and may influence the results (16).
- Use of different interviewers may endanger the reliability of the method (22).
- The total number of participants that can be interviewed within a small period of time will be limited if only one interviewer is available.

Two recall methods could be used in the longitudinal study: the cross-check dietary history interview method and the 24-hour recall method. The dietary history aims to discover the usual food intake pattern of individuals over a relative long period of time, whereas the 24-hour recall collects food consumption data over a specified period, usually 24 hours. Beal (23) pointed out the particular need of 'cooperation and intelligence' of the subject, when performing a dietary history, but Persson (18) found the 13 year old children just showing enough 'cooperation and intelligence' to fulfill the interview requirements.

Cross-check dietary history interview (dietary history)

The dietary history, introduced as a research tool by Burke (24) and modified by others (20,22) was adapted for use in a teenage population. Each subject was interviewed personally by a trained nutritionist. The interviews lasted about one hour.

The purpose was to establish the subject's overall eating pattern by obtaining information on the average intake on schooldays as well as on weekend days. To serve as a framework the pupil's mealtimes and type of meals were discussed first on the five schooldays, and after that on the two weekend days. The subject was instructed to indicate the number of times per day, week or month he/she consumed the foods. Food items that were eaten less than once a month were not recorded. The period covered by the dietary history was about one month. In the second part of the interview a cross-check list of most food items came under review in a chronological order. The quantities of all food items were recorded in standard household portion sizes. By comparing the quantities indicated in the first and second part of the interview it was possible to make a check-up of the right intake.

The 24-hour recall method (24-recall)

The 24-recall collects dietary information over the immediate past 24 hours (20,25,26). In an interview of about 15 minutes the food consumption was estimated over the preceding day in household measures on the specific meal times. The interview form was precoded, based on a

Dutch original dietary pattern (27). Separate sheets were used for breakfast, coffeebreak, lunch, teabreak, dinner and during the evening. As there is a great variation in the subject's daily diet (18,26,28), especially between schooldays and weekend days (29,30), the 24-recall was repeated twice in one week; on Monday, to measure the consumption on Sunday (weekend day); and on Friday, the intake on Thursday (schoolday). The choice of one school day and one weekend day was considered the minimal sample to achieve representative food information on an average weekday of these subjects.

To facilitate quantitation in both recall methods, foodmodels were used such as glasses, spoons, cups and polysterene models of fruits and potatoes (31). To verify the amount of sugar in tea and/or coffee, yoghurt etc. pupils were asked to spoon the amount out on a balance. Likewise they were asked to butter a slice of bread to be sure of what amount of margarine was used.
After the first interview period the pupil's mother was contacted by the nutritionist to give more information about the manner of preparing dishes such as adding butter or milk to vegetables, kind and quantity of meat, milk etc.

Design and Sample selection

The study was carried out with pupils of a secondary school in Amsterdam (St.Ignatius College). The pupils were asked to participate in the study on a voluntary basis, and the interviews were held at school during school hours. The study population consisted of 26 pupils of the first form (14 girls and 12 boys) and 23 pupils of the third form (11 girls and 12 boys). From the original sample 3 pupils from the first form had to be excluded from the results because of illness during the study. One half of the pupils, in each form, were examined by the dietary history and the other half by the 24-recall (see Table 3.1.). Girls and boys were divided equally over the two interview methods (Figure 3.1.).

Table 3.1.: Number of pupils in the two age groups that were interviewed by the 24-recall and the dietary history.

FORM	*SUBJECTS*	*METHODS*	
	Age (years)	24-recall N	dietary history N
First	12/13	12	11
Third	15/16	12	11

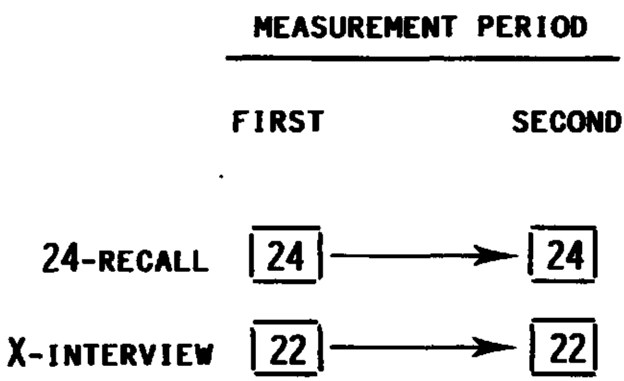

Figure 3.1.: Measurement design and number of pupils interviewed by the 24-recall and the dietary history method (X-interview).

The interviews were carried out in two periods in 1975: The first interview in September/October, and the second interview in November/December. They were held by the same interviewer in both periods. Between the two interviews of the same pupil was at least an interval of one month. An interval of one month was thought to be the minimum, necessary to avoid the influence of the memory and the maximum to prevent seasonal variations.

Data analysis

All fooditems and corresponding serving sizes were converted into food and quantity codes according to the NEVO table data nutrient files (formerly called UCV-table). A computer program (32) was used to determine the daily nutrient intake of energy, protein, fat, carbohydrate and alcohol. Statistical analysis of the data was carried out with the computer programs of the Statistical Package of the Social Sciences (33), by paired signed-rank t-tests on a level of significance $p < 0.05$.

Calculations of the dietary intake of each pupil were made for every method in both measurement periods:

- Of a schoolday; in the case of the dietary history a mean of five schooldays, and of the 24-recall the intake of the Thursday.
- Of a weekend day; in the case of the dietary history a mean of the Saturday and Sunday, of the 24-recall the intake of the Sunday.

The reproducibility of each method was calculated by analyzing the intra-individual differences of the nutrients between the first and the second measurement.

In addition, the average nutrient intake of the different methods was calculated by age groups.

Results

In table 3.2., means of the energy and nutrient intake, calculated from the data of the first and second interview by the two different methods are summarized, separately for the schoolday, and weekend day.

Table 3.2.: Mean and standard deviation (sd) of nutrient intake of the pupils (girls and boys) obtained by the 24-recall and the dietary history in the two measurement periods for schooldays and weekend days.

METHODS	*24-RECALL*				*DIETARY HISTORY*			
Type of day	schoolday		weekend day		schoolday		weekend day	
Pupils (N)	24		24		22		22	
Measurement period	1	2	1	2	1	2	1	2
Energy, mJ	11.5	10.8	11.3	10.9	11.2	9.5	12.1	10.4
sd	6.0	3.3	2.8	5.0	3.3	2.8	3.8	2.9
Protein, gram	85	75	70	80	90	75	95	85
Fat, g	135	120	115	120	115	100	125	115
Carbohydrate, g	300	295	300	285	310	260	340	280
Alcohol, g	0	0	3	7	0	0	1	1

Table 3.3.: The mean daily nutrient intake for the two age groups (girls and boys), obtained by the 24-recall for the first and second measurement, and the standard deviation of the mean difference (diff-sd).

TYPE OF DAY	*SCHOOLDAY*				*WEEKEND DAY*			
Age group (year)	12/13		15/16		12/13		15/16	
Pupils (N)	12		12		12		12	
Measurement	1	2	1	2	1	2	1	2
Energy, mJ	10.0	9.5	13.1	12.0	10.3	9.0	11.4	12.7
diff-sd	1.6		6.7		1.4		4.7	
Protein, gram	70	65	95	85	65	65	80	90
diff-sd	15		45		20		30	
Fat, g	110	100	155	135	110	95	125	145
diff-sd	35		110		35		80	
Carbohydrate, g	270	270	330	320	300	250	305	320
diff-sd	70		110		55		85	

On an average, the results of the 24-recall and of the dietary history show slightly higher mean values on the first measurement compared with the second measurement in energy, protein, fat and carbohydrate. (The only exception is the mean nutrient intake of the age group 15/16 on the weekend day; the second measurement with the 24-recall gives higher values compared with the first measurement, Table 3.3.) The differences, however, are not statistically significant (P 0.05). As far as the energy intake is concerned the standard deviations are high, but tend to decrease in the second measurement in comparison with the first one.
These youngsters rarely consume alcoholic drinks so that alcohol will not be analyzed further.
The frequency distribution of the energy intake of the subjects on schooldays, measured with the dietary history, is presented in figure 3.2.A., and of the 24-recall in figure 3.2.B.
The energy intake on the schoolday, was for about 75 % of the pupils between 6.3 and 12.6 megajoules (mJ) in both interview periods. No one reported an energy intake below the 4.2 mJ, whereas an energy intake of more than 16.7 mJ was estimated in about 28 % of the pupils for both methods. In figure 3.3. a frequency distribution is presented of the difference-scores between first and second measurement of the two methods of the energy intake on schooldays. This score is the mean-individual difference between the value measured in the first interview minus the value of the second interview.
The difference-scores on the schoolday for the 24-recall vary between the - 7.5 and the + 20.9 mJ, and for the dietary history between - 2.5 and + 7.5 mJ. The mean difference-score of the whole group of pupils interviewed with the 24-recall was + 0.8 mJ, and for the dietary history + 1.6 mJ. In figure 3.4. the difference-scores on the weekend day are shown: for the 24-recall the mean difference was -.08 mJ, for the dietary history + 1.7mJ. The range was respectively - 15.1 to + 5.0 mJ and - 2.5 to + 7.5 mJ.

The average intake of energy and macronutrients, from both methods in the first and second period, divided into age groups, are summarized in

Table 3.4.: The mean daily nutrient intake for the two age groups (girls and boys), obtained by the dietary history for the first and second measurement, and the standard deviation of the mean difference (diff-sd).

TYPE OF DAY	*SCHOOLDAY*				*WEEKEND DAY*			
Age group (year)	12/13		15/16		12/13		15/16	
Pupils (N)	11		11		11		11	
Measurement	1	2	1	2	1	2	1	2
Energy, mJ	10.5	9.2	11.9	9.9	11.1	9.8	13.1	11.1
diff-sd	2.3		2.1		2.2		2.1	
Protein, gram	80	70	95	80	85	80	105	90
diff-sd	15		15		15		15	
Fat, g	115	100	120	105	120	105	130	120
diff-sd	30		25		25		30	
Carbohydrate, g	280	255	340	265	305	260	370	295
diff-sd	65		60		75		65	

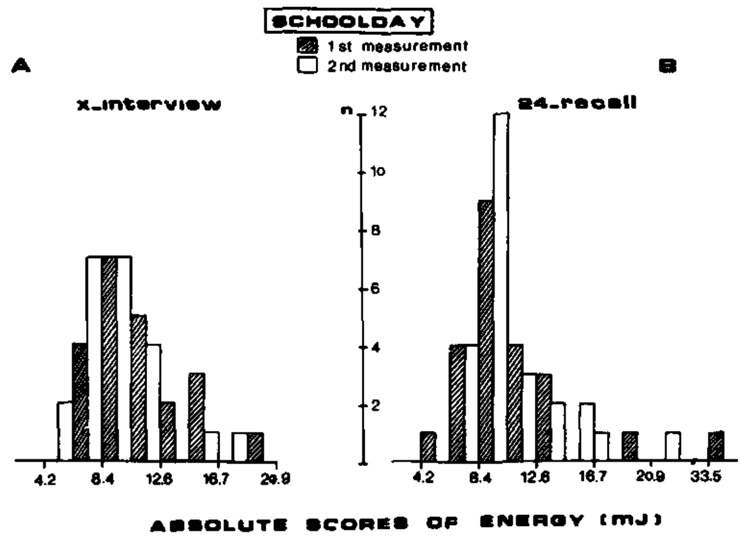

Figure 3.2.: A. The absolute scores of energy for a mean schoolday in two measurement periods, by the dietary history (X-interview).
B. The absolute scores of energy for a mean schoolday in two measurement periods, by the 24-recall.

table 3.3. and 3.4.. The standard deviation of the difference between the two periods is in the age group 15/16 for the 24-recall 3-4 times higher than in the age group of 12/13. In the same age groups, measured with the dietary history, the standard deviation of the difference is almost the same.

Discussion

A difficulty in studying free-living individuals is to obtain precise information, because all the methods rely on the information supplied by the subjects themselves (28).

In this study the reproducibility of the 24-recall and of the dietary history was measured by comparing the mean scores of the nutrients of the first with those of the second interview. The results tend to show lower nutrient intake values in the second interview compared with the first, and can be explained as the regression to the mean (34).

The absolute scores, as well as the difference-scores are more extreme when recorded with the 24-recall compared with the dietary history. This may be explained by the use of the interview method; the dietary history obtains the usual diet, whereas the 24-recall assesses the incidental diet.

The frequency distribution of the difference-scores between the first and second measurement is in the dietary history group considerably smaller than in the 24-recall group (Figure 3.3.). The distribution in the case of the dietary history is the same over the schoolday as well as over the weekend day (Figure 3.4.).

The distribution of the frequency in difference-scores between the two recall methods shows that this is distributed more evenly round a zero difference in the 24-recall than in the dietary history. The latter is more in favour of a better mean estimate of the food intake, the former indicates a smaller intra-individual variation in repeated measurements.

Persson (18) showed that the intra-individual variation is far too great to be represented only by 24-hours food intake. The high

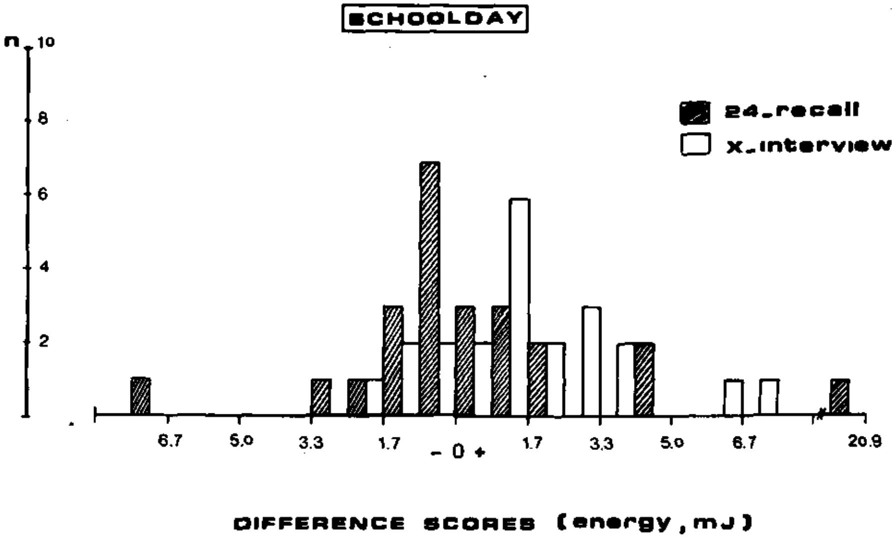

Figure 3.3.: The difference scores of energy on a mean schoolday between the first and second measurement for the 24-recall and the dietary history (X-interview).

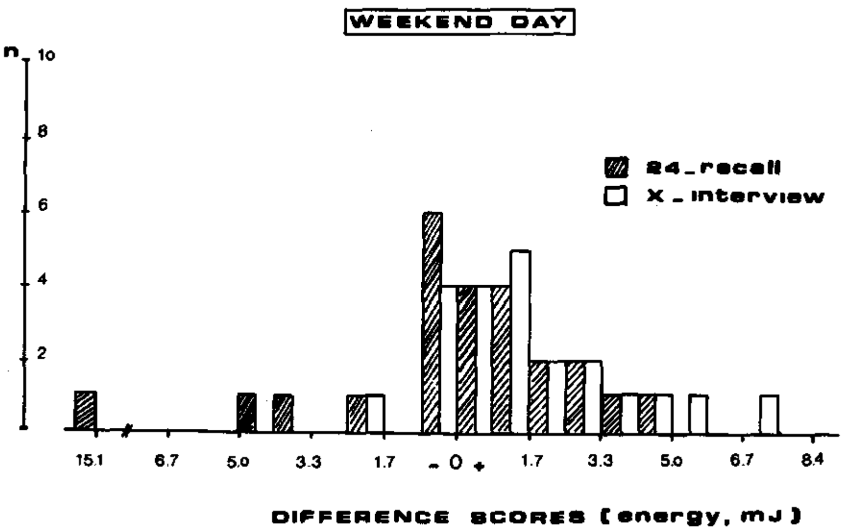

Figure 3.4.: The difference scores of energy on a mean weekend day between the two measurement periods for the 24-recall and the dietary history (X-interview).

intra-individual variance of this method causes problems in computing correlations, such as relevant in growth and development studies. This problem is not eliminated by increasing the number of studied individuals, but through an increase of numbers of 24-recalls.
Variations in reproducibility of the 24-recall between the two age groups, shown by the standard deviation of the difference between the repeated measurements, indicate that reproducibility seems to decrease with age in these teenagers. The dietary history did not show this tendency. Although, the complex questions of a dietary interview may be difficult for teenagers to answer properly. Emmons found that the ability of schoolchildren to correctly recall a school lunch improved with age (14), so their memory seems good enough. Persson (18) found the 13 year old children cooperative and intelligent enough, as already stated. This favours the use of the dietary history in a longitudinal study with repeated measurements.
It is often stated that the dietary history results in higher nutrient intakes compared to other food consumption interview techniques (12,18,35,36). In the present study this statement appears only true for the 12/13 year old pupils on an average schoolday, but not for the 15/16 year olds and only in the first measurement (compare table 3.3 and 3.4).
The rather poorly correlated nutrient intake values in teenagers, obtained at the second measurement compared with the results of the first measurement could, generally speaking, be caused by age (6). The differences between the two interviews in the present study cannot be due to changes in food habits because the time between the two measurements was only one to one-and-a half month.

The day-to-day variation in the 24-recall studied by Balogh (26) and Hankin (37) was found very high within individuals. They described that it would be necessary to obtain at least four 24-recalls in order to have 95 percent probability to be in $\pm$ 20 percent of a person's true mean energy intake. This will have practical consequences for the longitudinal study.

The data obtained from the dietary history showed higher energy and nutrient values in the weekend day in both measurements. The values of the 24-recall however indicated no systematic differences between both measurement periods. Possibly the study design was partly the cause of this phenomenon: The 24-recall over the weekend took place on Monday and the data were taken of the Sunday. It could be expected that the food consumption on Saturday would be more elaborate, with the long evening (night) also shown by Persson (18), whereas on Sunday teenagers will go to bed earlier in view of the following schoolday. Within the scope of this study it was impossible to interview on Sundays (no schoolday).
The lower nutrient intake values measured in the second interview, can be explained as a test-effect. Pupils who tend to exaggerate in the first interview will give more realistic answers in the second. In the multiple-longitudinal study, however, a control group will be foreseen, consisting of pupils of the same age, who will be interviewed only once. When comparing the longitudinal group (with repeated measurements) with a control group (without repeated measurements), effects caused by the interview method, can be studied (see Chapter 2).
Apart from the reproducibility criteria a practical point also is the time needed to collect the data from the two methods. The 24-recall takes at least twice 15 minutes per week; that is, on Monday interviewing the food consumption of the Sunday and on Friday asking about the intake on Thursday. One school lesson lasts 50 minutes, so, 3 pupils can be interviewed in one lesson. When a schoolday has 6 or 7 lessons, about 20 pupils can be interviewed on one schoolday. Because of the day-to-day variation, it was not a good idea to use also the other schooldays to recall. Thus, in one week only 20 pupils could be interviewed by one dietician.
The dietary history takes about 50 minutes, that is one lesson. With the 6 to 7 lessons a day, it is possible to interview 6 to 7 pupils per schoolday, Since there is no need to execute this method on a particular day of the week, all of the five schooldays can be used. This meant that 30 to 35 pupils could be interviewed in one week by the same dietician.
Because of the undesirable, but possible, inter-interviewer variations, only one dietician can be used for the longitudinal study. The dietary

history therefore has an advantage over the 24-recall, because considerably more pupils can be measured per week.

Conclusions

Within the limitations of the present study about the reproducibility of the 24-recall and the dietary history in teenagers, the following conclusions can be drawn:

1. The 24-recall shows the largest intra-individual differences between the first and second measurement.
2. The difference-scores of the 24-recall tend to increase with age.
3. The dietary history shows a tendency to lower total energy intake in the second interview compared with the first.
4. Although both methods leave much to be desired, in the multiple-longitudinal study preference will be given to the dietary history for two reasons:

   _a_ More pupils can be interviewed per week by one nutritionist

   _b_ Any systematical changes in nutrient intakes, caused by testeffects, will be checked by use of control groups in which no repeated interviews will be taken.

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CHAPTER 4

Longitudinal Changes in Nutritional Habits of Teenagers: differences in intake between schooldays and weekend days

G. Bertheke Post Han C.G. Kemper L. Storm - van Essen

1. Longitudinal changes in nutritional habits were studied in Dutch adolescents from 12 to 17 years of age (131 girls and 102 boys). The dietary differences on schooldays and weekend days are reported.

2. In girls only small changes in nutritional habits were seen as they grew older. In boys there was a gradual increase in food intake with age.

3. Overall, higher nutrient intakes could be seen on weekend days. The energy intake on weekend days was consistently higher for girls and boys in all age-groups. The proportional intakes of fat and sugar were rather high, especially on weekend days. The alcohol consumption increased with age for girls as well as boys, and was for some individuals extremely high (boys) on weekend days.

4. The observed levels of intake compared with the recommendations showed a rather low intake of polyunsaturated fatty acids, polysaccharides and iron.

The nutritional survey reported in the present paper was part of a detailed multiple longitudinal study on growth and health of teenagers (Kemper *et al.* 1983). This investigation was designed to describe the course of the physical and mental development of teenagers, and to find out whether there is a period of deterioration in their state of health. For example, does the style of living change, particularly with respect to the daily food intake? Today there is an increasing awareness that the increasing costs of medical and health services must be controlled and that our society would be better served by devoting more effort to research into methods of primary prevention, i.e. changes from diagnosis to health promotion. Within the scope of this growth and health study it was considered important to have information about the quantitative and the qualitative aspects of nutritional habits of children in their teens. In the present paper the results of measurements of the daily diet are reported, especially the differences between schooldays and weekend days.

SUBJECTS AND METHODS

Subjects

In the study on growth and health of teenagers (Kemper *et al.* 1983) the measurements were taken during four consecutive years, from 1976 to 1980. Initially, the study involved about 600 pupils of the first and second forms of two secondary schools in The Netherlands. The group of pupils studied may not therefore be considered as representative of the Dutch teenage population in general. The pupils of these two schools have a level of intelligence above the average for their age. The parents of our subjects had a higher level of education, occupation and income than that found in an average Dutch family (Kemper, 1985). The pupils of one school (Amsterdam) were measured yearly and they are referred to as the longitudinal group.

The pupils were in the first and second forms at the start of the study at which time these two year-groups had average ages of 13 (first form) and 14 (second form) years. Because

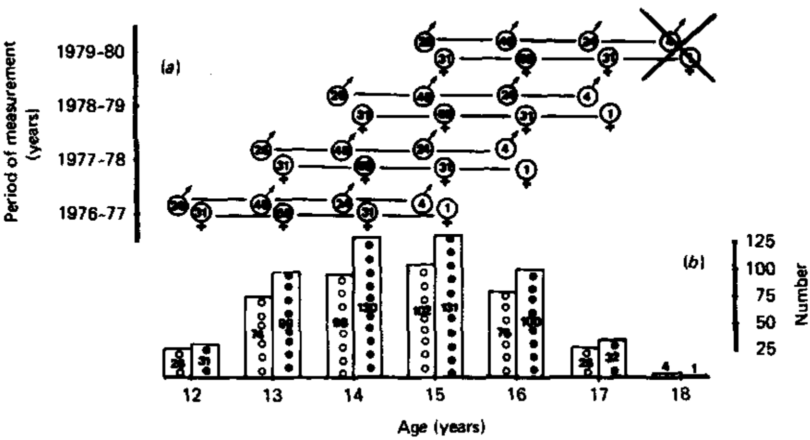

Fig. 1. (*a*) The number of boys and girls measured during the 4 years of the longitudinal study and (*b*) the total number of boys (○) and girls (●) per age-group.

of this difference of 1 year between the two groups of subjects (first and second forms) it was possible to check for interfering factors such as time of measurement effect and cohort effect that can present problems in interpreting the results of longitudinal research (Kemper & Van't Hof, 1978). In the second school (Purmerend) with a comparable group of pupils, 25% of the group were selected at random each year and examined, so that in 4 years all pupils in this group were examined once: this is called the control group. In this design, comparison of the results for the longitudinal group with the results of the control group could give an indication of testing effects.

Over the duration of the study 24% of the pupils in the longitudinal group dropped out. Most of them (sixty-eight pupils) moved to a different type of school or out of the area. Only six pupils actually refused to continue participation. Finally the longitudinal group consisted of 131 girls and 102 boys, on whom the results are based. After checking for interfering effects the longitudinal data were arranged in age-groups irrespective of the year of measurement. In this way a developmental pattern over 6 years (from 12 to 18 years) could be covered, with most observations at the ages of 14 and 15 years. An overview of this final data arrangement is given in Fig. 1 which shows the number of girls and boys measured during the 4 years and the total number of girls and boys measured per age-group.

Measurement of food intake

The measurement of the food intake took place every year in the months January, February and March. Therefore seasonal bias is unlikely.

The schoolchildren in the present study did not have a fixed pattern of meals. In The Netherlands hot lunches are not served at school. Most of the pupils take sandwiches with them for lunch and have a hot meal at home in the afternoon. Because most teenagers are not particularly conscious of their eating and drinking habits we tried to find a special approach to determine the normal daily diet of the subjects with accuracy. A modification of the cross-check dietary history interview (Beal, 1967; Marr, 1971; Post & Kemper, 1980) was used to ascertain the individual food intake. It lists a series of items, covering the entire range of foods and drinks, appropriate to a teenage population. In an interview with a nutritionist (the same throughout the study) all foods listed came under review with special reference to frequency and amounts. Information on foods eaten during regular meals as

Table 1. *The height, body-weight and percentage body fat of Dutch girls and boys in the longitudinal group*

(Mean values with their standard errors)

Age (years)...		12	13	14	15	16	17
			Girls				
No.		31	98	129	130	99	32
Height (m)	Mean	1·55	1·61	1·65	1·67	1·69	1·68
	SE	0·011	0·007	0·006	0·006	0·007	0·013
Wt (kg)	Mean	42·2	48·0	52·0	54·9	57·4	57·9
	SE	1·3	0·9	0·8	0·8	0·9	1·2
Body fat (%)	Mean	22·8	24·5	25·6	26·6	27·4	28·1
	SE	0·9	0·5	0·4	0·4	0·5	0·6
			Boys				
No.		26	73	95	102	76	28
Height (m)	Mean	1·51	1·59	1·65	1·73	1·78	1·81
	SE	0·014	0·008	0·008	0·007	0·007	0·008
Wt (kg)	Mean	38·4	43·4	48·9	55·6	61·0	63·8
	SE	0·9	0·7	0·8	0·8	0·9	1·8
Body fat (%)	Mean	15·1	16·0	16·2	16·0	16·3	17·0
	SE	0·7	0·5	0·4	0·4	0·4	1·0

well as between meals (so-called snacks) were collected separately for normal schooldays and for weekend days. The next step was to make inquiries about each food item. The subject was instructed to indicate the specified number of times per day, week or month the foods were consumed. Only the food items eaten at least twice monthly were recorded. The amounts were reported in household measures and common portion sizes. A variety of visual aids (such as glasses, bowls, spoons, and also polystyrene shapes of potatoes, apples and other fruits) were used to estimate quantities. Since it was assumed that teenagers do not necessarily know all the details regarding their food consumption, particularly with respect to its preparation, we also developed a questionnaire for the parents about details of several food items consumed by their children, e.g. skimmed or whole milk, kind and quantity of meat, addition of butter or sauce to vegetables and potatoes. For each individual all amounts were expressed in g for the five schooldays and the two weekend days.

All the dietary information was analysed using a computerized food-composition table (Cramwinckel *et al.* 1977), which was modified and supplemented as required. The following food characteristics were calculated and are discussed: energy, protein, fat, carbohydrate, dietary fibre, alcohol, minerals and vitamins. When it was useful, comparisons have been made with recommended dietary allowances (RDA) of The Netherlands Nutrition Council (Voedingsraad, 1978, 1981) and the Food and Agricultural Organization/World Health Organization (FAO/WHO) (1973).

RESULTS

In Table 1 the height, body-weight and percentage body fat of the longitudinal group are given. The mean body-weight of girls, between 12 and 17 years of age, increased from 42 to 58 kg, and for boys from 38 to 74 kg. Over the same period percentage fat, calculated from the sum of four skinfolds (Durnin *et al.* 1967), increased from 23 to 28% in the girls and from 15 to 17% in the boys.

Testing effect

Of the possible interfering factors on reported nutrient intakes, we found a testing effect in boys for energy, protein and carbohydrate intakes. This is illustrated for energy in Fig.

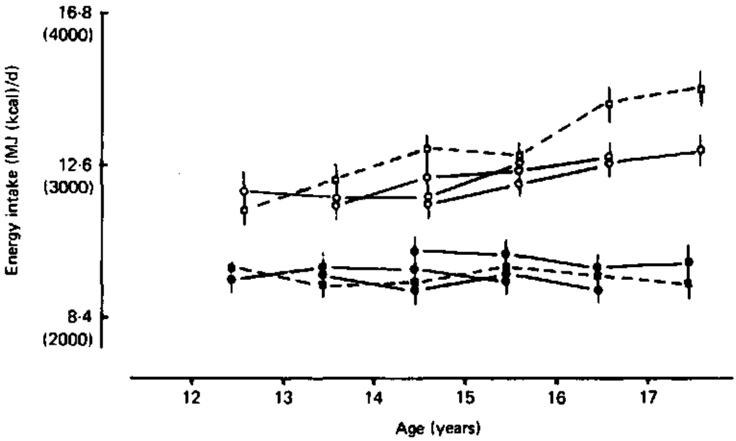

Fig. 2. Testing effect in the energy intake of boys illustrated by the mean scores of the three birth cohorts (——) and the mean scores of the control group (---) *v.* calendar age. (○, □), ♂; (●, ■), ♀; (■, □), control groups; (●, ○), longitudinal groups. Points are means with their standard errors represented by vertical bars.

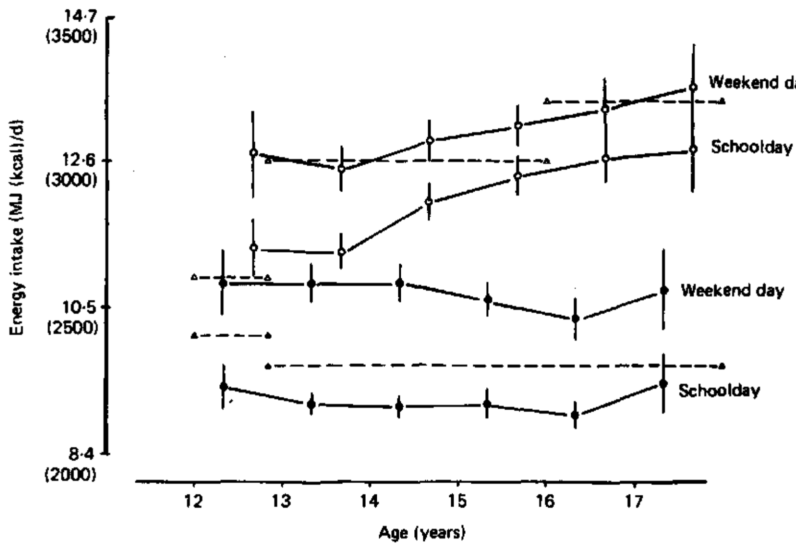

Fig. 3. Energy intakes for schooldays and weekend days in girls (●, ▲) and boys (○, △) *v.* calendar age. (△---△, ▲---▲), Dutch recommended dietary allowances. Points are means with their standard errors represented by vertical bars.

2 where it can be seen that the increase in the mean energy intake over the study period was more pronounced in the control group than in the longitudinal group.

Energy

The average energy intakes of girls and boys on a mean schoolday and a mean weekend day are shown in Fig. 3. The daily intake for girls remained on the same level during the

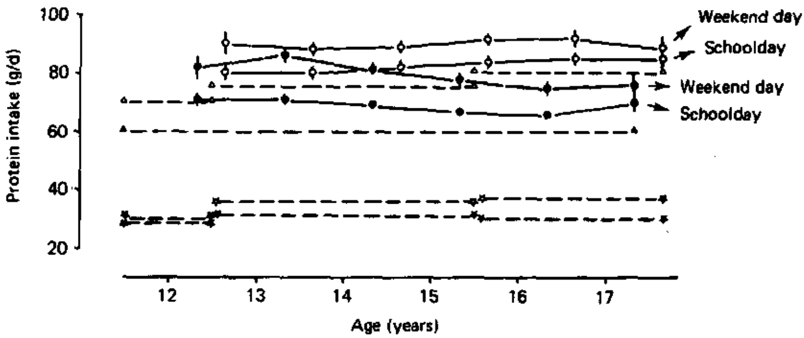

Fig. 4. Protein intake for schooldays and weekend days in girls (●, ▲, ★) and boys (○, □, ☆) *v.* calendar age. (△---△, ▲---▲), Dutch recommended dietary allowances; (☆---☆, ★---★) Food and Agricultural Organization/World Health Organization (1973) recommended allowances. Points are means with their standard errors represented by vertical bars.

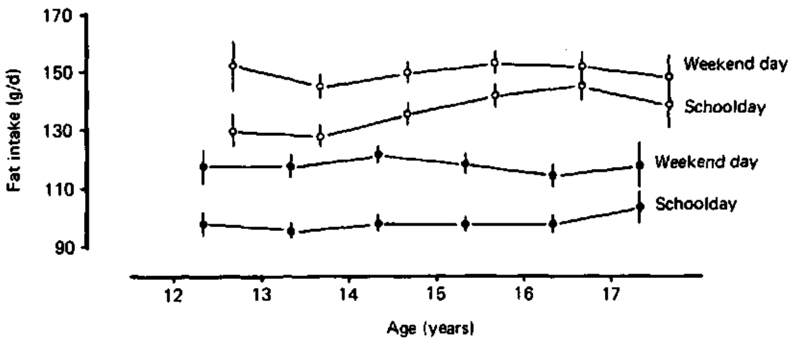

Fig. 5. Fat intake for schooldays and weekend days in girls (●) and boys (○) *v.* calendar age. Points are means with their standard errors represented by vertical bars.

whole age-range, whereas the intake for boys increased with age by about 1–1·5 MJ/d (on a mean schoolday as well as on a mean weekend day). On a weekend day girls and boys ate consistently more than on a schoolday. For girls the difference in intake was 1·4 MJ/d; for boys the difference was 1·3 MJ/d at age 12–13 years, decreasing to 0·8 MJ/d as they grew older (16–17 years old). Boys also ate consistently more than girls and the difference became more pronounced as they grew older in the course of the study. At age 12 years the difference was 21% on a schoolday and 17% on a weekend day. At age 17 years this difference had increased to 36% on a schoolday and 27% on a weekend day.

Protein

The mean dietary protein intake for girls and boys of 12–17 years is shown in Fig. 4. Girls had 10–15% higher protein intakes on weekend days compared with schooldays. The greatest differences were found in the age-group 13–15 years. Boys also showed a higher protein intake on a mean weekend day, but the difference decreased from 13% for 12–13 years old to 5% for 17–18 years old, as the total protein intake on schooldays increased with age. The quality of the protein depends on the proportions of animal and vegetable protein in the daily diet. For both sexes the intake of vegetable protein remained almost the same on weekend days and schooldays. On a schoolday as well as on a weekend day

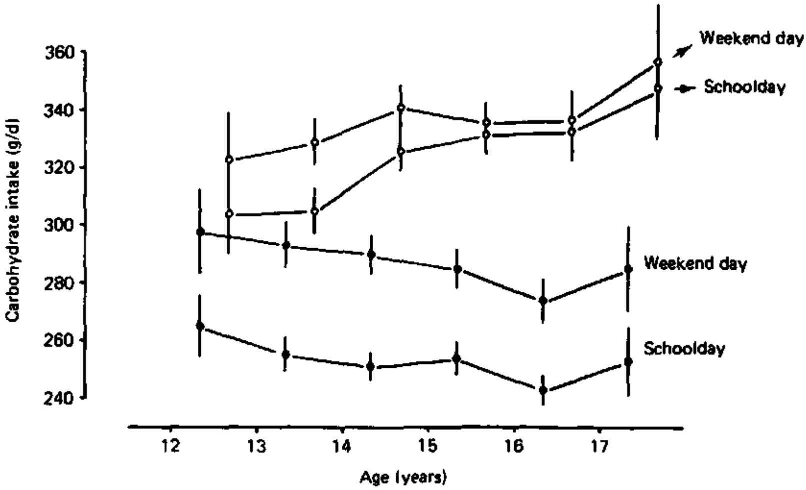

Fig. 6. Carbohydrate intake for schooldays and weekend days in girls (●) and boys (○) *v.* calendar age. Points are means with their standard errors represented by vertical bars.

the intake of animal protein was almost twice that of vegetable protein. On weekend days the intake of animal protein was about 10 g more for girls, and 5 g more for boys, than on schooldays.

Fat

Fig. 5 shows the total fat intake on a mean schoolday and on a mean weekend day. For girls there was no age-effect. Boys increased their fat intake on a mean schoolday as they grew older. On a weekend day the mean fat intake for boys was about 7–15% higher, and for girls about 20% more than on a schoolday.

Dietary cholesterol tends to elevate serum cholesterol and polyunsaturated fatty acids (PUFA) tend to lower serum cholesterol. The cholesterol intake of the girls and boys was very much higher on weekend days than on schooldays. For girls the difference was about 60% and for boys it was about 50%.

The intake of PUFA was almost equal between schooldays and weekend days for girls and boys. Girls in all age-groups had a mean intake of 15 g PUFA/d. Boys had about 20 g/d, slightly increasing with age.

Carbohydrate

Fig. 6 shows clearly the difference in carbohydrate intake between schooldays and weekend days for girls (12–15% higher on weekend days). In boys this was true only for the youngest age-groups (7% higher). In general boys increased their carbohydrate intake with age, whereas older girls tended to decrease their carbohydrate consumption.

The intake of mono- and disaccharides (total sugar) supplied 24% of the total daily energy intake for the girls and 22% for the boys. In absolute values there was a tendency to decrease the intake with age for girls, but for boys there was an increase with age.

Dietary fibre

The dietary fibre intakes for the youngest girls and boys were 23 and 25 g respectively with no difference between weekend days and schooldays. As they grew older the intake increased

Table 2. *Percentage of pupils who report consuming alcoholic beverages, by age, for schooldays and weekend days*

	Girls (*n*131)		Boys (*n*102)	
Age (years)	Schoolday	Weekend day	Schoolday	Weekend day
12–13	—	6	—	4
13–14	4	9	6	15
14–15	7	22	7	16
15–16	14	33	19	28
16–17	16	44	42	51
17–18	41	62	50	68

Table 3. *Alcohol intake (g) of girls and boys who report consuming alcohol, for a mean schoolday and a mean weekend day*

(Mean values with their standard errors)

	Girls (*n*131)				Boys (*n*102)			
	Schoolday		Weekend day		Schoolday		Weekend day	
Age (years)	Mean	SE	Mean	SE	Mean	SE	Mean	SE
12–13	—	—	1	1·0	—	—	5	—
13–14	1	0·3	6	1·4	1	0·3	4	0·9
14–15	2	0·6	5	1·0	2	0·6	6	1·2
15–16	3	0·8	6	1·0	8	3·7	15	3·4
16–17	3	1·0	10	1·4	12	2·6	27	4·2
17–18	4	0·5	11	1·7	17	6·0	29	5·8

a little, but more markedly on schooldays, so that on a weekend day the intake was about 5 g lower.

Alcohol

The intake of alcohol increased with age, especially during the weekend. The consumption of alcoholic drinks on schooldays started at about age 15–16 years at which time the mean consumption was 0·4 g/schoolday for girls and 1·5 g/schoolday for boys. The amounts increased to 1·5 g/schoolday for girls of 17–18 years and 8·6 g/schoolday for boys of the same age. At the weekend, 12–13-year-old girls and boys only consumed an average of 0·1 and 0·2 g/d respectively, but there was a large increase in this level so that by 17–18 years of age average consumption by the girls was 7·1 g and by the boys 19·6 g/weekend day.

Because there was a large number of 'non-drinkers' the distribution of alcohol intake was skewed and mean alcohol intake of all subjects does not give a good indication of the true pattern. Therefore the percentage of alcohol consumers was determined (Table 2) and their mean alcohol intake per mean schoolday and weekend day (Table 3) calculated. The mean alcohol intake increased with age, on schooldays and especially on weekend days, for girls and boys. In general, both girls and boys reported an increasing consumption of light alcoholic drinks (such as beer and wine) as they grew older.

Minerals

The calcium intake for girls on schooldays was about 900 mg in all age-groups. On a weekend day the intake was somewhat higher, by between 40 and 120 mg, depending on

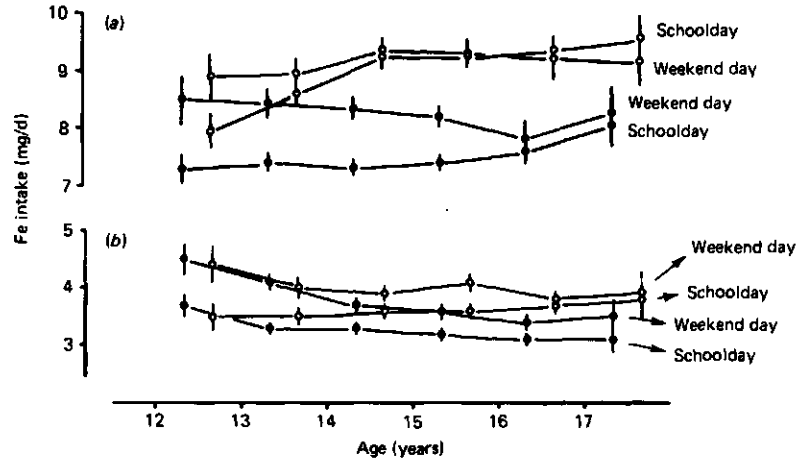

Fig. 7. Iron intake in (*a*) non-haem and (*b*) haem compounds for schooldays and weekend days in girls (●) and boys (○) *v*. calendar age. Points are means with their standard errors represented by vertical bars.

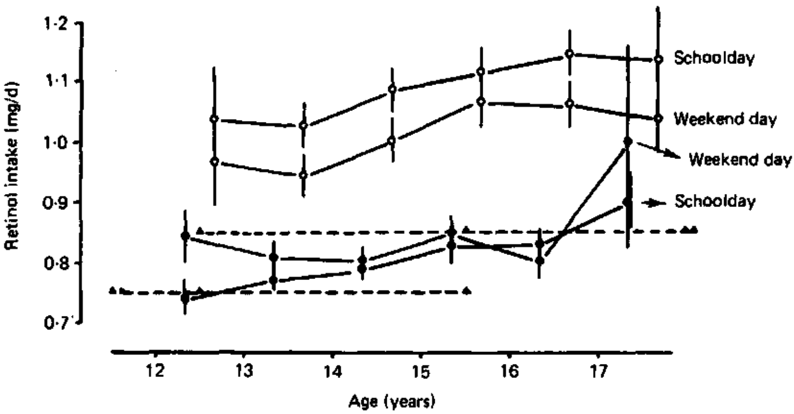

Fig. 8. Retinol intake for schooldays and weekend days in girls (●, ▲) and boys (○, △) *v*. calendar age. (△---△, ▲---▲) Dutch recommended dietary allowances. Points are means with their standard errors represented by vertical bars.

age. Boys had a mean daily Ca intake of 1090 mg on schooldays and weekend days. Only in the higher age groups did this intake increase in the weekend days by about 100 mg/d.

In the present study the total daily iron intake of 12–13-year-old girls was 11·5 mg, decreasing to about 11·0 mg as they grew older. Boys of 12–13 years had an intake of 12 mg Fe/d and this increased to 13·2 mg/d in the 17–18 year olds. Only the youngest age-groups showed higher total Fe intakes on weekend days, the difference being about 16% for both girls and boys. The Fe intake was divided into haem-Fe compounds and non-haem-Fe compounds. The intakes of non-haem-Fe were about two times as high as the amount of haem-Fe (Fig. 7). The haem-Fe intake for girls on a mean weekend day was about 0·5 mg higher compared with schooldays irrespective of age. In boys this difference was only seen in the youngest group where the intake was about 1 mg higher on weekend days. The non-haem-Fe intake for girls was about 1 mg higher at weekends in the first four age-groups

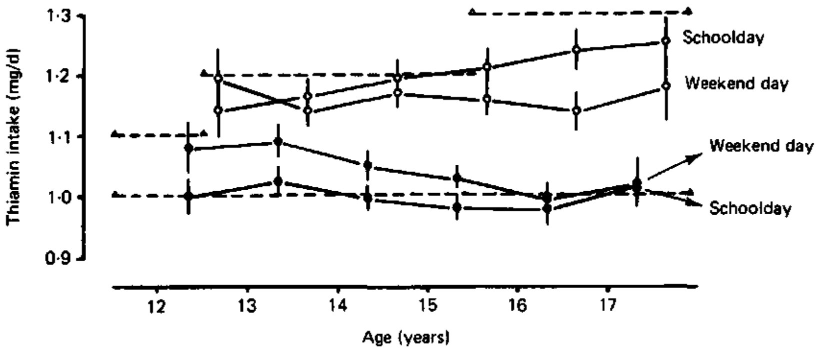

Fig. 9. Thiamin intake for schooldays and weekend days in girls (●, ▲) and boys (○, △) *v.* calendar age. (△---△, ▲---▲) Dutch recommended dietary allowances. Points are means with their standard errors represented by vertical bars.

but equal in the older groups. In contrast the boys initially showed a lower intake on weekend days (about 0·9 mg), but after the age of 15–16 years the non-haem-Fe intake increased and was 0·4 mg higher than that on a schoolday.

Vitamins

In girls retinol (vitamin A and β-carotene) intake only showed a difference between schooldays and weekend days in the youngest and oldest age-groups (about 0·1 mg; Fig. 8). Boys had, on a weekend day, a lower retinol intake of about 0·1 mg than on a schoolday for the whole age-range.

The thiamin intake of girls was about 1·0 mg/schoolday and remained quite stable in all age-groups (Fig. 9). On a weekend day the intake of 12–13-year-old girls started on the somewhat higher level with a tendency to decrease with age. For boys 12–14 years old, the intake was 1·1 mg thiamin/schoolday and tended to increase for 15–18 year olds to 1·2 mg/d. Fig. 9 shows that on a weekend day the mean intake fluctuated somewhat with age, being about 1·2 mg with lower intakes than on schooldays.

The pyridoxine intake of girls on schooldays (1·2 mg) did not change with age (Fig. 10). On the weekend days there was a lower intake, and this tended to decrease a little up to 16 years of age. Boys had similar constant pyridoxine intakes with lower intakes at the weekend.

The ascorbic acid intake increased a little with age for girls. Boys had fluctuating intakes in the different age-groups. As Fig. 11 shows, the ascobic acid intakes on weekend days were much lower than those on schooldays for both girls (about 20 mg) and boys (about 30 mg).

DISCUSSION

Measurement of food intake

In a preliminary investigation we tried to find out which of the methods, the 24 h recall or the cross-check dietary-history method, was the best to estimate the food intake of children in the age-groups 12–18 years old (Post & Kemper, 1980). The cross-check dietary-history method gave the smaller intra-individual differences between test–retest measurements, and these differences were not significant. In addition it was less time-consuming and so this was the method we finally chose.

The food-intake interview used in the present study has many similarities with the

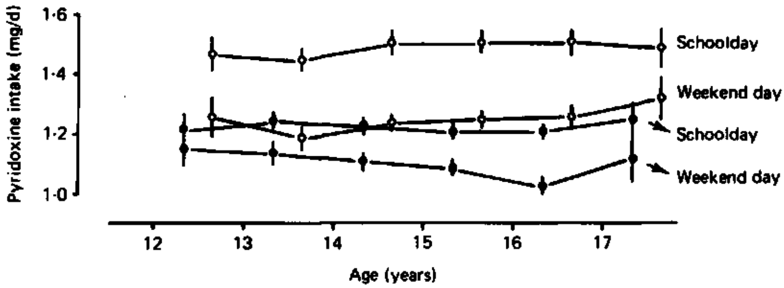

Fig. 10. Pyridoxine intake for schooldays and weekend days in girls (●) and boys (○) *v*. calendar age. Points are means with their standard errors represented by vertical bars.

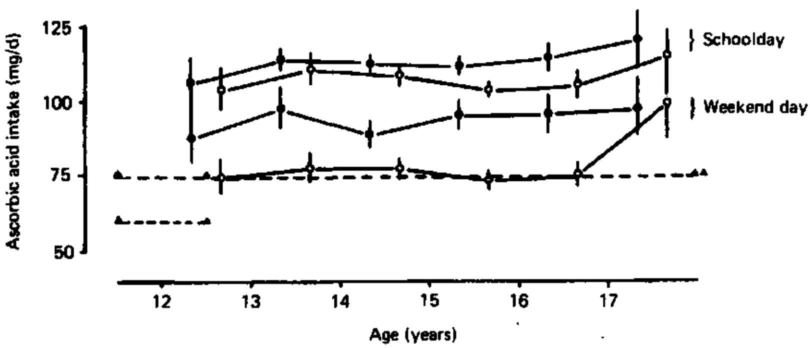

Fig. 11. Ascorbic acid intake for schooldays and weekend days in girls (●, ▲) and boys (○, △) *v*. calendar age. (△---△, ▲---▲) Dutch recommended dietary allowances. Points are means with their standard errors represented by vertical bars.

dietary history interview method described by Van Staveren (1985). Van Staveren (1985) demonstrated that the protein intake estimated from an interview agreed with the nitrogen excretion in the urine.

Test effects

Test effects were only found in boys for energy, protein and carbohydrate intake. It is possible that the lower amounts found in the longitudinal group were caused because the boys became more aware of what they were eating or they were less inclined to overestimate their intake in the course of the study, or both. In the control school (Purmerend) the subjects had higher protein intakes than of those in the longitudinal group from the start of the study. This school effect might be related to the somewhat higher socio-economic background of the parents in Purmerend. A longitudinal study of Hackett *et al.* (1984), for example, indicated a positive correlation between social class and protein intake.

Food intake

In the literature there are few studies describing the differences between schooldays and weekend days, thus in order to compare our findings with the literature we calculated the intake per mean weekday:

$$\frac{(5 \times \text{mean schoolday}) + (2 \times \text{mean weekend day})}{7}.$$

Table 4 summarizes the studies with which our results are compared. However, it must be kept in mind that differences in results may be caused by: (1) different methods of information collection; such as records over 3 or 7 d, recall over 24 h, dietary history, or combinations of these methods; (2) differences in design: longitudinal *v.* cross-sectional data collection; (3) differences in the time of year (season); (4) differences in weight and height of the populations.

Compared with the longitudinal study of Huenemann *et al.* (1974), the energy intake seemed to be equal for boys (aged 16 years) but higher by about 1 MJ/d for girls (aged 16 years) in the present study. The energy intakes for 12–16-year-old girls and boys in the Ten State Nutrition Survey (Hegsted, 1976) seem very similar to our findings. Durnin *et al.* (1967) found, for 14-year-old Glasgow schoolchildren in 1964, a mean daily energy intake which is almost identical to the intakes of the 14-year-old girls and boys in the present study. However, in their 1971 study, Durnin *et al.* (1974) found somewhat lower intakes for both girls (−1·1 MJ) and boys (−1·3 MJ). Also, Hackett *et al.* (1984) described a nutritional longitudinal survey in England with lower energy intake for girls (about −1·4 MJ) and boys (about −2·2 MJ) aged 11–12 years, compared with the 12-year-olds in the present study. In contrast Barber & Bull (1985) reported a mean intake of 9·3 MJ/d in 15–18-year-old English girls (not on a slimming diet), which is similar to that found in the present study. In Britain, energy intakes have been decreasing over the past decades, and this is thought to be a reflection of lower energy expenditure (Buss, 1982). In The Netherlands, dietary surveys among teenagers are scarce, therefore it is difficult to recognize differences in energy and nutrient intakes over the past years. Although, Van Schaik & Kenter (1972) reported the same daily energy intakes for 17-year-old girls (9·8 MJ), they found much higher intakes for 17-year-old boys (14·5 MJ) compared with the present study (13·0 MJ).

Woodward (1984) described energy intakes among Tasmanian teenagers (12–15 years old), expressing the results as median values (equal to the 50th percentile) rather than mean values. On analysis the median values of energy intake for the groups of girls and boys in the present study were almost equal to the mean values, and so it seems unlikely that this difference in expression could account for the somewhat higher energy intakes of our 12–13-year-old boys (11·2 MJ/d) compared with the Tasmanian boys (10·8 MJ/d). By age 13–14 years, the intakes between the two groups were comparable.

Considering the Dutch RDA and the recommendations of the FAO/WHO (1973), the mean daily energy intake of those in the present study, seemed to be not too high (Fig. 12). The inter-individual differences, however, were great (one individual may consume twice the amount taken by another). For girls there seemed to be no change in energy intake with age. This fits rather well with the Dutch RDA. For boys there was an increase with age, which coincides with the recommendations of the FAO/WHO (1973) but not with the Dutch RDA. Girls increased their body fat by 5% but the daily energy expenditure of the girls remained fairly constant with age (Verschuur & Kemper, 1985). However, the energy expenditure per kg body-weight decreased for girls with age. It is not clear whether the girls with increased body fat were the same ones who decreased their energy expenditure or, possibly, that they underestimated their energy intake.

The protein intakes of the girls (70–75 g/mean weekday) and boys (80–85 g/weekday) are not dissimilar to, and lie about the mid-point of, those of the studies listed in Table 4, with the notable exception of the extremely high intakes of 125 g/d reported by Huenemann *et al.* (1974) for 16-year-old boys in the USA.

Since vegetable protein possesses a lower nutritive value than animal protein, relatively more is required. Thus we computed the total animal protein intake/kg body-weight of the 10% of the girls and boys with the lowest protein intakes. These girls and boys, 12–13 years old, showed an intake of about 1 g animal protein/kg body-weight per d, which is equal to the requirements for this age-group (de Wijn & Van Staveren, 1984). As they grew older,

Table 4. *Summary of the studies that were used to compare the present findings*

Source	Subject: Sex	Subject: Age (years)	Design	Method of food data collection	No. of measurements	Time of year	Available information: Wt	Ht	E	Ma	Mi	V	Remarks
Barber & Bull (1985)	♀	15–25	Cross-sectional	14 d diary	1	Spring Summer	—	—	×	×	×	×	
Chase Schorr *et al.* (1972)	♂+♀	12–17	Cross-sectional	3 d record	1	?	—	—	—	—	×	×	Only vitamin A + vitamin C
Durnin *et al.* (1974)	♂+♀	14·5	Cross-sectional	7 d weighed inventory	1	12 months	—	—	×	×	×	—	
Hackett *et al.* (1984)	♂+♀	11–12	Longitudinal	3 d record + interview	5	12 months	—	—	×	×	×	×	
Hegsted (1976)	♂+♀	12·5–15·5	Cross-sectional	24 h recall	1	12 months	×	×	×	—	—	—	Population with high socio-economic status
Huenemann *et al.* (1974)	♂+♀	16	Longitudinal	7 d record	4	12 months	×	×	×	×	×	×	
Van Schaik & Kenter (1972)	♂+♀	17	Cross-sectional	Dietary history	1	Sept–Nov, Feb–March	—	—	×	×	×	×	
Woodward (1984)	♂+♀	11–16	Cross-sectional	24 h record	1	?	—	—	×	×	×	×	Data in median values with explanatory variables
Kemper (1985)	♂+♀	12–18	Longitudinal	Dietary history	4	Jan–Apr	×	×	×	×	×	×	Present study

×, Available; Wt, weight; Ht, height; E, energy; Ma, macronutrients; Mi, minerals; V, vitamins.

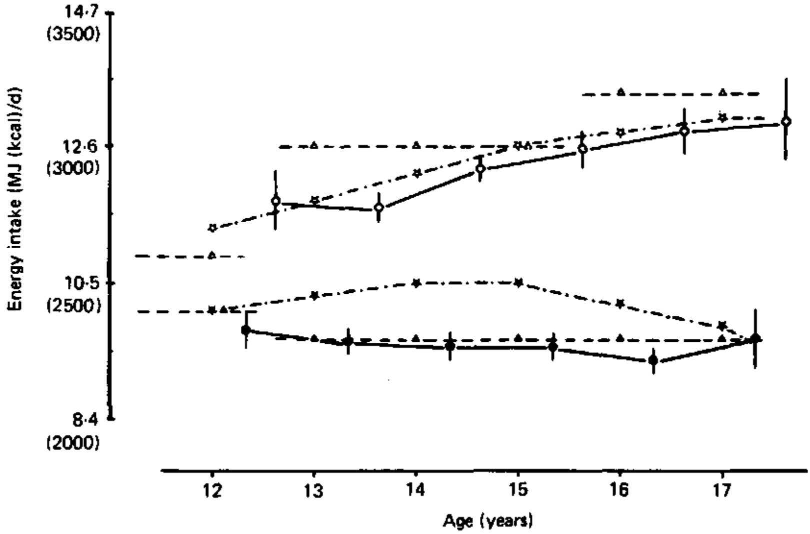

Fig. 12. Daily energy intake of girls (●, ▲, ★) and boys (○, △, ☆). *v.* calendar age. (△---△, ▲---▲), Dutch recommended dietary allowances; (☆-·-·-☆, ★-·-·-★), Food and Agriculture Organization/World Health Organization (1973) recommended dietary allowances. Points are means with their standard errors represented by vertical bars.

these amounts decreased steadily to about 0·5 g/kg for the 17–18 year olds, which is far below the recommendations. These lower animal protein intakes were not compensated by more vegetable protein.

In the control school (Purmerend), there was a generally higher intake of protein by girls as well as boys at all ages. This might be related to differences in the socio-economic background of the families between the two schools with possible influence on the eating habits. Durnin *et al.* (1974) found markedly lower protein intakes by boys in the lowest social classes.

The fat intake of the 16-year-old American girls studied by Huenemann *et al.* (1974) was 90 g/d and for boys 145 g/d. In a study of Scottish children, Durnin *et al.* (1974) reported a fat intake for 14-year-old girls of 93 g/d and for boys of 115 g/d. In an earlier Dutch survey (Van Schaik & Kenter, 1972), 17-year-old girls had a mean daily fat intake of 100 g and the boys of 145 g. The amounts of fat consumed by girls in the present study were higher than claimed in the American study but equal to those reported by Van Schaik & Kenter (1972). The fat intakes by boys were similar in all the studies. Our findings agreed also with those observed in a study on the fat consumption of the total population of The Netherlands (de Wijn & Van Staveren, 1984) and also with those of Durnin *et al.* (1974) in Scotland. High fat intakes are implicated in the aetiology of atherosclerosis which may be initiated in early childhood. There is a tendency for populations consuming high levels of fat to exhibit higher serum lipid levels. The high intake of cholesterol in the weekend days and the low intake of PUFA by the girls and boys indicates that more attention should be paid to dietary fat intake in this age group.

Over 20% of energy was supplied by sugar and this was also found by Hackett *et al.* (1984) for children of about 12 years of age. This percentage increases the possibility of development of dental caries but may also be associated with other health problems such as overweight and heart disease.

Van Vliet *et al.* (1982) describes, in another Dutch longitudinal group, high percentages of alcohol drinkers: 30% of 13-year-old girls and boys and 80% at the age of 18 years. Another Dutch study (Schuurman, 1983) reports the proportion of alcohol drinkers among 13 to 18-year-old schoolchildren as being 11% of the girls and 26% of the boys. There is no report of differences between age groups, but the percentages given are much lower than those in the present study.

In comparison with the record method used by Van Vliet *et al.* (1982) and Schuurman (1983), our interview method was conducted on an individual basis by an experienced nutritionist and this may give a more realistic impression of alcohol consumption. However, the moral and emotional significance of alcohol consumption is probably much higher than for most other nutritional items and this may give rise to some additional inaccuracies in reported consumption. Notwithstanding this reservation, it is interesting to note that girls and boys who reported consuming more than 10 g alcohol/weekday had significantly higher intakes of energy and most other nutrients compared with non-drinkers. This is in contrast to the assumption, which is sometimes made, that alcohol consumers have lower nutrient values in their diets compared with non-drinkers. Further, the distribution of alcohol consumption is such that 5% of boys reported consuming 30 g/weekday at age 16–17 years, rising to 50 g/weekday at 17–18 years. If these reported consumptions are accurate it is clear that there may be serious adverse effects on health. Even if they do include some element of exaggeration they still point to a perception of desirability and acceptability, at least amongst the immediate peer group, which should give cause for concern.

Allowing for the fact that adolescence is a period of rapid growth and Ca is needed mainly for bone growth, we can conclude that the intake of Ca in the groups was sufficient.

The Fe intake for the girls were on a somewhat higher level (about 2·0 mg/d) than in most studies (Chase Schorr *et al.* 1972; Van Schaik & Kenter, 1972; Huenemann *et al.* 1974; Hackett *et al.* 1980) but 0·5–1·5 mg/d lower than that in Tasmanian girls (Woodward, 1984) and comparable to the Fe intakes reported by Durnin *et al.* (1974). The boys had Fe intakes almost equal to those reported by Van Schaik & Kenter (1972), higher than the findings of Hackett *et al.* (1980) and Barber & Bull (1985), but lower than those in the other studies (about 2·0–4·0 mg/d). However, although the average for the girls and boys in the present study met the recommended levels of Fe intake, this conceals the fact that many children had much lower intakes than recommended. On the 25th percentile, for example, Fe intakes for girls and boys were only 60 and 70% respectively of the recommended levels. Barber & Bull (1985) also described an intake of 70% of the recommended Fe for 15–18-year-old girls. Our impression is that serious attention should be paid to the daily Fe intake of adolescents. However, this must take account of known mechanisms of adaptation to high and low intakes, and also distinguish between haem and non-haem compounds.

The mean retinol intakes of the girls, including the tendency to increase retinol intake with age, appear sufficient to achieve recommended levels. The difference in retinol intake between girls and boys can be explained by the total fat intake (boys about 30 g/d more than girls, mostly due to the extra butter and margarine intake).

The thiamin intakes in the present study were similar to those reported in the literature, except for American boys who have almost 0·5 mg higher thiamin intakes/d (Van Schaik & Kenter, 1972; Huenemann *et al.* 1974). The recommended values take into account the energy intake and are set at 0·4 mg/4·2 MJ. Considering the total energy intake of our adolescents, the needs for thiamin are met perfectly (girls 0·44 mg/4·2 MJ and boys 0·40 mg/4·2 MJ). Most carbohydrate-rich foods (polysaccharides) are also usually rich in thiamin, but when eating habits change to the use of more refined carbohydrates (in the present study these sometimes accounted for about 50% of the total carbohydrate intake) it may be possible that the thiamin intake will reach borderline values. Nevertheless, in our group of adolescents the mean intake was sufficient.

In the present study, girls had lower riboflavin intakes (0·4 mg) than American girls (Huenemann *et al.* 1974) but higher (0·4 mg) than other Dutch girls (Van Schaik & Kenter, 1972). For boys Huenemann *et al.* (1974) mentioned 1·2 mg higher riboflavin intakes than those in the present study, and Van Schaik & Kenter (1972) 0·4 mg higher. However, taking into account the protein intake or the energy intake, or both, the intakes of riboflavin in our study appear satisfactory.

The daily ascorbic acid intake in girls was higher (20–25 mg/d) than that reported in the literature (Chase Schorr *et al.* 1972; Van Schaik & Kenter, 1972; Huenemann *et al.* 1974) and more than 50 mg higher than in the longitudinal study of Hackett *et al.* (1984). For boys the intakes were almost similar, except for the children in the study by Hackett *et al.* (1984). These high intakes may be due to the Dutch habit of a dinner with vegetables and potatoes, besides which there is an abundance of fruit available.

Conclusions

It is necessary to take into account that the dietary intake measured by the cross-check dietary-history interview in teenagers shows possible testing effects, at least in boys, as a result of the repeated measurements.

The teenage girls had a constant energy intake as they grow older, with consistently higher intakes on a weekend day than on a schoolday. The total energy intake of boys increased gradually with age, on a mean schoolday as well as on a mean weekend day; in all age-groups there was a slightly higher intake on weekend days. In relation to the fat intake, special attention should be paid to the very high cholesterol intake during the weekends.

Another point of concern is alcohol consumption. Most of the consumption of alcoholic drinks was concentrated at the weekend and in such high quantities (especially in boys) that this might be seen as detrimental to health.

Overall, higher nutrient intakes could be seen on weekend days, and this was most evident for energy intake (protein, fat, carbohydrate and alcohol intake). In comparison with RDA we must conclude that the daily food intake of teenagers did not contribute enough PUFA and polysaccharides. The observed levels of intake of vitamins and mineral were sufficient. However, the Fe intake for girls was borderline.

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CHAPTER 5

Snacking Habits in Dutch Adolescents

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The longitudinal and multidisciplinary study "Growth and Health of Teenagers" was carried out in the Netherlands at two secondary schools. In this article the snacking habits of 131 girls and 102 boys of 12–17 years of age are reported as well as the nutrient values and the methods applied. For the whole age range about 20% of the total daily energy intake was supplied by snacks. Snacks provided 10% of the protein intake, 18–29% of the fat intake, 25–30% of the total carbohydrate intake and about 10% of calcium and iron intake. The consumption of alcoholic beverages increased strongly with age (5–65% "users," from 1 to about 15 g alcohol per "user") and is the most important source of "empty" energy.

Adolescence is a period in life when the intake of energy and nutrients would seem to influence the state of health of the developing child. Since it is often said that snacks, between-meal foods, provide the teenager with a substantial proportion of energy but little else in the way of nutrients, it is of great importance to be informed about the quality of the teenage diet. In the years 1976–1980 we carried out the multiple longitudinal study "Growth and Health of Teenagers" (Kemper et al., 1985, 1983). This investigation was designed to describe the course of the physical and mental development of teenagers, and to find out whether there is a period of deterioration in their state of health. In order to account for

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changes in development, measurements were also taken of the style of living, especially as regards normal daily diet and habitual physical activity. In this article the results of measurements of the daily diet, in particular of the snacks, will be reported.

SUBJECTS

The study "Growth and Health of Teenagers" was carried out at two secondary schools in the Netherlands. Therefore the group of pupils studied may not be considered as representative of the teenager population of the Netherlands. The pupils of this type of schools have a level of intelligence above the average for their age. The parents of our subjects had a higher level of education, occupation, and income than found in an average Dutch family. We started this study in 1976 with the pupils of the first and second forms of both schools. These pupils had an average age of 13 (first form) and 14 (second form). The pupils of one school (Pius X Lyceum, Amsterdam) our so called *longitudinal group* were measured yearly in four successive years. Because our sample consisted of two groups of subjects with a lag in age of one year, we could check for two possible interfering effects. Time of measurement effect and cohort effect actually always present problems in longitudinal research (Kemper and Van 't Hof, 1978).

Of the second school (Ignatius College, Purmerend) each year another 25% of a comparable group of pupils was examined, the so called *control groups*. Comparing the results of our longitudinal group with the results of the control group, we were able to trace the possible interfering effect caused by repeated measurements on the same subject.

During the years of the study there were 24% drop-outs. Most of them (68 pupils) moved to a different type of school or out of the area. Only six pupils refused to continue participation. Finally our longitudinal group consisted of 131 girls and 102 boys. The observations of the 4-year study were grouped at calendar age. In this way a developmental pattern over 6 years was covered (from 12 to 17 years), with most observations at the ages of 14 and 15.

METHODS OF SAMPLING FOOD DATA

To avoid interference of seasonal variations, our measurements took place in the same months every year (January, February, and March). A modification of the cross-check dietary history interview (Beal, 1967; Marr, 1971; Post & Kemper, 1980) was used to ascertain the individual food intake of the teenagers. It lists a series of items, covering the entire range of foods and drinks, making allowance for teenagers. In an inter-

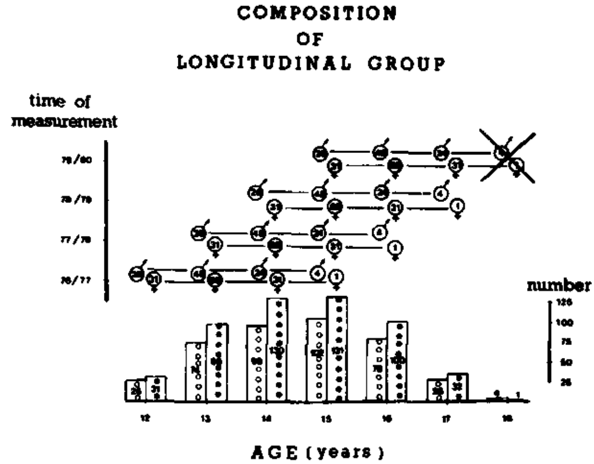

Figure 1. The composition of the age groups in our longitudinal study. The upper part shows the girls and boys per study year. The lower part shows the number of girls and boys per age group.

view with a nutritionist (the same throughout the study) all foods usually consumed came under review with special reference to frequency and amounts. Data on foods eaten during regular meals as well as between meals (so called "snacks") were collected, separately for normal schooldays and for weekend days. The next step was to make inquiries about each food item. The subject was instructed to indicate the specified number of times per day, week, or month he/she consumed the foods. Only the food items eaten at least twice a month were recorded. The amounts were reported in household measures and dimensions. Food models were used to illustrate common portion sizes such as glasses, bowls, spoons, and also polythene imitations of potatoes, apples, and other fruit.

Since it was assumed that teenagers do not know everything about their food consumption and the way of preparation, we also developed a questionnaire for the parents about details of several food items consumed by their children, e.g. skimmed or whole milk, kind and quantities of meat, addition of butter or sauce to vegetables and potatoes.

For each individual all amounts were converted into grams for the five schooldays and the two weekend days.

The schoolchildren in this study do not have a fixed pattern of meals. In the Netherlands hot lunches are not served at school. Most of the pupils take sandwiches with them for lunch and have a hot meal at home in the afternoon. It is difficult to give a precise definition of snacks. We decided to reckon food items among the snacks when they belong to one of the following food-groups and were eaten between meals:

Table 1. Mean and standard error of height, weight and body fat over calendar age for girls and boys from the longitudinal group.

Age	12	13	14	15	16	17
			Girls			
Number	31	98	129	130	99	32
Height, cm	154.7	160.5	164.8	167.2	168.5	168.3
st. er.	1.1	0.7	0.6	0.6	0.7	1.3
Body weight, kg	42.2	48.0	52.0	54.9	57.4	57.9
st. er.	1.3	0.9	0.8	0.8	0.9	1.2
Body fat, %	22.8	24.5	25.6	26.6	27.4	28.1
st. er.	0.9	0.5	0.4	0.4	0.5	0.6
			Boys			
Number	26	73	95	102	76	28
Height, cm	151.3	158.8	165.3	172.6	178.2	180.7
st. er.	1.4	0.8	0.8	0.7	0.7	0.8
Body weight, kg	38.4	43.4	48.9	55.6	61.0	63.8
st. er.	0.9	0.7	0.8	0.8	0.9	1.8
Body fat, %	15.1	16.0	16.2	16.0	16.3	17.0
st. er.	0.7	0.5	0.4	0.4	0.4	1.0

Sweets, such as candybars, chocolates, gums, cakes, cookies, biscuits, sweet rolls, etc.
Soft drinks, lemonade, fruit juice, alcoholic beverages, etc.
Snackbar items, such as French fried potatoes, dressed rolls, ice cream.

All these dietary data were coded and stored in the computer. The code numbers of the food items were based on the food-composition table of the Uniform Coding Committee (U.C.V.) (Cramwinckel, Doesburg, Hezemans, Lemmens, & Reintjes 1977).

The same table was used to calculate the nutrient composition and energy value of the diet of each individual (Nie, Dadlai, Hull, Jenkins, Steinbrenner, & Bent, 1975). The following food characteristics were calculated and will be discussed: energy, protein, fat, carbohydrate, alcohol, minerals and vitamins. Energy and nutrient value per mean weekday is calculated by:

$$\frac{5 \times \text{schoolday} + 2 \times \text{weekend day}}{7}$$

RESULTS

In Table 1 some anthropometric details of our longitudinal group are summarized.

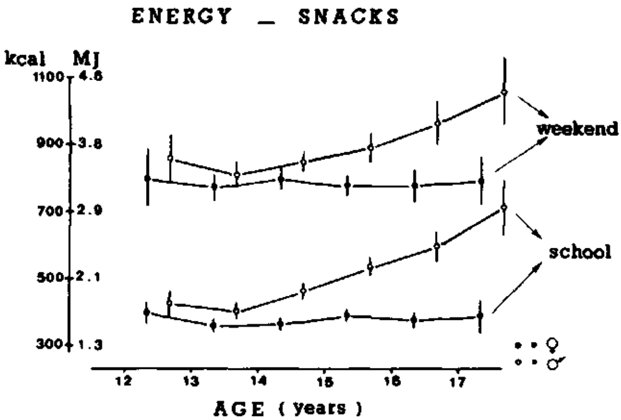

Figure 2. Mean and standard error of the energy intake (Kcal/mJ) with snacks by girls and boys for schooldays and weekend days.

Energy

Mean and standard error of energy intake through snacks are shown in Figure 2. Snacks contributed 1.6 mJ (circa 380 kcal) on a schoolday and 3.3 mJ (circa 790 kcal) on a weekend day to the total energy intake of the girls in the whole age range. The snacks consumed by 12 to 14 year old boys supply 1.7 mJ (circa 410 kcal) on a schoolday, increasing to 3.0 mJ (circa 720 kcal) for the older age groups. On a weekend day the energy intake through snacks was 3.5 mJ (circa 840 kcal) for the 12–14 year old boys, and increased with age to 4.4 mJ (circa 1060 kcal).

A mean percentage of 20–22 was contributed by snacks to the daily energy intake of girls as well as boys (see Tables 2 and 3). Only for the boys of 17/18 years was the percentage higher (circa 5).

The total energy intake through snacks on schooldays was about 18% for girls and 16 to 24% for boys. On the weekend days these percentages were 31 for girls, and 28% to 33% for boys. There seems to be a school effect for boys on schooldays. The group of boys of the control school (Ignatius College) had systematically lower scores in the intake of energy. This school effect for boys on schooldays is illustrated in Figure 3.

We found almost the same development for girls and boys, though somewhat more pronounced for boys.

Protein

The total daily protein intake as well as the protein intake through snacks for girls and boys is shown in Figure 4. The snacks consumed by 12–18 year old girls on a schoolday had a protein content of 6 g (9% of the total daily intake) and on a weekend day 15 g (18% of the total intake),

Table 2. Percentages contributed by snacks to the total intake of nutrients per mean weekday (schoolday/weekend day) for girls, 12–17 years old.

Day	Age	Energy	Protein	Fat	Carbohydrate	Total Iron	Retinol	Thiamine	Riboflavin	Pyridoxine	Ascorbic Acid
mean weekday	12	22	12	20	26	11	12	10	6	5	4
schoolday		18	9	14	23						
weekend day		31	17	32	34						
mean weekday	13	21	11	19	25	12	10	12	6	5	18
schoolday		17	8	14	21						
weekend day		30	17	31	32						
mean weekday	14	22	12	20	25	12	10	12	8	5	15
schoolday		17	9	14	22						
weekend day		31	19	32	32						
mean weekday	15	22	13	21	26	14	10	12	8	5	16
schoolday		18	9	15	23						
weekend day		32	19	32	34						
mean weekday	16	22	12	20	26	14	10	13	9	5	20
schoolday		18	9	14	23						
weekend day		33	20	32	35						
mean weekday	17	22	12	18	26	11	8	13	8	4	24
schoolday		17	9	13	22						
weekend day		31	18	28	33						

Table 3. Percentages contributed by snacks to the total intake of nutrients per mean weekday (schoolday/weekend day) for boys, 12–17 years old.

Day	Age	Energy	Protein	Fat	Carbohydrate	Total Iron	Retinol	Thiamine	Riboflavin	Pyridoxine	Ascorbic Acid
mean weekday	12	20	10	16	25	11	6	10	6	4	13
schoolday		16	8	11	22						
weekend day		28	16	27	32						
mean weekday	13	19	10	16	23	11	7	9	6	4	9
schoolday		15	7	12	20						
weekend day		27	16	27	30						
mean weekday	14	20	10	17	24	12	7	10	6	4	9
schoolday		16	8	13	22						
weekend day		28	16	26	32						
mean weekday	15	21	12	18	26	12	8	11	8	4	7
schoolday		18	9	14	23						
weekend day		29	17	27	31						
mean weekday	16	23	12	19	27	14	9	12	10	5	7
schoolday		20	10	15	25						
weekend day		30	17	27	32						
mean weekday	17	26	14	22	29	14	7	15	9	6	16
schoolday		24	12	19	27						
weekend day		32	18	28	34						

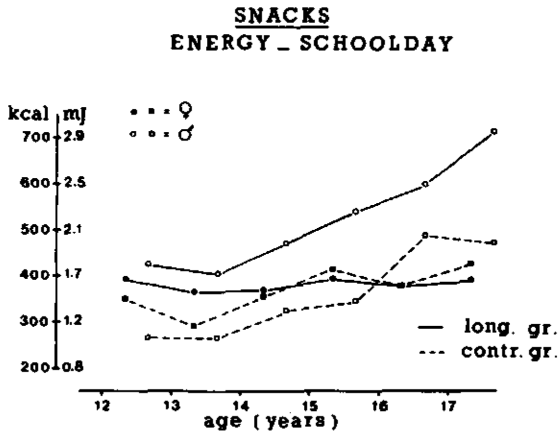

Figure 3. The energy intake with snacks per schoolday by girls and boys of the longitudinal groups and the control groups.

see Table 2. For boys of 12 to 15 years of age the protein intake through snacks on a schoolday was the same as that of the girls, i.e. 6 g (6% of the daily intake), see Table 3. At the age of 17/18 boys consumed 10 g protein (12%) through snacks per schoolday. On a weekend day the intake for boys of all age groups increased to 15 g protein (17% of the total intake).

On an average weekday girls as well as boys consumed 12% of their total daily protein intake with snacks.

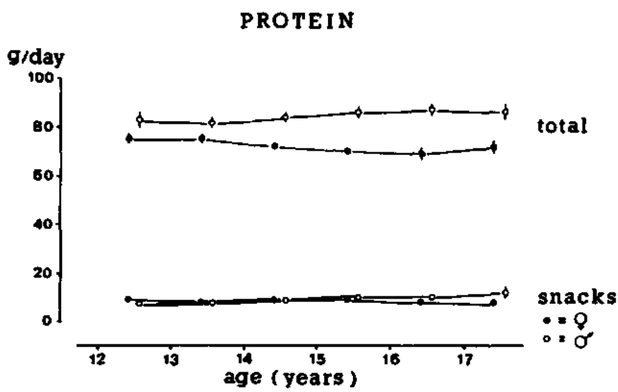

Figure 4. The total daily protein intake as well as the protein intake by snacks in mean (gram) and standard error, for girls and boys by age.

FAT

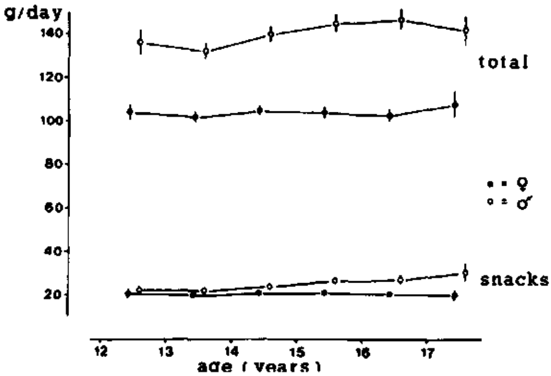

Figure 5. The development of the total fat intake as well as the fat intake with snacks per mean weekday, in mean (gram) and standard error for girls and boys.

FAT

Figure 5 shows the mean and standard error of the total fat intake and the amount contributed by snacks. The mean fat intake through snacks for girls on a schoolday was about 15 g, i.e. circa 14% of the total daily fat intake (see Table 2). On a weekend day the snacks provide for about 35 g fat, 31% of the total intake. There was no change with age. The boys' intake increased with age (see Table 3). On a schoolday 12/13 year old boys consumed snacks containing 15 g fat (11% of the total fat intake), for 17/18 year old boys the amount was about 25 g (19%). On a weekend day the snacks provide for about 40 g, 27% of the total fat intake. This percentage did not change with age.

The intake of polyunsaturated fatty acids (PUFA) through snacks was, for the girls of all age groups, about 3 g per mean weekday, 20% of their total daily intake. For boys PUFA provided by snacks increased slightly with their age from 3 to 5 g per mean weekday, about 17% of the total intake. For girls the contribution of PUFA on a weekend day was more than twice the amount of a schoolday (14% versus 30%). Snacks were responsible for the small differences in total daily PUFA intake between schooldays and weekend days.

The cholesterol intake through snacks was, for girls of all age groups, about 12% (30–35 mg) of their total daily intake (mean weekday). On weekend days the amount of cholesterol through snacks more than doubled, compared with the intake on schooldays (20 mg versus 55–75 mg). For boys snacks provided 8–12% (30–40 mg) of their daily (mean weekday) cholesterol intake, increasing with age. Also for boys, the cholesterol content of the snacks on weekend days was more than twice as high

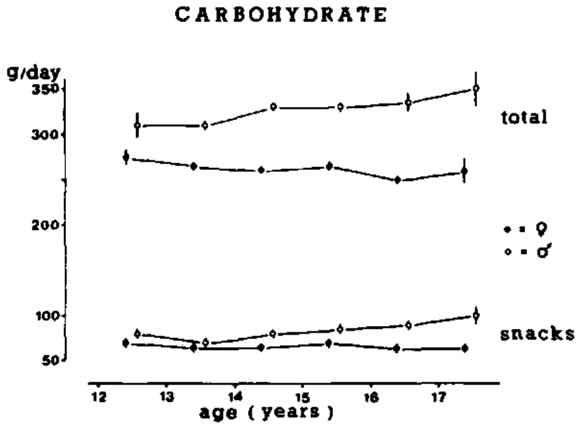

Figure 6. The total daily carbohydrate intake as well as the carbohydrate intake with snacks, in mean (gram) and standard error, for girls and boys.

as on schooldays (50–60 mg versus 15–30 mg). However, these increases in total cholesterol through snacks during weekend days was not the main source. The regular meals in the weekend contributed an extra amount of about 100 mg cholesterol.

Carbohydrate

For girls, the snacks provided 55–60 g (circa 20%) of the total carbohydrate on a schoolday (see Table 2). On a weekend day the amount was 95–100 g, which is circa 33% of the total carbohydrate intake. There was no change with age. On a schoolday boys of the age of 12–14 years consumed snacks containing 60–70 g carbohydrate, which is 20–22% of the total daily intake (Table 3). This amount increased to 27% for boys of 17/18 years of age. Also on the weekend days the intake of carbohydrate through snacks increased with age for boys to 100–120 g per day. The percentage of the total carbohydrate increased from 30 to 34%. Figure 6 illustrates the mean daily carbohydrate intake and the amount provided by snacks for girls and boys. Almost two-thirds of the total amount of carbohydrates out of snacks consisted of mono- and disaccharides, for girls as well as for boys, on schooldays as well as on weekend days.

Alcohol

Because not all teenagers consumed alcoholic beverages, the alcohol intake is only given as an average for the girls and boys that used alcohol. In the age group 12/13 boys as well as girls used alcoholic beverages only in the weekend, resulting in an alcohol consumption for girls of about 1

Table 4. Pupils consuming alcoholic beverages as percentages of the longitudinal group by age, for schooldays and weekend days.

Age (years)	Girls Schoolday	Girls Weekend Day	Boys Schoolday	Boys Weekend Day
12/13	—	6	—	4
13/14	4	9	6	15
14/15	7	22	7	16
15/16	14	33	19	28
16/17	16	44	42	51
17/18	41	62	50	68

g per day, and for boys of about 5 g per day (see Tables 4 and 5). The percentage of alcohol consumers increased with age, but remained different for schooldays and weekend days.

The percentage of girls consuming alcohol on schooldays increased from none at age 12/13 to about 40% at age 17/18. On weekend days the increase was even stronger: from 6% at age 12/13 to 62% at age 17/18. Not only did the percentage of drinkers increase, but also the amount of alcohol consumed: on schooldays from 1 g (13/14 years) to 4 g a day and on weekend days from 1 to 11 g per drinker per day.

The percentage of boys consuming alcohol on schooldays increased from none at age 12/13 to 50% at age 17/18, and on weekend days from 4% to 68%. The amount of alcohol increased from 1 to 17 g per schoolday and from 5 to 29 g per weekend day. In general, both boys and girls increasingly consumed light alcoholic drinks (such as beer and wine).

Minerals

Snacks provided about 100 mg *calcium* on a mean weekday, for both girls and boys and all age groups. This is about 10% of the total daily calcium intake. The *iron* intake through snacks was about 1.3 mg per mean weekday for the girls in all age groups. The heme iron content decreased for girls with age (from 0.15 to 0.07 mg) caused by a lower consumption

Table 5. Mean and standard error (in parenthesis) of alcohol intake (in grams) for girls and boys by age, for a mean schoolday and a mean weekend day.

Age (years)	Girls Schoolday	Girls Weekend Day	Boys Schoolday	Boys Weekend Day
12/13	— (—)	1 (1.0)	— (—)	5 (—)
13/14	1 (0.3)	6 (1.4)	1 (0.3)	4 (0.9)
14/15	2 (0.6)	5 (1.0)	2 (0.6)	6 (1.2)
15/16	3 (0.8)	6 (1.0)	8 (3.7)	15 (3.4)
16/17	3 (1.0)	10 (1.4)	12 (2.6)	27 (4.2)
17/18	4 (0.5)	11 (1.7)	17 (6.0)	29 (5.8)

of meat products in the form of snacks. For boys snacks contributed 1.3 mg to the total iron intake per weekday for 12/13 year olds, increasing to 1.8 mg for 17/18 year old boys. The heme iron intake from snacks fluctuates around 0.15 mg for boys through the different age groups. Therefore, the nonheme iron content of snacks was responsible for the total increase. For both girls and boys snacks provided between 11–14% of the total daily iron intake (Tables 2 and 3).

Vitamins

Tables 2 and 3 show the different kinds of vitamins and the percentages supplied by snacks. For girls of all ages about 10% of the daily *retinol* intake (0.8 mg/day) was provided by snacks. For boys this percentage was 7 (±1.1 mg/day) with only small changes with age. Ten percent of the daily *thiamine* intake (1.0–1.2 mg/day) was supplied by snacks for girls as well as for boys. This percentage tends to increase with age to 13 for girls and 15 for boys. Per mean weekday, 6 to 10% of the total *riboflavin* intake (1.3–1.7 mg/day) was provided by snacks for girls and boys, increasing with age. About 5% of the daily *pyridoxine* intake (1.2–1.4 mg/day) was contributed by snacks for girls as well as for boys, of all age groups. There was a remarkable difference in the *ascorbic acid* intake through snacks between girls and boys. For girls of 12/13 years 15% of the daily ascorbic acid intake (100–115 mg/day) was provided by snacks. This percentage increased to 24 for 17/18 year old girls. Boys of 12/13 years consumed 13% of the daily ascorbic acid intake (90–110 mg/day) through snacks. This percentage decreased to 7 for 15–17 year old boys, and increased again to 16% for the oldest boys, 17/18 years. The increase is caused by the higher consumption of fruit juices (Table 5). The quantity of fruit juices drunk by the older age group of the girls is double the amount consumed by the youngest girls. (Normal fruit was not included in the snacks in our study; see methods.)

DISCUSSION

The quality of the food consumed by teenagers is more or less influenced by the consumption of snacks. Snacks do provide a substantial proportion of the daily intake of energy and of some nutrients.

In our longitudinal study we found a school effect only for boys. An explanation may be that the longitudinal group had more opportunity to buy snacks in the vicinity of the school (in the breaks there was a mobile snackbar outside the school). This assumption is based on the fact that we found this effect only on schooldays. Experience taught us that in comparison with boys, girls are more interested in questions like "What are healthy foods?" and might therefore pay more attention to what they

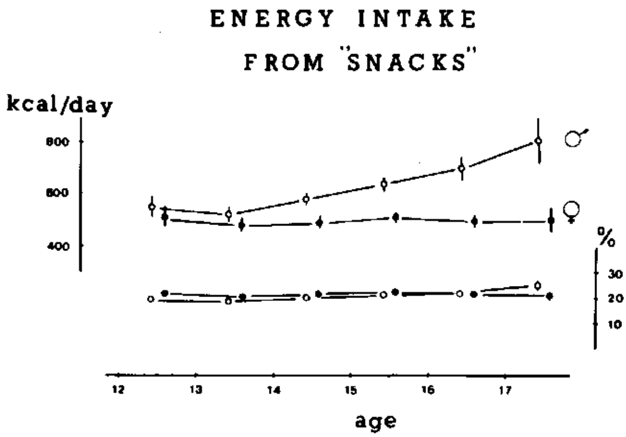

Figure 7. The daily energy intake by snacks and its percentage of the total daily energy for girls and boys by age, in mean and standard error.

eat. It is also possible that girls tend to produce answers likely to be appreciated. In our group of adolescent girls and boys snacks supplied about one-fifth of the total daily energy intake (Fig. 7). A study by Verdonk, Notte-de Ruyter and Huyghebaert-Schoolmeester (1982) showed that Belgian adolescents (13–19 years old) obtain circa 22% of the total daily energy intake from between-meal foods. American teenagers (Thomas and Call, 1973) consumed between-meal foods in an amount that also provided 22% of their daily energy intake. The adolescents in different countries seem to have about the same habits in this respect. However, there may be an effect caused by time of measurement. The survey among the American teenagers (Ten-State Nutrition survey, Schwerin et al., 1981) took place from 1968 to 1970, the Belgian survey in 1978 and our survey from 1976 to 1980. It is possible that between 1970 and 1980 the total snack consumption in the Netherlands (and/or in Europe) changed in the direction of the food habits described for American teenagers.

Although snacks are not eaten because they are an important source of protein, we still see that in our study 10% of the total daily protein intake was supplied by snacks (Fig. 4). This percentage fits in rather well with the Belgian study (10% of the daily protein intake) and also with the American adolescent girls (11%). Only the American boys consumed snacks with a higher protein content (15% of the daily intake). In our study the protein quality was mostly defined by vegetable protein. A double or even higher intake of vegetable protein compared with animal protein was found for girls as well as for boys.

It is often stated that snacks are the main source of fat. A high fat content of the diet, particularly a high content of saturated fat (SF) and cholesterol, is regarded a risk factor in the development of cardiovascular diseases (CVD), whereas the consumption of PUFA is often considered to reduce this risk (Brussaard, Katan and Knuiman, 1982; Voedingsraad, 1982). In our study we see that about 18–20% of the daily fat intake was provided by snacks (fig. 5). Snacks also contributed

PUFA in 20% of the total daily intake. However, the total daily PUFA intake was rather low for teenagers (15–20 g/day).
Cholesterol in about 10–12% of the total daily intake. The total daily cholesterol intake of girls was actually too high (circa 275–300 mg/day) and was markedly too high for boys (circa 300–360 mg/day).

The fat consumed through "snacks" has the same proportion SF and PUFA as through meals, so we could not endorse the negative statement concerning the high fat content of snacks.

The fat intake of Belgian teenagers from between-meal foods also amounted to about 18%.

Considering the mono- and disaccharides contents, snacks provide 15–20% more "empty" energy, compared to meal items. In this connection we have to take into account that tea and coffee, mostly used with sugar (in the Netherlands often between-meals, but in this study not separated from meals, see methods) were not reckoned as snacks. Therefore, the percentage "empty" energy will be higher.

The most amazing amount of "empty" energy was contributed by alcoholic beverages. In the first year of the study we saw that about 5% of our teenagers had some drinks with alcohol only in the weekend (Table 5). In the fourth year of the study this percentage was 45 for schooldays and about 65 for weekend days. The percentage of drinkers among girls and boys increased drastically with age, although for boys somewhat stronger than for girls. Also the amount of the total daily alcohol consumed increased remarkably with age, for both girls and boys, only the intake of boys between 16 and 18 was three to four times as high as that of girls, per schoolday and per weekend day (see Table 5). Another study in The Netherlands reported higher percentages of alcohol drinkers. Van Vliet, Hofman, Muller, & Valkenburg (1982) found in a longitudinal study that 30% of 13 year old girls and boys and 80% at the age of 18 consumed alcohol. Schuurman (1983) described alcohol users among 13–18 year old schoolchildren: 11% of the girls and 26% of the boys. There was no report of the difference between the age groups, but these percentages are much lower than those found in our study. Special attention should be paid to the group of alcohol consumers. A mean alcohol consumption of 17 g per schoolday and 29 g per weekend day for 17/18 year old boys means that some of them must have an extraordinarily high intake. This may adversely affect health conditions, concerning social behaviour, diseases of the liver and danger in traffic.

Although snacks do contribute to the intake of protein (10%), minerals (circa 10%) and different vitamins (circa 5–25%), the proportion of these nutrients was lower than in the daily meals.

CONCLUSION

In conclusion, considering that with snacks "empty" energy food items are consumed, it still seems that snacks contribute relatively well to the nutrient intake of adolescent girls and boys. However, the distribution of protein, iron and some vitamins in snacks is lower than in meals. Since 20% of the total daily energy is supplied by snacks, there is no deficiency in the intake of nutrients. Consumption of higher amounts of snacks, however, is not advisable because the nutrient density is lower compared to the daily food consumption.

Special attention should be paid helping the teenager limit the consumption of alcoholic beverages, considering the fact that drinking habits increase with age and will have consequences for the future.

The research "Growth and Health of Teenagers" was carried out by the following project-team: C. van der Bom, P.J. Dekker, H.C.G. Kemper, M.G. Ootjers, G.B. Post, J.W. Ritmeester, H. Schalekamp, J. Snel, P.G. Splinter, L. Storm-van Essen, and R. Verschuur. This research was supported by grants from the Dutch Prevention Fund (project number 28-189a), The Foundation for Education Research (SVO, project number 0255), and the Dutch Heart Fund (project number 76.051–79.051).

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CHAPTER 6

Food Intake of Teenagers in Comparison with a Dutch Nutrition Education Programme

Introduction

Food and eating patterns are partly depending on the national food production and availability. In a Western society, such as the Netherlands, food products from all over the world are available, and within the economical range of most of the people. Nevertheless traditional food habits seem to have strong roots and are often difficult to change.

Health authorities, such as the Dutch Food and Nutrition Board, have formulated guidelines for the daily nutrient intakes, judged to be adequate for the maintenance of good nutrition in the population of the Netherlands (1). They are intended to serve as goals for planning food supplies, for public health nutrition programmes. There are many steps between these population directed programmes and guidelines and the food selection and consumption of the individual.

In promoting a desirable food intake to the general public there is the question of finding effective methods for mediating information. Also, what the contents of nutrition-education should be or how it should be put in practice, must be given much thought. In addition it has to be realized that much agencies and organizations are promoting and selling certain dietary practices not purely from a health point of view, and this gives a lot of tension in the field of nutrition education.

In the past, education programmes were based on undernutrition. In the Netherlands the food guide based on five food groups 'Basic Five' (Dutch: De Schijf van Vijf) are out of date for nutrition education of the public, because they were only based on nutrient deficiences, and not suitable to meet current nutritional problems like too much fat and

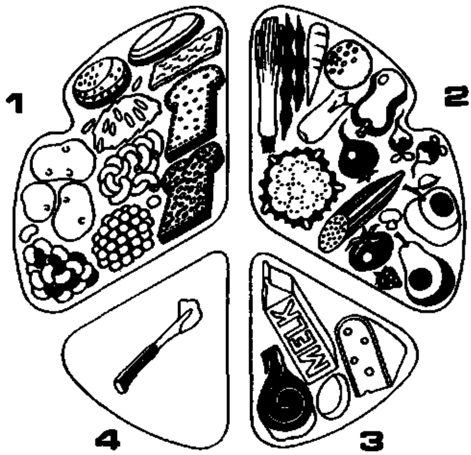

Figure 6.1.: The meal-planning-disk.

Table 6.1.: The four segments of the meal-planning-disk with the conditions for food items to be placed in, the main groups of food products and the main important nutrients (4).

SEGMENT	*CONDITIONS*	*FOOD PRODUCTS*	*NUTRIENTS*
1	≥40 energy % of poly-saccharides	potatoes, rice, bread, cereals, pulses	polysaccharide, dietary fibre, vegetable protein, B-vitamins, minerals
2	≥20 mg vit.C per 4.2 MJ	vegetables, fruit	vitamine C, dietary fibre, minerals
3	≥10 energy % protein	milk,milkproducts, meat,meatproducts fish,poultry,egg	animal protein,fat B-vitamins, minerals
4	vitamin A, vitamin D	butter,(low fat) margarines, some frying fat	vitamin A, linoleic acid

its relation with atherosclerosis (2). In succession to the 'basic five', new promotional material was prepared and published in 1980 to meet the new goal of guidelines to healthy food, and is called the 'Meal-planning-disk' (Dutch: De Maaltijdschijf) (3,4). The pamphlet intends to promote better eating patterns by planning a good meal with different food products, and at the same time provides the basis of the recommended daily nutrient intake.

Allthough the meal-planning-disk hss been intended for the general public, and not specifically for teenagers, the data gathered on food consumption of teenagers, from the study 'Growth and Health of Teenagers', offer a good opportunity to compare their eating habits with the principles of the recommended intake of food products, as advised by the meal-planning-disk (5,6).

It will be important to find out to what extent recommended food items are consumed by adolescents and which food products are most important to account for the nutrients present in the food items.

The intention of this chapter is not to evaluate if the meal-planning-disk is a good nutrition education model, but to describe the quality and the quantity of the teenager's nutrition in relation to the levels promoted by the meal-planning-disk.

The practical implications of the comparisons between the food intake of the adolescents and the guidelines of the meal-planning-disk are:

a. to show a relevant basis on which the terms of the meal planning can be stated,
b. to give information on which nutrition education at schools can be founded.

Methods

The principles of the meal-planning-disk

The meal-planning-disk is divided into four segments (Figure 6.1.). In each segment food items, having similar nutrient composition, are grouped together (4). In Table 6.1. these nutrient conditions are stipulated, as well as some of the main food products which belong to

Table 6.2.: Conditions for food products in the four segments of the meal-planning-disk as first or second priority (4).

SEG-MENT	*CONDITIONS FOR first PRIORITY*	*FOOD PRODUCTS OF first PRIORITY*	*FOOD PRODUCTS OF second PRIORITY*
1	no added sugar, ≥14 g dietary fibre per 4.2 MJ	whole meal bread, rye bread, whole grain rice, whole grain macaroni pulses	white bread, currant bread,Dutch rusk, polished rice, macaroni
2	no added sugar, ≥14 g dietary fibre per 4.2 MJ	fresh, tinned- and frozen vegetables as well as fruit	apple sauce,sweet-and-sour products, fruit-sirup, fruit juices
3	no added sugar more protein than fat	skim-,low-fat milk/ -products, low-fat meat, -fish, eggs, low-fat cheese	whole milk/-products (evt.with sugar), rich meat and fish, rich cheese
4	fat,≥1/3 linoleic acid	diet margarines,low-fat margarines, frying fat rich of linoleic acid	butter, other margarines

Table 6.3.: The recommendations for the daily serving sizes of food products for the age range 12 to 20 years, of both sexes (4).

FOOD GROUP	*AMOUNT (age 12 - 20 year)*		*GRAMS/ML*
bread	8 slices		240
potatoes;	6 pieces		450
or pulses			150 (dry)
or rice			75 (dry)
or macaroni			75 (dry)
vegetables;			
leafy green (purchased)		400	250 (mean)
or cooked		275	
or other (purchased)		275	
or cooked		230	
salads		100	
fruit			150
milk	4 glasses		500 ml
cheese	1 slice		15
meat/fish/chicken			50
meat products	3 slices		45
egg	2 or 3 / week		20
low fat margarine			40
margarine			15

that particular segment. It is recommended that in planning a good meal, it is necessary to have food items from all four segments.
Another object of the meal-planning-disk is the prevention of diseases of Western civilization, such as coronary heart diseases and obesity. Therefore, in each segment, some food items are preferable to others in the same segment. These are indicated as food products of the first and second priority. These nutrient conditions and some of the particular food items are summarized in Table 6.2..

In taking all these conditions together, there remain, of course, food products which cannot be classified according to one of the four segments. These products are grouped together in a so-called 'restgroup', with no standard of priority. The brochure states, that these food items are not important for planning a good meal, but may function as a so called 'decoration' of the meal, as well as 'snacks' between meals.

The recommended serving sizes of food products

The meal-planning-disk not only gives guidelines to prepare healthy meals, but also recommends a daily food supply of food products for groups of a given age and sex, containing all the nutrients necessary for normal growth and health. These recommendations are indicated as mean values for the different categories. In Table 6.3. all the food groups are summarized, together with the recommended portions (in grams or milliliters) for the age group 12 - 20 years (4). In these recommendations no difference is made between girls and boys.
In the calculations the recommended amount (grams or milliliters) of each food group is put at 100 percent, the substitutes included.
Each subject's dietary intake is analysed to provide the foods and nutrients consumed from each food group.

Measurement of the food consumption

The food consumption was estimated from a dietary history in the first four months of the year, by the same dietician (see Chapter 2 and 3).

Table 6.4.: The total number and age range of teenagers measured in four years of the study.

YEAR OF MEASUREMENT	*GIRLS*	*BOYS*	*AGE year*	*(range)*
1977	206	187	13	(12-14)
1978	176	146	14	(13-15)
1979	172	152	15	(14-16)
1980	173	139	16	(15-17)

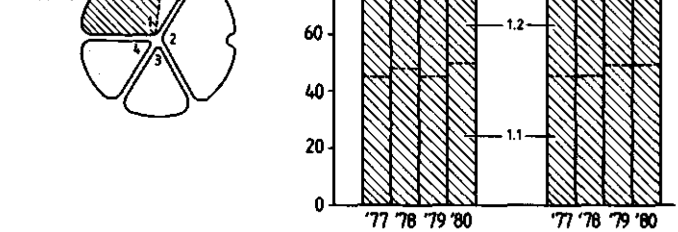

Figure 6.2.: The daily intake of polysaccharides of girls and boys during the four years of measurement is given: (a) in absolute values on top, and (b) in percentages over the segments of the meal-planning-disk. The percentages are divided in first priority (1.1) and second priority (1.2) for segment 1.(2 = segment 2, 3 = segment 3, and R = restgroup.) The overall mean percentage is indicated in the meal-planning-disk.

Subjects

In order to get the largest possible number of girls and boys in the different age groups, the food consumption data of all the participants in the study 'Growth and Health of Teenagers' are included in this analysis: pupils of the longitudinal group as well as the pupils of the control group (8). In Table 6.4. the number of girls and boys involved in this part of the study is given over the four years of measurement. Altogether more than 1350 interviews were analysed for this purpose from 1977 to 1980. The mean ages vary from 13 to 16 over these years.
In each year of measurement the consumption of the food groups is determined separately for girls and boys in relation to the standards, as shown in Table 6.3..

Treatment of the data

To evaluate diets in terms of foods all the food items consumed by the teenagers are listed. The nutrient analysis data base is modified to include the meal-planning-disk foodlist and rating system (7). All food items are classified to one of the four segments, or to the 'restgroup'. At last the items are arranged in the first or second priority group.

Results

1. Food products relevant for the nutrient intake

The contribution of the food products to the total nutrient intake is expressed in percentages of each of the segments.

Segment 1

The intake of polysaccharides is supplied for 80 % by the food products of segment 1 (Figure 6.2.). This is irrespective of age and sex. The most important source of these polysaccharides appears to be the whole meal bread group in the teenager's consumption with more than 30 percent, food products of the first priority (see Figure 6.3.). Potatoes are of secondary importance, and white bread comes in the third place. The contribution of the whole meal bread group increases with age,

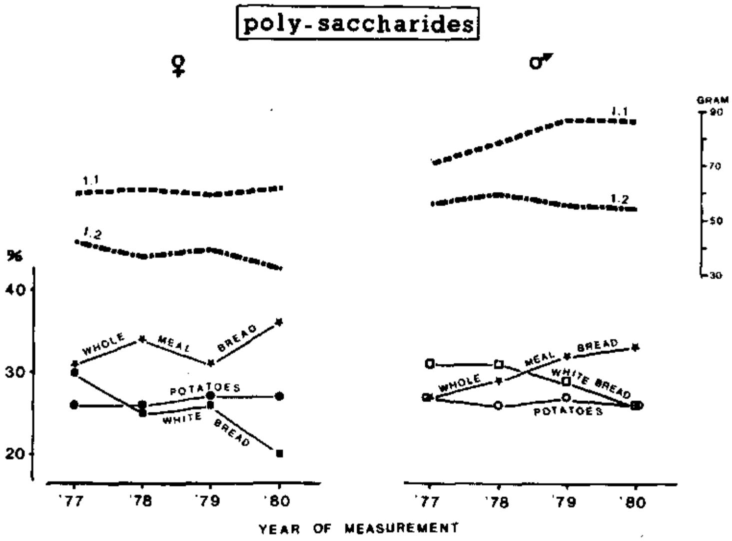

Figure 6.3.: The total contribution of poly-saccharides by food products of segment 1, with first priority (1.1) and second priority (1.2), is given in grams, for girls and boys during the four years of measurement (upper part). The main food products important for this intake are given in percentages (lower part).

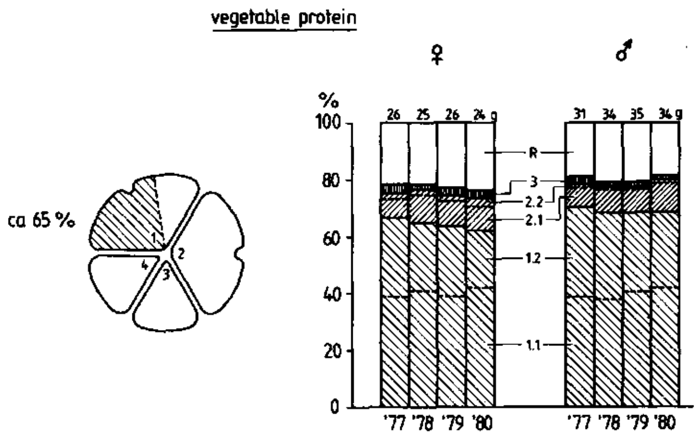

Figure 6.4.: The daily intake of vegetable protein of girls and boys during the four years of measurement is given: (a) in absolute values on top, and (b) in percentages over the segments of the meal-planning-disk. The percentages are divided in first priority (1.1) and second priority (1.2) for segment 1, and for segment 2 (2.1 and 2.2). 3 = segment 3, R = restgroup. The overall mean percentage is indicated in the meal-planning-disk.

whereas the consumption of white bread products decreases, for girls as well as for boys.
Other nutrients provided by the food products in this segment are:
- vegetable protein for 60 to 70 % (Figure 6.4.),
- non-haem iron for 50 % (Figure 6.5.),
- thiamin for about 40 % (Figure 6.6.).
The whole meal bread group also supplies the largest quantity of the intake of these nutrients.

Segment 2

The food items of segment 2 supply for 70 to 80 % the total intake of ascorbic acid (Figure 6.7.). In the first place girls' consumption of citrus fruit contributes the most important quantity of this nutrient, but in boys the consumption of vegetables is more important for the intake (Figure 6.8.). Both are food products of the first priority. With age, for girls and boys the above mentioned food groups shift from the first to the second place. Girls, in the age group of 16, drink much orange juice contributing to about 28 % of the ascorbic acid.

Segment 3

Almost all the food items of animal origin are grouped together in this segment, therefore it is understandable that animal protein intake is provided almost totally by this segment. Figure 6.9. shows the range of importance of the different food items, cheese (a food item with second priority) with 15 % on the first place for girls and boys.
The whole group of milk and milkproducts supplies about 80 % of the calcium intake for these teenagers, with cheese and whole fat milk (second priority products) adding up to ca. 60 % in both sexes (Figure 6.10.).
The meat products in this segment mostly give the total haem iron intake (95%), with beef (first priority products) about 20 % for girls and boys (Figure 6.11.).
The consumption of milk and milk products, with whole fat milk in the first place (second priority), provides 65 to 70 % of the riboflavine intake for these teenagers (Figure 6.12.).

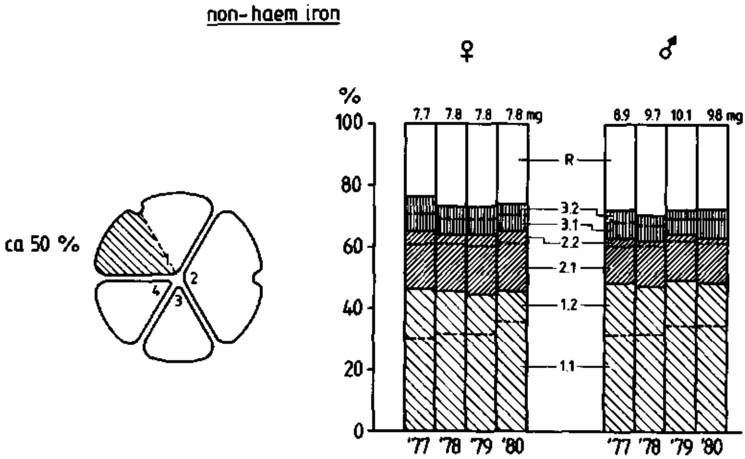

Figure 6.5.: The daily intake of non-haem iron of girls and boys during the four years of measurement is given: (a) in absolute values on top, and (b) in percentages over the segments of the meal-planning-disk. The percentages are divided in first priority (1.1) and second priority (1.2) for segment 1, for segment 2 (2.1 and 2.2), and segment 3 (3.1 and 3.2), R = restgroup. The overall mean percentage is indicated in the meal-planning-disk.

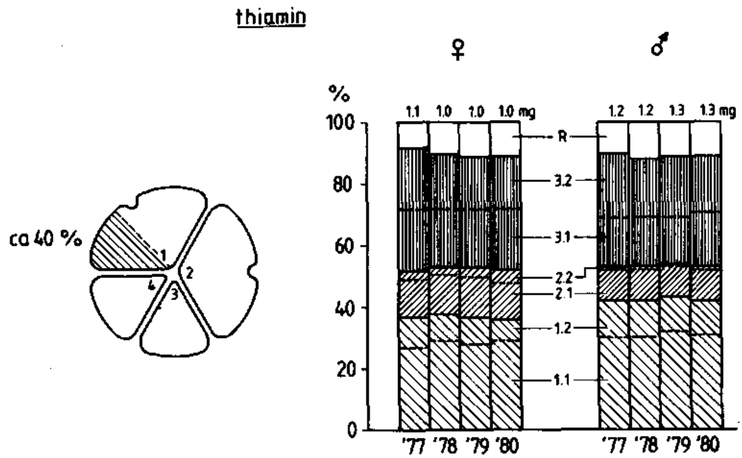

Figure 6.6.: The daily intake of thiamin of girls and boys during the four years of measurement is given: (a) in absolute values on top, and (b) in percentages over the segments of the meal-planning-disk. The percentages are divided in first priority (1.1) and second priority (1.2) for segment 1, for segment 2 (2.1 and 2.2), and segment 3 (3.1 and 3.2), R = restgroup. The overall mean percentage is indicated in the meal-planning-disk.

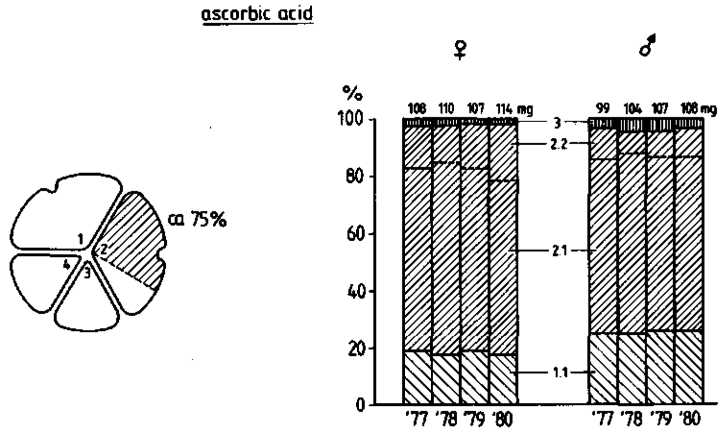

Figure 6.7.: The daily intake of ascorbic acid of girls and boys during the four years of measurement is given: (a) in absolute values on top, and (b) in percentages over the segments of the meal-planning-disk. The percentages are divided in first priority (1.1) for segment 1, in first (2.1) and second priority (2.2) for segment 2, 3 = segment 3. The overall mean percentage is indicated in the meal-planning-disk.

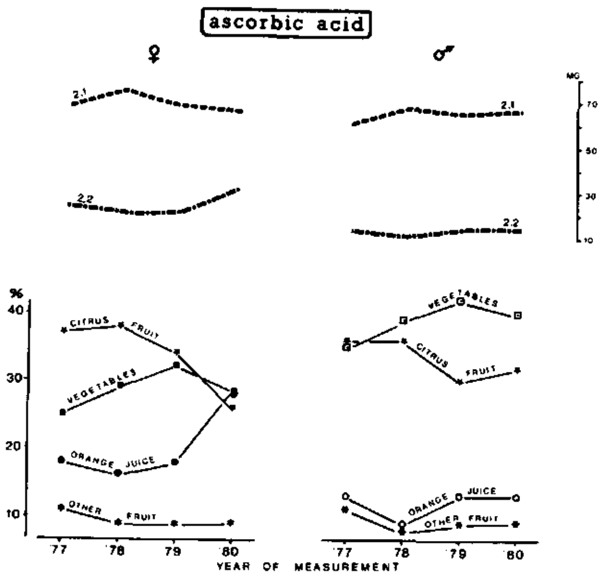

Figure 6.8.: The total contribution of ascorbic acid by food products of segment 2, with first priority (2.1) and second priority (2.2), is given in milligrams (MG), for girls and boys during the four years of measurement (upper part). The main food products, important for this intake are given in percentages (lower part).

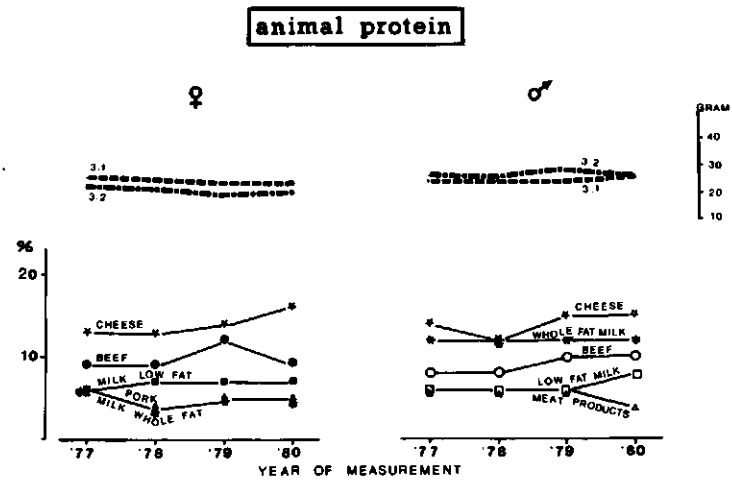

Figure 6.9.: The total contribution of animal protein by food products of segment 3, with first priority (3.1) and second priority (3.2), is given in grams, for girls and boys during the four years of measurement (upper part). The main food products important for this intake are given in percentages (lower part).

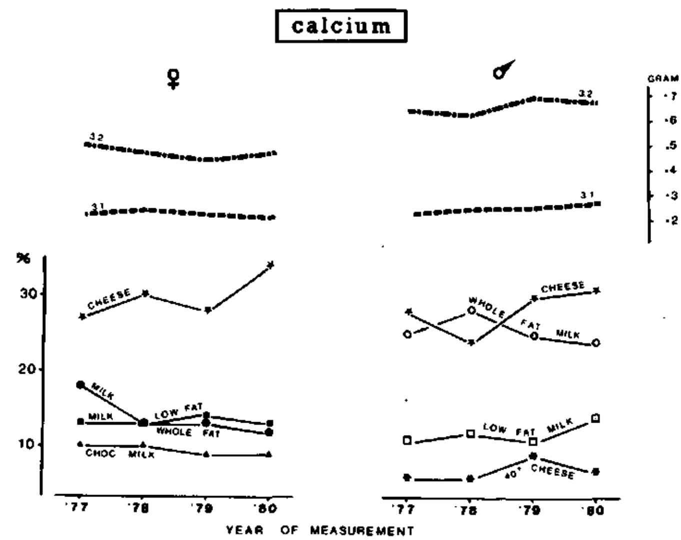

Figure 6.10.: The total contribution of calcium by food products of segment 3, with first priority (3.1) and second priority (3.2), is given in grams, for girls and boys during the four years of measurement (upper part). The main food products important for this intake are given in percentages (lower part).

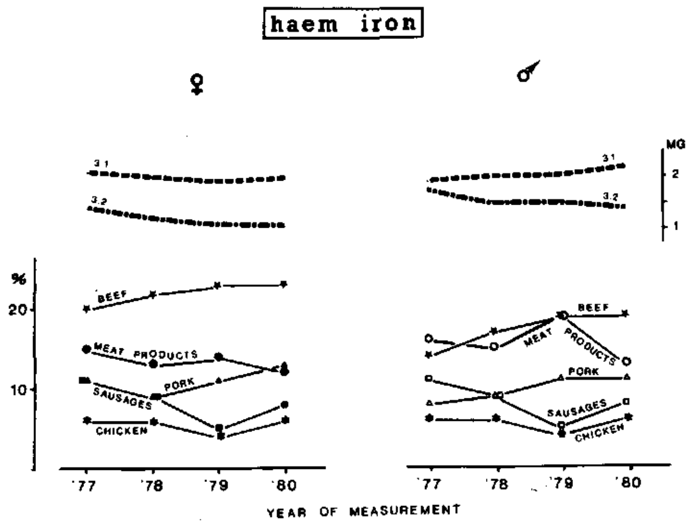

Figure 6.11.: The total contribution of haem iron by food products of segment 3, with first priority (3.1) and second priority (3.2), is given in milligrams (MG), for girls and boys during the four years of measurement (upper part). The main food products important for this intake are given in percentages (lower part).

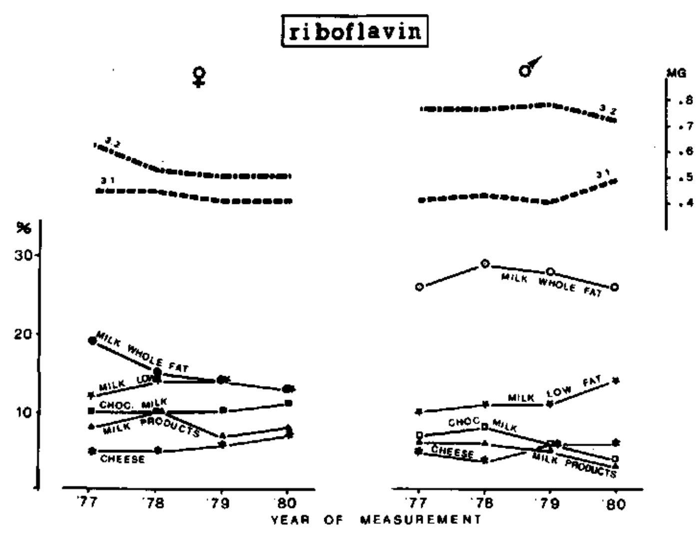

Figure 6.12.: The total contribution of riboflavin by food products of segment 3, with first priority (3.1) and second priority (3.2), is given in milligrams (MG), for girls and boys during the four years of measurement (upper part). The main food products important for this intake per day are given in percentages (lower part).

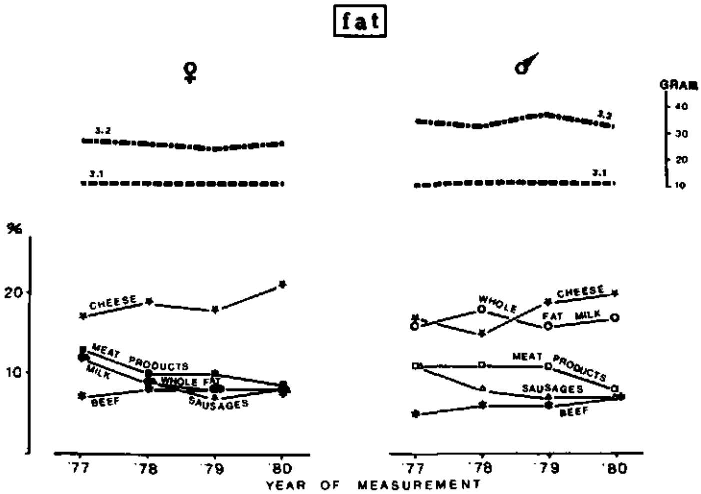

Figure 6.13.: The total contribution of fat by food products of segment 3, with first priority (3.1) and second priority (3.2), is given in grams, for girls and boys during the four years of measurement (upper part). The main food products important for this intake are given in percentages (lower part).

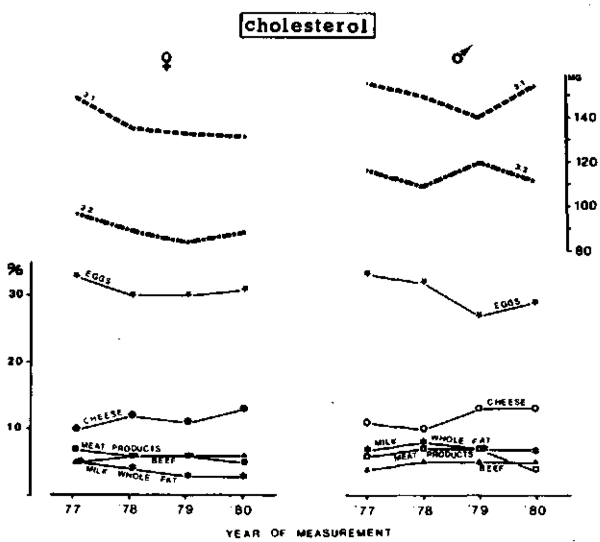

Figure 6.14.: The total contribution of cholesterol by food products of segment 3, with first priotity (3.1) and second priority (3.2), is given in milligrams (MG), for girls and boys durind the four years of measurement (upper part). The main food products important for this intake are given in percentages (lower part).

The food items grouped together in segment 3 are the main source of the total daily fat intake (41-45%). Figure 6.13. shows the contribution of the different food products in this segment. The consumption of cheese seems to supply about 20 % of this fat intake.
About 80 % of the total daily cholesterol intake is also supplied by the food products in this segment. The consumption of eggs (a first priority product) is responsible for more than 30 % of the cholesterol of this segment for girls and boys (Figure 6.14.). The contribution of cholesterol by eggs tends to decrease with age.

Segment 4

The food items in this segment form about 35 to 40 % of the total daily fat intake. Margarine with poly-unsaturated-fatty-acids (PUFA) contribute 30 % of the linoleic acid intake.
In the Netherlands artificial retinol is added to all the margarines, therefore these products contribute about 55 % of the total retinol intake.

'Restgroup'

Some food products gathered together as the 'rest' seem important in the contribution of PUFA (Figure 6.15.) to about 30 to 35 %. Peanut butter is in this category the principle source (18 %), with nuts on a second place (14 %).
The'restgroup' supplies about 50 to 60 % of the total daily intake of mono- and disaccharides. Figure 6.16. shows that sugar added to coffee, tea and yoghurt, together with the soft drinks already form about half of this contribution.

2. *The recommended quantity of foods*

The food intake of girls as well as boys in the age groups 12 - 17 years, does not show the recommended quantity as suggested in the meal-planning-disk. In comparison with the recommended serving sizes the consumption amount to:
- only 25 % of the low fat margarines (Figure 6.17.),
- about 50 % of the vegetables (Figure 6.18.),

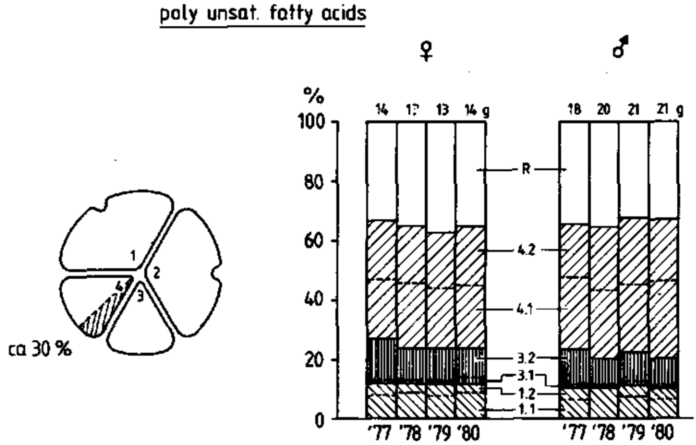

Figure 6.15.: The daily intake of PUFA of girls and boys during the four years of measurement is given: (a) in absolute values on top, and (b) in percentages over the segments of the meal-planning-disk. The percentages are divided in first priority (1.1) and second priority (1.2) for segment 1, for segment 3 (3.1 and 3.2), and for segment 4 (4.1 and 4.2), R = restgroup. The overall mean percentage is indicated in the meal-planning-disk.

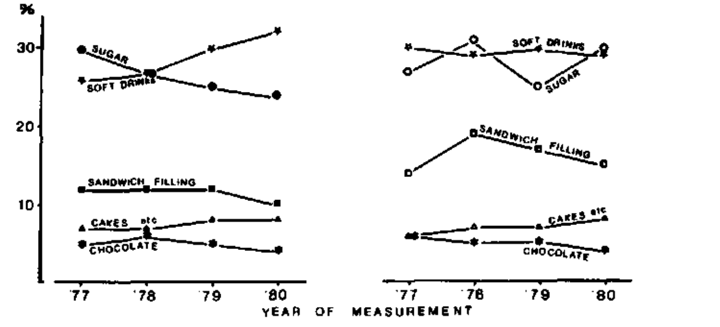

Figure 6.16.: The total contribution of mono- and disaccharides by food products of the 'rest group', is given in grams, for girls and boys during the four years of measurement (upper part). The main food products important for this intake are given in percentages (lower part).

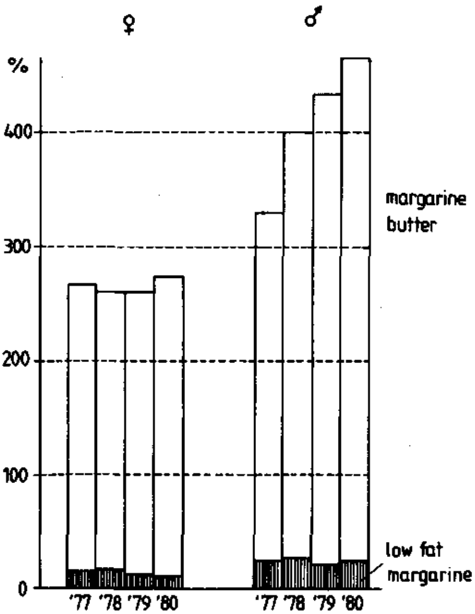

Figure 6.17.: The consumption of low fat margarine and margarine/butter of girls and boys in comparison with the recommended serving sizes (= 100 %) during the four years of measurement.

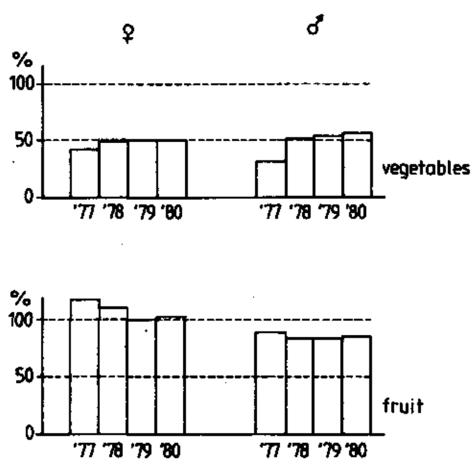

Figure 6.18.: The consumption of vegetables (upper part) and fruit (lower part) of girls and boys in comparison with the recommended serving sizes (= 100 %), during the four years of measurement.

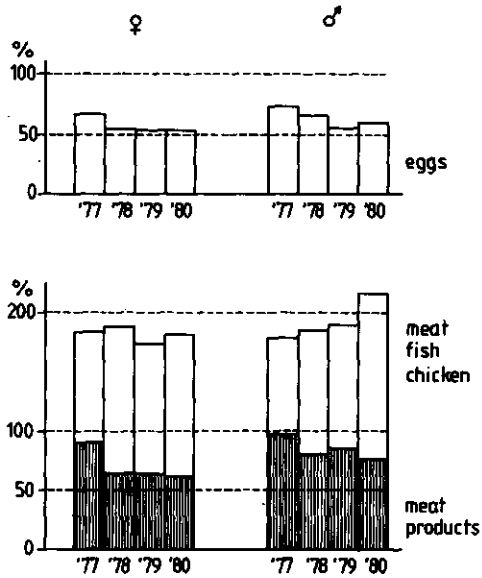

Figure 6.19.: The consumption of eggs (upper part), meat products and meat/fish/chicken (lower part) of girls and boys in comparison with the recommended serving sizes (= 100%), during the four years of measurement.

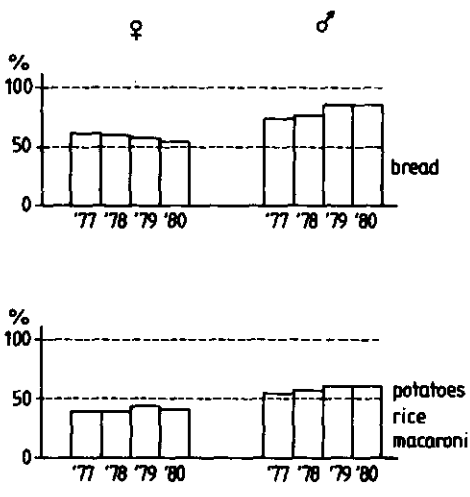

Figure 6.20.: The consumption of bread (upper part) and potatoes/rice/macaroni (lower part) of girls and boys in comparison with the recommended serving sizes (=100 %), during the four years of measurement.

- about 50 % of the eggs (Figure 6.19.),
- about 50 % of the group potatoes (rice and macaroni included) (Figure 6.20.).

The consumption of milk and milk products decreases in girls with age (Figure 6.21). Girls 16/17 years old only consume half of the recommendation.

At all ages girls consume the recommended portions of fruits (Figure 6.18.), whereas boys never reach that standard. Boys, however, consume more bread than girls, and nearly meet the recommendation in the older age groups (Figure 6.20.).

However, there are also food products which are consumed in larger quantities than recommended: Girls and boys, show a consumption of 180 % of meat (Figure 6.19.), 250 % of cheese (Figure 6.21), and about 300 % of the margarines and butter group (Figure 6.17.).

In boys the 'over' consumption of cheese and margarines/butter even increases with age.

Discussion

The professional responsibility of nutrition educators and counsellors is to provide the public at large with valid, understandable information on the relationship between diet, health and disease. Evaluation of dietary inadequacy has traditionally consisted of information of the nutritional value of foods. The public is probably more likely to understand recommendations in terms of foods rather than in terms of nutritive value (9). Reported evaluations of dietary intake data by food group usage, in conjunction with nutrient contribution by food groups, is very limited (10-12).

Unfortunately little nutrition education programmes are specifically aimed at adolescent groups (13-15).

The meal-planning-disk is a public information guide in the Netherlands, with special attention for the various meals of the day. This guide is not intended as a standard against which dietary quality is rigorously assessed, but to create a useful tool to choose adequately food items in planning healthy nutrition.

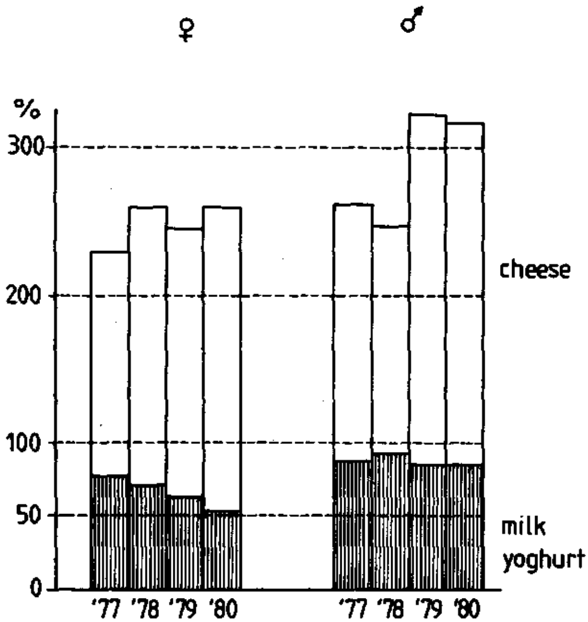

Figure 6.21.: The consumption of cheese and milk/yoghurt of girls and boys in comparison with the recommended serving sizes (=100 %), during the four years of measurement.

The study 'Growth and Health of teenagers' offers a large sample of food consumption data of girls and boys during their teens. In this study, however, it is not possible to separate the food intake in meals (breakfast, lunch and dinner). Therefore the results can only be indicative of the total consumption during the day (16,17).

Nutrient contribution

The food items in the meal-planning-disk are grouped over four segments by their nutrient value. It is indicated that the contribution of the foods in **segment** 1 are most important for the intake of polysaccharides, dietary fibre, vegetable protein, B-vitamins and minerals (see Table 6.1.). For the teenagers in this study, however, of the minerals 45 % of the non-haem iron intake is supplied by these food products. Of the B-vitamins, thiamin and pyridoxine are provided to about 40 %, and riboflavin only 15 %. It is needed to be more specific by indicating which vitamins and minerals are important from segment 1.

Food items in **segment** 2 are combined because they are important in the contribution of ascorbic acid, dietary fibre and minerals. Of the minerals, only 20 % of the non-haem iron intake of the teenagers is supplied by the foods of this segment. On the other hand, some vitamins are furnished by these food items, e.g. the beta-caroteen intake supplies 30 % of the total retinol intake, and the intake of pyridoxine is met by 20 %. Again the definition seems to lack the necessary specification.

Segment 3 is supposed to supply the majority of animal protein, B-vitamins and minerals. However, no mention is made of retinol and cholesterol. The teenagers seem to draw up to 40 % of the retinol intake from the food items in this segment. A special point is the large contribution of the daily cholesterol intake by the food products in this segment (about 80 %), together with more than 40 % of the total fat consumption. The milk products in this segment appear to be responsible for 20 % of the intake of mono- and disaccharides, and this indicates that milk products, and especially with added sugar (food products of a second priority), are an important source of sugar intake.

The food products in **segment 4** determine the intake of fat, retinol and linoleic acid. The teenager's food consumption, however, gives a lower fat intake by the foods of this segment compared with the contribution of segment 3. Therefore, when promoting a lower daily fat intake, more attention should be paid to food products with low fat in segment 3.
The food items indicated in the model as the so-called **'restgroup'**, seem to be important for teenagers as a source of vegetable protein, poly-unsaturated-fatty-acids and non-haem iron. They may seem to be the 'decoration' of the meals, and/or as snacks, but it is probably advisable to give them a more proper place with a priority scale as well.
The meal-planning-disk must be, a valid and a practicle nutrition education model for the general public. Therefore it is understandable to mention groups of nutrients like 'minerals' and 'vitamins'. On the other hand, when one particular segment contributes a great percentage of a special nutrient, it is recommended to refer to that specific nutrient and not to a whole group of nutrients. To endorse the importance of the different segments in one meal, one should indicate that nearly all segments contribute to the total nutrient intake.

Recommended quantity of food products

The food consumption of the teenagers is not very much in agreement with the recommended portion sizes, given by the brochure of the meal-planning-disk. Actually, depending on sex, these teenagers consume much more meat, cheese and margarines, but less bread, potatoes, vegetables and milk. A goal of the meal-planning-disk is on the one hand to diminish the use of meat and fat products, and on the other hand to increase the use of cereals, bread and vegetables in order to prevent chronic behavioural diseases. The teenagers in this study seem to consume quite differently food items from the recommendations, and so nutrition education will also be necessary for this age group.
In this public information guide the recommended serving sizes are called the daily basis for a good food pattern. However, little attempt is made to explain the possibility of substitution of one food item by another.

The teenagers in this study, for instance, consume less milk and milk products compared to the recommendation. The possible lower animal protein intake and calcium intake, however, has no consequences, because they eat much more cheese than recommended. The same phenomenon is seen for the too low intake of meat products and eggs, which is balanced by an 'over' consumption of fresh meat, chicken and fish.

The low consumption of bread, potatoes and vegetables is not fully compensated by other food products in these teenagers. Although food products like nuts and peanut butter contribute about 20 percent of the total daily intake of vegetable protein, non-haem iron and dietary fibre, still the teenagers showed marginal intakes of these nutrients compared with the recommended requirements.

It is essential to inform teenagers about the role diet plays in maintaining their health. To such information should be added suggestions about diet composition. Such suggestions must indicate that there are daily variations in amounts of food consumption and that a certain flexibility in food choice is not only acceptable but also necessary.

The results of this investigation reveal, however that the Dutch meal-planning-disk still has its weak points, which have not been improved in the 1987 revision (18). The difference, seen in 1987, is that some of the food items, set apart before, are now grouped together, like meatproducts and eggs together with meat, fish and chicken. Another improvement is more variety in the recommended serving sizes, like slices of bread and pieces of potatoes for boys between the age groups 11-16 and 16-20 years. The 1987 brochure differentiates the recommended serving sizes for age and sex, but hardly mentions the necessity of physical activity. It states that the recommendations are the mean for the age category in question, and by taking a slice of bread or a potato extra or less, everyone's consumption will be satisfied. At least this is an understatement and needs extra attention. The amount and intensity of daily physical activity differs not only between girls and boys, and between ages, but also shows a great variety within age and sex groups (19).

Conclusions

To present a realistic meal-planning-disk for the use in public health services, it will be necessary at least for teenagers to make the nutrient definitions more specific for each of the four segments, and also of the restgroup.

The recommendations concerning the food products for the daily consumption need also more details concerning the possibilities to replace one food product by another, and must take into account the differences in energy expenditure.

Depending on the objectives of the education programmes, certain food items could be highlighted more than others. E.g. different etnic groups within a society, may get different priority recommendations in food items. Such decisions can only be taken when adequate information is available about dietary patterns of such groups.

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CHAPTER 7

Longitudinal Changes in Eating Patterns from Teenager to Adult

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Han C.G. Kemper

Abstract

Dutch adolescents (107 girls and 93 boys) were studied longitudinally from the age of 12 to 21. The dietary habits were examined five times by means of the dietary history method.
Girls showed an almost constant total energy intake, 9.5 MJ during the whole age range. The total energy intake of boys gradually increased from 11.5 MJ at the age of 12 to 13.8 at the age of 21.
In both sexes the proportion of the energy supply from fat was approx. 5 % higher than recommended by the Dutch Nutrition Board (40-43 en%), and from carbohydrate 5-10 % lower ($\pm$ 45 en%). The total protein intake was sufficient (12 en%). Almost twice as much animal protein than vegetable protein was consumed in both sexes. The observed levels of intake showed, as compared with the recommendations, a rather low intake of poly-unsaturated fatty acids, polysaccharides, and iron (especially for the females).
The alcohol consumption strongly increased over the period of study to 7 grams per day for the girls and to 17 grams per day for boys.
'Snacks' contributed for 20 - 25 % to the total daily energy intake for both sexes. The nutrient density was lower compared to the daily food consumption.

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1. Introduction

'The future lies with the young'; this can only be true if healthy development can be provided throughout the growth period. Therefore it is necessary to offer them the best possible lifestyle with balanced nutrition. In the multiple longitudinal study 'Growth , Health and Fitness of Teenagers' (Kemper et al , 1985) food consumption and habitual physical activity were measured annually for four years , in a group of teenagers from 12 to 17 years of age. The results showed that the proportion of nutrients was typical Western and did not fully meet the recommendations. The amount of physical activity, especially the strenous type, diminished in the youngsters as they grew older. These findings in lifestyle were not reflected in unfavorable development of the physical and psychological characteristics of these teenagers. (Kemper et al, 1983)
To verify the nutritional value of the diet at adult age in relation to nutritional status at school age, the same teenagers were studied when they were in their early twenties. Therefore, in 1985, the longitudinal sample was recalled for a fifth measurement.
In this article the results of the measurements of the eating habits are presented, as part of the 'Amsterdam Growth and Health Study'.

2. Methods

2.1 Study population

The present study is a continuation of the study 'Growth and Health of Teenagers' (Kemper et al, 1983) and is carried out with a longitudinal sample from a secondary school in Amsterdam, The Netherlands (Pius X Lyceum). The measurements are taken yearly during four successive years, starting in 1976/1977, and ending in 1979/1980 ('schoolage period'), with a fifth assessment in 1985 ('young adult age'). A total of 107 girls and 93 boys are measured five times. Of the original 233 subjects

the total drop-out percentage is 14.1 %, but considerably more girls (18.3%) than boys (8.8%) dropped out.
The age of the girls and boys varies from 12 to 15 years at the first measurement in 1976, mean age 13.5 (±0.6) years, and from 20 to 23 years, mean age 21.5 (±0.6), at the fifth measurement in 1985.

2.2. *Anthropometry*
Each year body height, body weight and four skinfolds were measured to characterize the dimensions and composition of the body of the sample population during the study period (Table I).

Table I: Mean and standard error of height, weight and the sum of four skinfolds of the girls and boys in the longitudinal group, by chronological age.

Year Measurement **Chronological Age**	**1977** **13.5**	**1978** **14.5**	**1979** **15.5**	**1980** **16.5**	**1985** **21.5**
			Girls (n = 107)		
Body height (cm)	163 (.7)	166 (.7)	168 (.6)	169 (.6)	170 (.6)
Body weight (kg)	48.8 (.9)	52.5 (.9)	55.8 (.9)	57.7 (.9)	62.4 (.9)
Sum of four skinfolds (mm)	40 (1.5)	42 (1.7)	46 (1.6)	48 (1.7)	54 (1.8)
			Boys (n = 93)		
Body height (cm)	161 (.9)	169 (.9)	175 (.8)	179 (.7)	183 (.6)
Body weight (kg)	45.4 (.9)	52.0(1.0)	58.1(1.0)	63.1 (.9)	71.4 (.9)
Sum of four skinfolds (mm)	28 (1.1)	28 (1.2)	28 (1.2)	30 (1.3)	36 (1.5)

2.3. *Food consumption measurement*

The food consumption was measured using a modification of the cross-check dietary history interview and supervised by the same researcher over the entire study (Post et al 1987).

In an interview all foods listed are reviewed with special reference to frequency and amounts. Information on foods consumed during regular meals as well as between meals (so-called snacks) are collected separately for the five 'workdays' and for the two weekend days. Only the food items eaten at least twice monthly are recorded. For each individual all amounts are expressed as a weighted average for the whole week. The total energy and the amount of the different nutrients are calculated by multiplying the weights of foods consumed with the appropriate values from a computerized Dutch food-composition table (NEVO, 1985).

The following food characteristics are calculated: (a) macro-nutrients, such as total energy intake, protein, fat, carbohydrate, alcohol; (b) minerals, such as calcium and iron; (c) vitamins, such as retinol, thiamin, riboflavin, pyridoxine and ascorbic acid. Separately the contribution of the snacks to some nutrients are calculated.

It is rather difficult to give a precise definition of 'snacks', the between meals food products. Food items are defined as 'snacks' when they are eaten between meals and belong to one of the following food groups:

- Sweets, such as candy bars, chocolates, gums, cakes, cookies, biscuits, sweet rolls, etc.
- Soft drinks, lemonade, fruit juices, alcoholic beverages, etc.
- Snackbar items, such as french fried potatoes, dressed rolls, ice cream, etc.

If suitable, comparisons with Dutch recommended allowances will be given. For the contribution of the nutrients the most important food groups, such as bread, potatoes, dairy products, cheese, sugar etc., will be mentioned.

3. Results

3.1. Anthropometry

The increase in weight in girls of about 4 kg over the last five years of the study (Table I), without an increase in height, is caused by a further increase in fat mass as demonstrated by the increase in the sum of the four skinfolds. A mean value of about 54 mm at age 21/22 corresponds with a percentage fat of the total body weight of about 30 %. (Durnin et al ,1967) In boys there is an increase of body weight by about 8 kg, but also in body height by about 4 cm. The increase in body fat is considerably lower than in girls and amounts to about 20 % at age 21/22.

3.2. Macro-nutrients

Figure 1 shows the average intake of total energy of girls and boys over a chronological age span of eight years, from 12/13 to 21/22 years of age. In girls the daily intake remains more or less on the same level throughout the whole period. For boys the mean energy intake increases consistently over the schoolage period by about 100 kcal (0.4 MJ), and over the last five years by about 200 kcal (0.8 MJ).

Figure 2 shows an increase of the total daily protein intake in boys during the study. In girls during schoolage there is a decrease from 75 to 70 gram, but at adult age the intake increases to the same level as at 12/13 years af age. The contribution to the total energy intake remains about 12 - 14 percent. (see Table II) The proportion of animal protein is slightly higher in girls than in boys.

The total fat intake increases during the schoolage period for boys (Figure 3) and remains at the same level after leaving school, whereas for girls the fat intake remains the same over the whole period. The contribution to the total energy intake is almost egual in both sexes (± 42 %). The proportion of poly-unsaturated-fatty-acids (PUFA) is also somewhat higher in boys (Table II).

The developmental changes in the total carbohydrate intake (Figure 4) are opposite for girls and boys, with decreases in girls, but increases in boys. The proportion of carbohydrate to the total energy supply

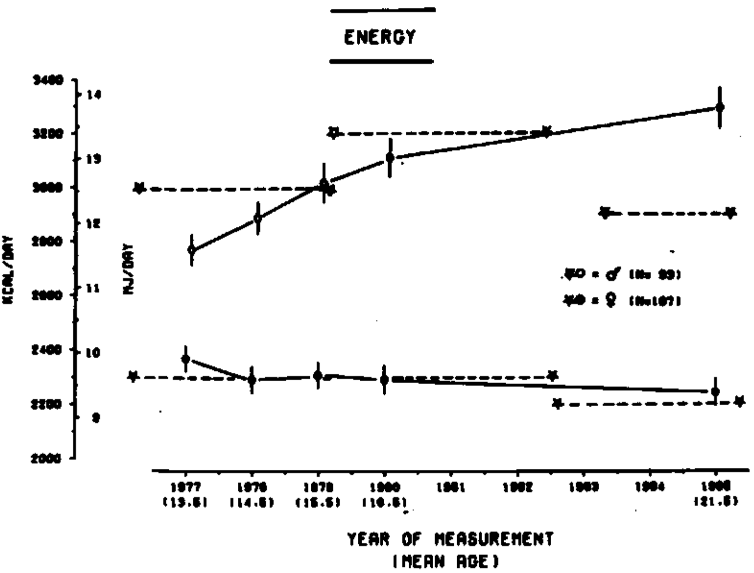

Figure 1 : Mean daily energy intake in girls and boys versus mean age. Standard errors are presented by vertical bars. The dotted lines (----) means the Dutch recommended dietary allowances for energy by a medium activity level.

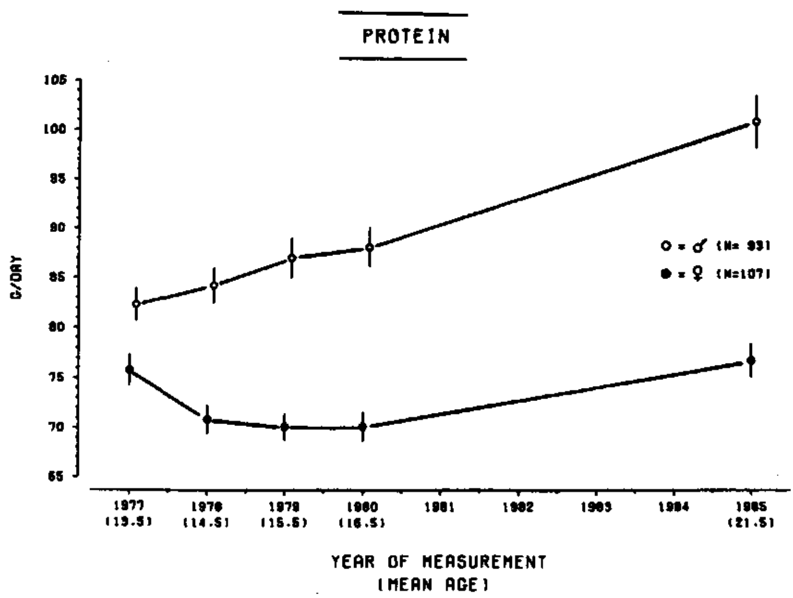

Figure 2 : Mean protein intake in grams per weekday, for girls and boys versus age. Standard errors are presented by vertical bars.

Table II: Mean and standard error (s.e.) of the total daily intake of energy, macro-nutrients, dietary cholesterol, and dietary fibre for girls and boys, by age.

Chronological age (year)	13.5	14.5	15.5	16.5	21.5
			Girls (n = 107)		
Energy (kcal)(s.e.)	2370(47)	2290(50)	2310(48)	2290(53)	2245(50)
(MJ)	9.9	9.6	9.7	9.6	9.4
Total protein (en%)	13(.2)	12(.2)	12(.2)	12(.2)	14(.2)
Vegetable protein (en%)	4.4	4.4	4.5	4.4	4.6
Animal protein (en%)	8.1	7.7	7.4	7.7	9.3
Total fat (en%)	40(.5)	42(.5)	41(.5)	41(.5)	41(.6)
PUFA (en%)	5.3	5.5	5.5	5.5	5.2
Total Carbohydrate(en%)	47(.4)	46(.5)	46(.4)	45(.5)	44(.6)
Mono/disacch. (en%)	24	23	24	23	22
Polysacch. (en%)	23	23	22	22	22
Total Alcohol (en%)	-	.1	.3(±.1)	.6(.1)	1.6(.2)
Dietary cholest. (mg/MJ)	29	29	29	30	33
Dietary Fibre (g/MJ)	2.3	2.4	2.5	2.5	2.4
			Boys (n = 93)		
Energy (kcal) (s.e.)	2770(56)	2885(59)	3015(72)	3110(71)	3294(75)
(MJ)	11.6	12.1	12.6	13.0	13.8
Total protein (en%)	12(.2)	12(.2)	12(.2)	12(.2)	12(.2)
Vegetable protein (en%)	4.3	4.4	4.5	4.4	4.4
Animal protein (en%)	7.4	7.1	6.9	6.8	7.9
Total fat (en%)	42(.5)	42(.5)	43(.5)	43(.5)	41(.5)
PUFA (en%)	5.8	5.9	6.3	6.4	5.7
Total Carbohydrate(en%)	46(.5)	46(.5)	45(.5)	44(.5)	44(.6)
Mono/disacch. (en%)	24	23	22	22	22
Polysacch. (en%)	22	23	23	22	22
Total Alcohol (en%)	-	.3(.2)	.9(.3)	1.3(.2)	2.7(.3)
Dietary cholest. (mg/MJ)	29	27	26	26	30
Dietary Fibre (g/MJ)	2.2	2.2	2.2	2.2	2.2

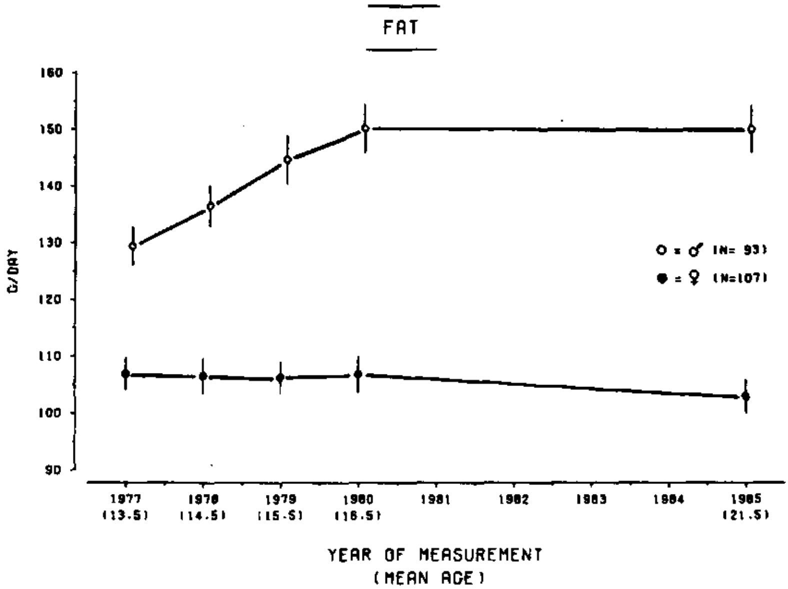

Figure 3 : Mean fat intake in grams per weekday for girls and boys versus age. Standard errors are presented by vertical bars.

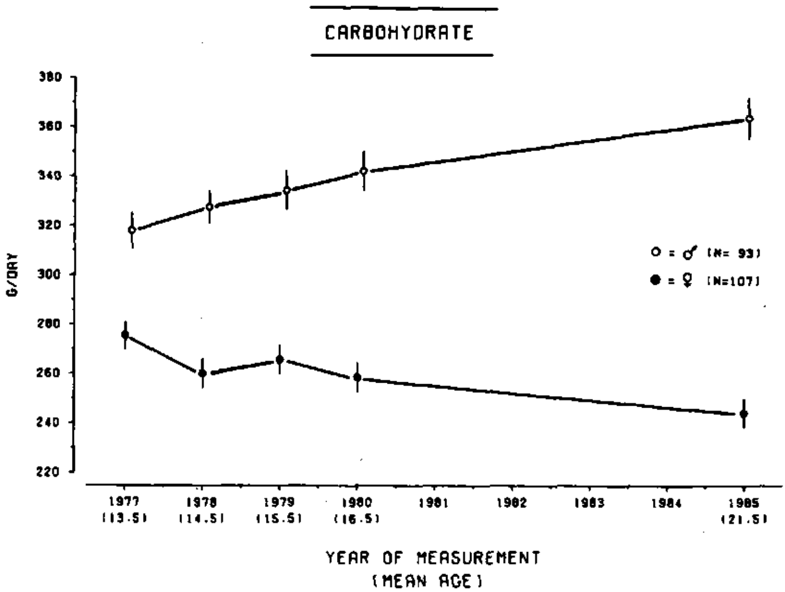

Figure 4 : Mean carbohydrate intake in grams per weekday for girls and boys versus age. Standard errors are presented by vertical bars.

however decreases somewhat for both sexes in their adolescence. The contribution of poly-saccharides (± 23 %) and mono-, and disaccharides (± 23 %) to the energy intake is equal for both sexes (Table II).
The energy intake from alcohol increases markedly faster in boys than in girls (Table II). Because there is a large number of 'non-drinkers', a mean alcohol intake for all boys and girls of about 2.5 % and 1.5% of the total energy intake, do not give a good indication of the true pattern. Therefore the percentage of alcohol consumers is also determined, with their mean alcohol intake per day. In general, both girls and boys report an increasing consumption of light alcoholic drinks (such as beer and wine) as they grow older, so that their mean alcohol intake increases with age (see Table III).

3.2.1. Food groups

Table IV shows the proportional energy intake of some food groups to the total intake during the study. The meat, dairy, and cheese products appear to contribute the most (about 30 %) to the energy intake, in the schoolage period as well as thereafter (Post, 1985). For bread, cereal products and potatoes the contribution is about 20 - 25 percent.
In Table V the contribution of food groups to the mean vegetable (Va) and animal (Vb) protein intake is shown. The most important food group in the consumption of vegetable protein is bread in both sexes (Table Va). In the first four years of the study meat and meat products supply almost 30 percent of the total animal protein intake, but after the schoolage period both sexes obtain almost 45 percent from these foods Table Vb).
The margarine/butter group is the main source of the fat intake for girls as well as for boys, contributing 40 percent.
Bread contributes about 45 percent of the polysaccharides, for girls there is a small decrease by about 5 percent over the years.

3.3. Minerals

The daily calcium intake for girls decreases over the schoolyears, but increases in boys. In both sexes it increases at adult age (Table VI).

Table III: Percentage of girls and boys who report consuming alcoholic beverages, and the mean intake (g) plus standard error (s.e.) per alcohol consumer, by age.

Chron.Age (year)	13.5	14.5	15.5	16.5	21.5
			Girls (n = 107)		
Consumers (%)	7	20	37	54	75
Amount (g)	1.7	2.1	2.5	3.5	6.9
(s.e.)	.4	.5	.5	.5	.7
			Boys (n = 93)		
Consumers (%)	12	22	32	51	75
Amount (g)	2.2	6.9	13.6	11.6	17.8
(s.e.)	.4	3.4	4.2	2.3	1.8

Table IV: Contribution of food groups to the total energy intake in girls (F, n=107) and boys (M, n=93), in the five measurements.

Chron.Age (yr)	**13.5**		**14.5**		**15.5**		**16.5**		**21.5**	
Sex	F	M	F	M	F	M	F	M	F	M
Food group	%	%	%	%	%	%	%	%	%	%
Bread, Cereal, Potatoes	23	25	24	25	23	25	22	27	22	25
Meat, Cheese, Dairy	29	28	28	25	26	25	27	25	30	29
Margarine, Butter, Fat	11	13	12	14	12	14	12	15	12	13

Table Va: Contribution (percentages) of food groups to the mean vegetable protein intake for girls (F) and boys (M) by age. (Standard error)

Chron.Age (yr)	**13.5**		**14.5**		**15.5**		**16.5**		**21.5**	
Sex	F	M	F	M	F	M	F	M	F	M
Veg.Protein(g)	26(.6)	30(.7)	25(.6)	32(.6)	26(.6)	34(.9)	25(.6)	34(.9)	26(.6)	36(.9)
Food group	%	%	%	%	%	%	%	%	%	%
Bread, brown	23	23	25	22	22	25	25	26	23	28
white	22	23	18	23	18	21	14	21	12	17
Potatoes	12	14	12	13	12	13	12	14	12	14
Vegetables	9	8	12	9	11	9	12	11	13	11

Table Vb: Contribution (percentages) of food groups to the mean animal protein intake for girls (F) and boys (M) by age. (Standard error)

Chron.Age (yr)	13.5		14.5		15.5		16.5		21.5	
Sex	F	M	F	M	F	M	F	M	F	M
An.Protein(g)	48(1.3)	51(1.3)	44(1.1)	51(1.5)	43(1.1)	52(1.5)	44(1.1)	53(1.6)	52(1.4)	65
Food group	%	%	%	%	%	%	%	%	%	%
Milk/-products	24	27	24	29	23	25	24	26	27	26
Cheese	17	17	19	15	18	22	18	20	21	20
Meat, beef	8	8	9	8	10	9	9	9	12	9
pork	10	8	11	8	9	9	11	9	12	12
other	4	4	4	4	5	4	4	4	8	9
Meat products	10	12	6	10	7	9	9	7	12	14
Egg	4	4	2	4	2	2	3	4	4	3

Table VI: Mean and standard error (s.e.) of the daily intake of minerals and vitamins for girls and boys by age.

Chron.Age (year)	13.5	14.5	15.5	16.5	21.5
		Girls (n=107)			
Calcium (mg)(s.e.)	990 (40)	900 (30)	900 (35)	895 (35)	1095 (45)
Haem iron (mg)	3.7(.1)	3.4(.1)	3.2(.1)	3.3(.1)	3.3(.1)
Non-haem iron (mg)	7.8(.2)	7.6(.2)	7.8(.2)	7.6(.2)	7.9(.2)
Retinol (mg)	.8(.02)	.8(.03)	.8(.03)	.8(.03)	.9(.03)
Thiamin (mg/4.2 MJ)	.45	.44	.43	.44	.45
(mg/4.2MJ non-fat)	.76	.76	.74	.77	.79
Riboflavin (mg)	1.5(.05)	1.3(.04)	1.3(.04)	1.3(.04)	1.5(.05)
(mg/g protein)	.02	.02	.02	.02	.02
Pyridoxin (mg)	1.3(.03)	1.2(.03)	1.2(.2)	1.2(.03)	1.5(.04)
Ascorbic acid (mg)	113 (5)	109 (4)	107 (4)	110 (5)	127 (5)
		Boys (n=93)			
Calcium (mg)(s.e.)	1080 (40)	1070 (42)	1145 (44)	1130 (47)	1395 (62)
Haem iron (mg)	3.8(.1)	3.7(.1)	3.7(.1)	3.9(.1)	4.3(.2)
Non-haem iron (mg)	8.6(.2)	9.1(.2)	9.4(.3)	9.4(.2)	10.1(.3)
Retinol (mg)	1.0(.03)	1.0(.03)	1.1(.04)	1.2(.04)	1.2(.05)
Thiamin (mg/4.2 MJ)	.41	.40	.40	.40	.41
(mg/4.2 MJ non-fat)	.71	.71	.72	.72	.73
Riboflavin (mg)	1.6(.05)	1.6(.05)	1.6(.06)	1.7(.06)	2.0(.07)
(mg/protein)	.02	.02	.02	.02	.02
Pyridoxine (mg)	1.4(.03)	1.4(.03)	1.5(.03)	1.5(.06)	2.0(.05)
Ascorbic acid (mg)	96 (4)	99 (4)	101 (4)	105 (4)	134 (5)

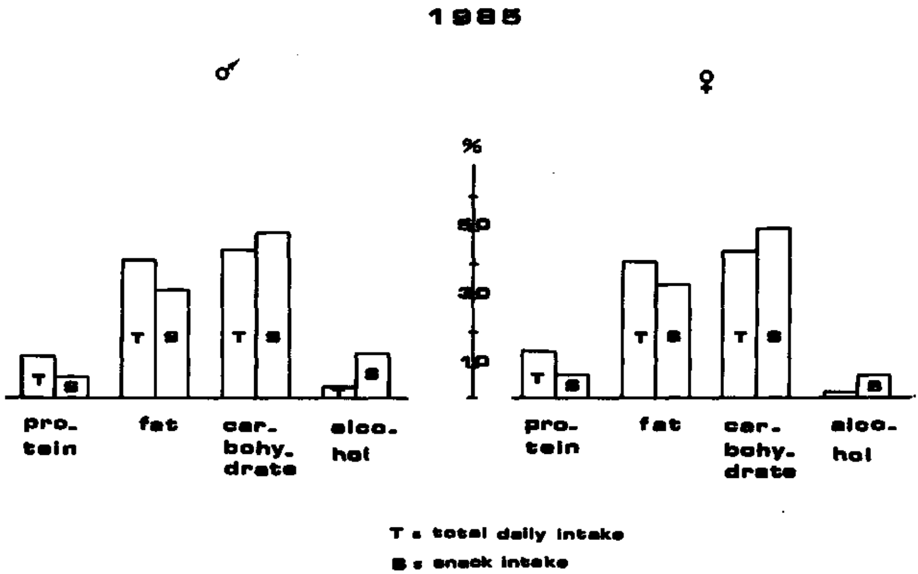

Figure 5 : Contribution in percentages of the macro-nutrients to the total energy intake of the total daily food consumption (T) and of the total snack consumption (S) in the last year of measurement, for girls and boys.

Milk and cheese play an important role in the total calcium intake, contributing approximately 80 percent.
The total iron intake for girls only changes slightly over the years, remaining at about 11 mg. The non-heme iron intake does not change very much, whereas the heme iron intake decreases (Table VI). The boys consistently increase their daily iron intake from 13 mg at age 13/14 to about 14.5 mg when they are 21/22 years of age. This increase is mostly due to the non-heme iron compound.

3.4. *Vitamins*

In boys the intake of all measured vitamins increases with age (Table VI). In girls the intake of vitamins fluctuates over the years.

3.5. *'Snacks'*

For girls, snacks contribute about 22 percent of the total daily energy intake during their schoolage period, and increases to 24 percent at adult age. For boys, the contribution of snacks is slightly lower, 20 percent, and increases to 22 percent at adult age.
Figure 5 shows the distribution of the percentages of macro-nutrients from the total energy intake, compared to the contribution of the total snack consumption. The contribution of fat from snacks to the energy intake is lower than the percentage of the total daily food consumption, but from carbohydrates it is higher.

4. Discussion

In grown-ups different levels of energy activity must be taken into account. In our study an activity questionnaire was used to estimate time spent on activities with an average energy expenditure of four times Basic Metabolic Rate or more (4 Met's, which equals walking of approx. 5 km/hr.). The weighed total activity score (Figure 6), is calculated by multiplying duration and intensity of the activities. This weighed total activity score decreases considerably during the schoolage period (Verschuur et al, 1985), but remains stable thereafter.

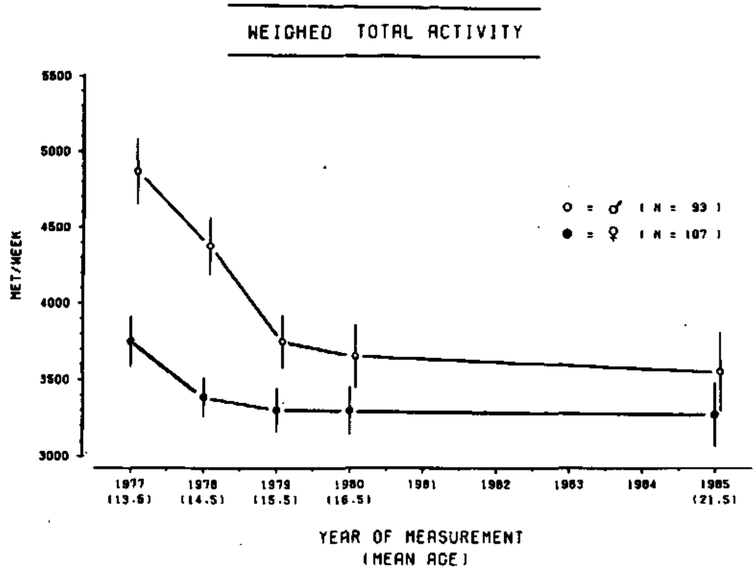

Figure 6 : The mean and standard errors of the weighed total activity score in Met's per week, for girls and boys versus the five measurements.

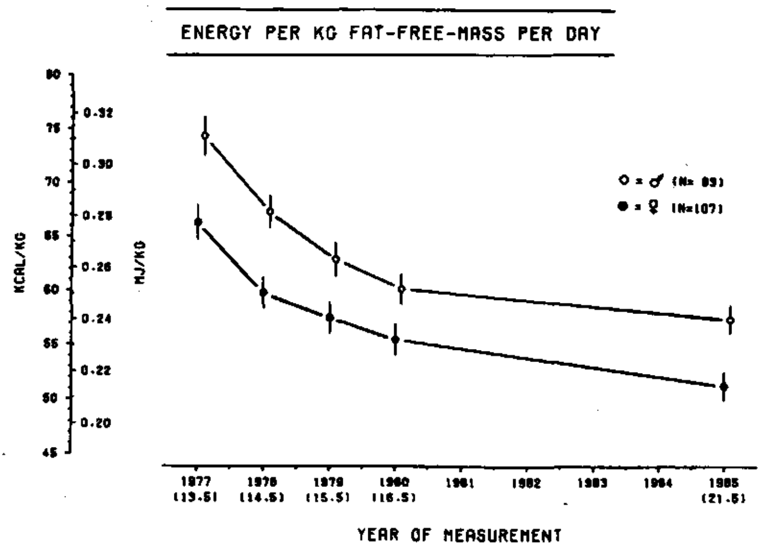

Figure 7 : The mean and standard errors of the daily energy intake per kg fat free bodymass, for girls and boys versus age.

The Dutch recommended daily allowances (RDA's, Voedingsraad, 1985) in the category of 'medium activity level' in both sexes is about 2200 kcal per day for females and 2900 kcal per day for males. These amounts are taken for comparison in figure 1 (dotted line). The mean daily energy intake of girls is close to the RDA's over the whole age range. In boys the daily energy intake does not fit with these RDA's; during schoolage the RDA's are higher and at adult age much lower.
Although the daily energy intake in girls corresponds with the RDA's, there is a constant increase in fat mass, as measured by an increase in the sum of four skinfolds from 40 to 54 mm. Thus it would seem that the intake of energy is too high for the activity level, and results in a positive energy balance over the years.
In boys, the fat mass increases by a significant amount after schoolage, as shown by the increased sum of their skinfolds from 30 to 36 mm.
This can possibly be explained by an increased intake, but a constant energy expenditure from 16.5 to 21.5 years of age.
Because body dimensions (such as height, weight) and body composition (percentage body fat) in the total energy intake play an important role, it seems to be more accurate to relate the energy intake to a measure of body mass. To compare energy intake with energy expenditure we calculated the energy intake per kg fat free mass, in order to correct for differences in body composition (Figure 7). The decrease of energy intake per kg fat free mass is similar to the decrease in physical activity (see Figure 6). The difference of about 5 kcal per kg fat free bodymass over the whole age range, between boys and girls, indicates the higher physical activity in boys over the girls, as shown in figure 6.
During the whole period of adolescence the contribution of energy through protein and fat is above the recommendations, whereas the supply of carbohydrate is too low (especially the contribution of poly-saccharides and dietary fibre, Table II). This is rather undesirable in relation to the aetiology of atherosclerosis in these youngsters. Poly-unsaturated fatty acids are also well below the RDA's. Nutritional education at all levels of schooling to provide understanding of healthy eating habits, as well as the content of the major nutrients in foods, seems desirable. Adolescence is a period of

increased self-awareness when an individual may be particularly sensitive to external pressures from peers, but also from communication media. Therefore it will be good to use this period for health education.

The lower consumption of cholesterol than that allowed by the RDA's, may already be a success from the campaigns of the last ten years on radio, television and in newspapers.

Over 20 percent of energy is supplied by sugar and sugar rich products in girls and boys over all the years of the study. The same is found by Hackett et al (1984) for children of about 12 years of age. This percentage increases the chance of development of dental caries but may be associated with other health problems such as overweight and hypertension.

Schuurman (1983) reports the proportion of alcohol drinkers among 13 to 18 years old schoolchildren as 11 percent of the girls and 26 percent of the boys. In the present longitudinal study the percentage drinkers increases with age, for both girls and boys, to 75 percent at adult age (Table III). Not only the number of drinkers and the amount of alcohol consumed, but also the proportion of 'heavy drinkers' increases. It is clear that this on a long term basis threatens their health.

In preventive medicine much attention is given to the relation between the calcium intake in the food, and the incidence of osteoporosis. The calcium intake meets only the Dutch recommendations when the girls and boys are grown-up, 21/22 years of age. The reason for this is not the increase of the intake, but merely the drop of the recommendations after the age of 19/20 years, for girls from 1000 mg to 800 mg, and for boys from 1200 mg to 800 mg. If the recommendations are correct, the calcium intakes may result in a good future for these young people!

Serious attention must be paid to the daily iron intake of adolescent girls. During the whole schoolage these girls consume on the average only about 75 percent of the RDA's, and boys about 85 percent. When the girls are 21/22 years the consumption is increased to about 93 percent of the allowances. The boys meet fully and more the standard (140 percent!). Barber and Bull (1985) also describe an intake of 70 percent of the recommended level of iron for 15 to 18 years old girls. During their teenage period, girls show a decrease in the intake of meat and meat products, so the complicated factor is the decrease of heme iron intake. Maybe, girls are more affected by the campaigns against bio-industry (a so-called hazard of the western societies). Nutrition education must take this item into the program, otherwise we may have to deal with young females with anemia.

The mean intakes of vitamins (Table VI) appears sufficient to achieve recommended levels, during the adolescent period as well as thereafter. On the average boys have higher intakes compared with girls, but when the energy intake is taken into account the differences are very small.

Although it is often stated that snacks are the main source of fat; the results show the lower relative contribution of fat in snacks (Figure 5), compared to the total daily intake. However, our data of the nutrient density show for some minerals and vitamins much lower values for snacks, indicating potential deficiencies in case of high contribution of snacks. In general, consumption of higher quantities of snacks, more than 20 % of the total daily energy intake, is not advisable.

5. Conclusions

The teenage girls have a constant energy intake as they grow older until they are young adults. The total energy intake in boys increases with age. In both sexes there is more or less overconsumption of energy, resulting in an increase of the total fat mass of the body.

In comparison with the RDA's it must be concluded that the daily food intake of teenagers and young adults does not contribute enough PUFA and polysaccharides, but does contribute too much fat and mono- and disaccharides.

Girls seem to have too low iron intake over the whole age range.

Another point of concern is the alcohol consumption of the older teenager and the young adults. The consumption of alcoholic drinks is mostly concentrated around the weekend, and in such high quantities (especially in the boys), this might seriously effect health conditions.

The nutrient density of snacks is lower than of the meal foods, but although about 20 % of the total daily energy intake is supplied by snacks in this population, it generally does not result in deficient intakes of nutrients.

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CHAPTER 8

The Quality of Food Intake in Relation to Health Aspects in Adolescense

Introduction

So far, the food intake of a Dutch adolescent population has been described during their teens till their adult age. In this chapter the accent will be on the relations between the qualitative aspects of the food intake and health aspects in this growing population. The nutritional requirements of young people and their relation to the basic physiological changes during growth are hardly known (1).

The quality of diets, started at home during childhood and maintained over a long period, through adolescence up to the adult stage, will contribute to the creation of a, good or bad, predisposition for health in later life. The adolescent period is characterized by a number of important physical changes, and the question arises: which influence has, over a long period, the food pattern on growth and development of these youngsters, and specially: Will there be a relation to changes in body build, body composition or the development of different lifestyles such as physical activity?

This chapter will describe the nutrient intake of a Dutch population of girls and boys during puberty, and investigate the relations between the quality of the diet on the one hand, and the physical development and physical activity on the other hand.

Methods

Study population

The subjects are 107 girls and 93 boys of the longitudinal group who completed the five years of the study: starting at age 13 and ending at age 21. The characteristics are described in Chapter 2.

Table 8.1.: Recommended Daily Allowances of nutrients for girls and boys between the ages 13 - 21 years (2).

	GIRLS			*BOYS*		
Age (years)	*13-15*	*16-19*	*>20*	*13-15*	*16-19*	*>20*
Year of Measurement	1 + 2	3 + 4	5	1 + 2	3 + 4	5
Nutrients						
1. Kilocalories /kg BW*	45	40	30	60	45	35
2. Protein /kg BW	1.2	1.0	0.9	1.5	1.2	0.9
3. Fat (en %)**	35	35	35	35	35	35
4. PUFA (en %)	10	10	10	10	10	10
5. Carbohydrate (en %)	55	55	55	55	55	55
6. Mono/disacch (en %)	15	15	15	15	15	15
7. Polysacch. (en %)	40	40	40	40	40	40
8. Calcium (mg)	1200	1000	800	1200	1200	800
9. Iron (mg)	15	15	12	15	15	10
10. Retinol (mg)	0.85	0.85	0.85	0.85	0.85	0.85
11. Thiamin (mg)	1.0	1.0	0.8	1.2	1.3	1.1
12. Riboflavin (mg)	1.5	1.5	1.3	1.8	2.0	1.5
13. Pyridoxine (mg)	2.0	2.0	2.0	2.0	2.0	2.0
14. Ascorbic acid (mg)	75	75	50	75	75	50
15. Cholesterol (mg)	315	315	275	440	440	360
16. Dietary fibre (g)	30	30	25	35	40	30

* BW = body weight
** en.% = energy percentage

Table 8.2.: The number of girls and boys, and the percentages of the longitudinal group, participating in the relatively high (HQ) versus low quality (LQ) food group.

	QUALITY OF FOOD INTAKE			
	HQ		LQ	
	N	%	N	%
girls	39	36	18	17
boys	22	24	12	13

Food intake measurement

The daily food intake is measured by a dietary history method, estimating the usual intake over the last month. The method is described in Chapter 2 and 3.

Nutrition Quality

In order to design a measure of the quality of the food intake of the subjects, sixteen nutrients are taken into account. Of these sixteen nutrients the Dutch recommended daily allowances (RDA) are taken as standard (2). The RDA's vary between different age categories. In this study the age groups concerned are;

- 13 to 15 years of age, measured in the first and second year of this study;
- 16 to 19 years of age measured in the third and fourth year of the study;
- $>$ 20 years of age measured in the fifth year of the study.

In Table 8.1. the ranges of the recommended amounts of the sixteen nutrients are summarized over the different age groups.

Someone meets the standard if the nutrient intake is equal to the recommendation (100 %) of that specific age group, with an allowed deviation of + or - 30 %. Nutrient recommendations are defined as the amount with which every person of the group in question meets his requirements. The Dutch Nutrition Council states that if the mean intake of the group is 20 % below the recommendations, many members of that group will have inadequate intakes (3). To make this statement even stronger the 30 % deviation is chosen. On the other hand, there are limits for the optimal effect of the nutrient intake in the human body (4). Therefore, an arbitrary limit of 30 % above the recommendations is chosen.

For every individual the amounts of each nutrient are scored as one (= 1) when the RDA standard (+/- 30 %) is reached. If the amount is either below or above that range the score is 'zero' (= 0). The total quality score of the food intake, after all the scores per subject have been added up, can vary per subject between 0 (as minimum, if all scores do not reach the RDA) and 16 (as maximum, when all 16 nutrients reach the RDA).

Of the total quality scores the median is calculated for every year of measurement, for the girls and boys separately. Then, for each year it is determined whether the total score of the subjects is above or below that median. If a subject scores at least three of the first four years of measurement above the median, and also at the fifth measurement, that subject will be considered to have had a relatively high quality of food (HQ) during her or his adolescence. On the other hand, if a subject scores at least three of the first four years below the median, and also at the fifth measurement, that one is classified to the group with a relatively low quality of food intake (LQ). In Table 8.2. the number of girls and boys, arranged in the relatively high (HQ) and low quality (LQ) food groups, are summarized.

Table 8.3. shows the median scores of the total scores per year of measurement for girls and boys, for the two quality food groups separately.

Table 8.3.: Medians (ranges) of the total nutrient score (0-16) for the years of measurement of girls and boys divided in the relatively high quality and the relatively low quality food group.

YEAR OF MEASUREMENT	*1*	2	*3*	*4*	5
	girls				
<u>Quality of food</u>					
'low'	9.0 (7-13)	8.6 (6-11)	9.0 (6-12)	8.8 (4-12)	8.5 (5-10)
'high'	12.2 (9-15)	11.0 (9-13)	11.6 (10-15)	12.0 (8-14)	11.8 (11-15)
	boys				
'low'	8.5 (6-11)	8.1 (6-10)	9.2. (6-11)	9.2. (6-13)	11.1 (8-12)
'high'	11.5 (7-15)	12.6 (11-15)	11.6 (8-14)	11.8 (7-14)	13.1 (13-14)

Physical Characteristics

In order to determine the relation between nutrition and health of the youngsters in this study, the following physical characteristics are taken into account:

- Body height, total body weight, and body fat measured as the sum of four skinfolds (5);
- Maximal aerobic power, measured during a treadmill test (6). The maximal aerobic intake per kg body weight ($\dot{V}O_2max/BW$) and the maximal slope of the treadmill are used as criteria of maximal aerobic power.
- Daily physical activity, based on an activity interview (7). The activity was differentiated in total activity time and activities in sportclubs. To classify activities according to their energy expenditure independent of body size (i.e. body weight), the ratio between work metabolic rate and basal metabolic rate (metabolic equivalent, MET) was used (8).

  The interview was limited to activities with a minimal intensity level of approximately 4 times the basal metabolic rate (4 METs), which equals walking with a speed of approximately 5 km/hour. Sports and non-sports activities were scored separately. The activities scored were subdivided into three levels of intensity, i.e. light, medium-heavy, and heavy activities in accordance with the three highest activity levels used by the WHO (8). They correspond to a relative energy expenditure of 4 - 7 METs for light physical activities (e.g. walking, baseball), 7 - 10 METs for medium-heavy activities (e.g. tennis, gymnastics), and 10 METs or more for heavy activities (e.g. soccer, basketball). The classification of types of activities in the three intensity levels was based on the average energy expenditure reported in the literature (7,9). The interview gathered the average weekly time spent during the previous 3 months in each of the three activity categories with a minimum of 5 minutes.

  In addition, a weighed activity score, combining duration and intensity, was calculated. The time spent per week per level of intensity was multiplied by a fixed value for the relative energy expenditure at that level; 5.5 METs for the light activities, 8.5 METs for the medium-heavy activities, and 11.5 METs for the heavy

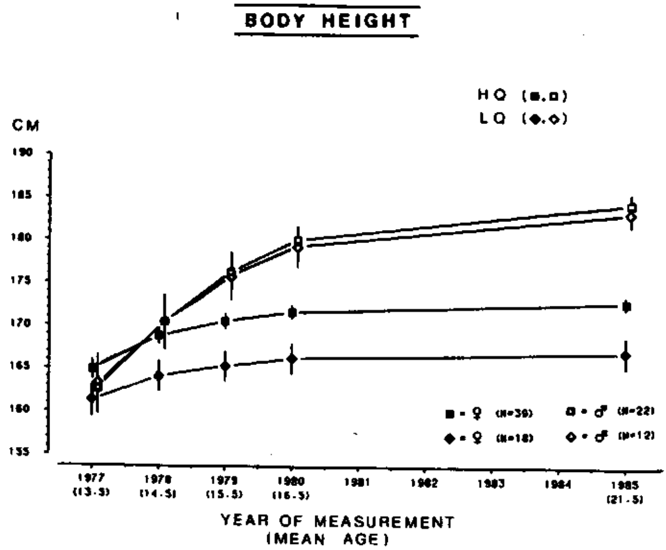

Figure 8.1.: Mean and standard error of body height (cm) of girls and boys with relatively high quality (HQ) and relatively low quality (LQ) diet, over the five years of measurement.

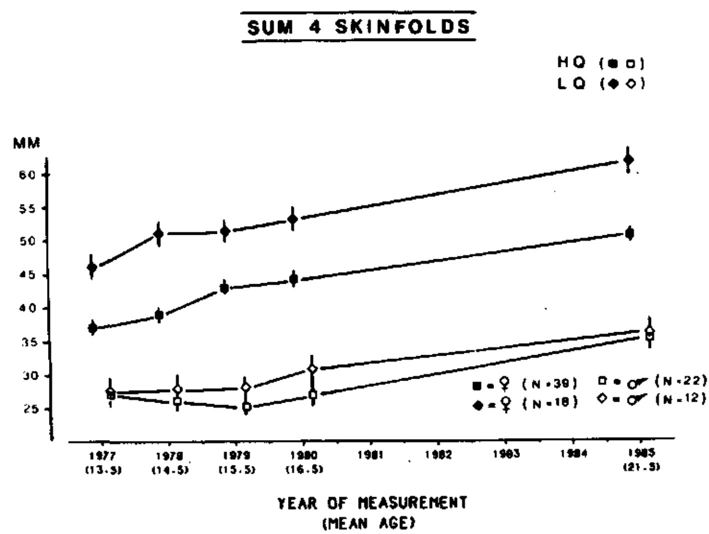

Figure 8.2.: Mean and standard error of the sum of 4 skinfolds (mm) of girls and boys with relatively high quality (HQ) and relatively low quality (LQ) diet, over the five years of measurement.

activities. The score of the three levels was added to a weighed activity score (METs/week).

Statistical Methods

The data are arranged according to the year of measurement for both sexes. The differences were tested using analysis of variance with repeated measurements (ANOVA) (10).

To test the influence of the different sources of variation within the total variance, a distinction has been made between the estimates of the variance caused by;

- the effects of time of measurement. The tests are carried out separately over the first four years of measurement (school period, mean ages of 13 to 17 years old), and over the last two years of measurement (period after school, mean ages of 17 to 21).
- the effects of 'food quality'; differences between the groups with relatively high and low quality of food intake;
- the effects of the interaction between food quality and time. This interaction effect analyses whether the development in time of the dependent variables differs between both food quality groups.

A critical region of $P < 0.05$ is used, to test the significance of the food quality effects and interaction of food quality with time of measurement.

Results

In order to examine whether the various food items in the selected 'high' and 'low' quality groups differ significantly ($P < 0.05$) on the sixteen nutrient criteria, this is tested each year with a t-test. The HQ group is considered to show a higher mean daily nutrient intake, and lower intakes of other nutrients, according to the recommendations (RDA), when compared to the intake of LQ group. In Table 8.4. it is demonstrated that four vitamins (except ascorbic acid), the two minerals calcium and total iron, the protein and the dietary fibre differ significantly between the two quality groups during at least three of

Table 8.4.: Results of the t-tests of sixteen nutrients between the two quality food groups and the five years of measurement.

NUTRIENTS	*GIRLS*	*BOYS*
Energy/body weight	*HQ	-
Protein/body weight	**HQ	**HQ
Fat	-	-
PUFA	-	-
Carbohydrate	-	*LQ
Mono/disacch.	-	**LQ
Polysacch.	-	-
Calcium	**HQ	**HQ
Iron	**HQ	**HQ
Retinol	**HQ	**HQ
Thiamin	**HQ	**HQ
Riboflavin	**HQ	**HQ
Pyridoxine	**HQ	**HQ
Ascorbic acid	-	-
Cholesterol	**HQ	-
Dietary fibre	**HQ	**HQ

- = the differences are not significant ($P<0.05$) in at least three of the five years;
* = the differences are significant ($P<0.05$) in at least three of the five years;
** = the differences are significant ($P<0.05$) in at least four of the five years.
HQ = High Quality food group have a higher mean intake,
LQ = Low Quality food group have a higher mean intake.

the five years of measurement. This is not the case with the other nutrients.

Concerning the physical characteristics (Table 8.5.), the girls with a HQ are significantly taller (Figure 8.1.), and have smaller skinfolds (Figure 8.2.) than the girls with LQ. They also possess a higher maximal aerobic power ($\dot{V}O_2max/BW$), and reach a higher maximal slope on the treadmill. The total time of these girls spent on activity, is also significantly higher (Figure 8.3.). These differences are present at all years of measurement.

Regarding boys, hardly any significant difference can be shown (Table 8.5.). Only between the fourth and the fifth measurement the boys with HQ have a significantly higher maximal aerobic power ($\dot{V}O_2max/BW$) compared to boys with LQ.

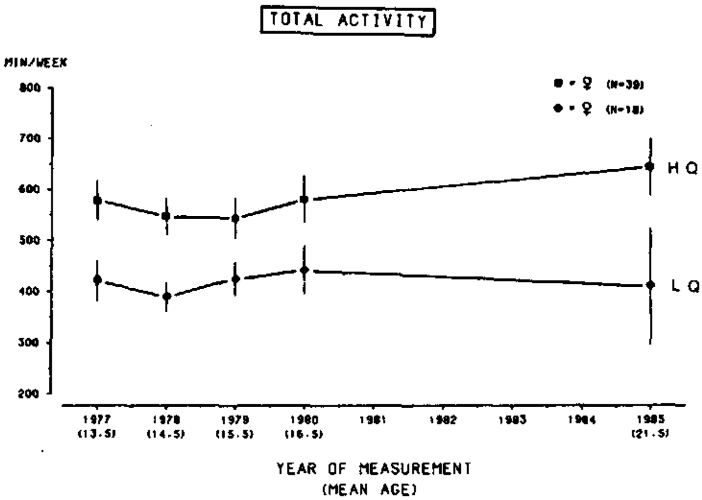

Figure 8.3.: Mean and standard error of total activity time (minutes per week) of girls with relatively high quality (HQ) and relatively low quality (LQ) diet, over the five years of measurement.

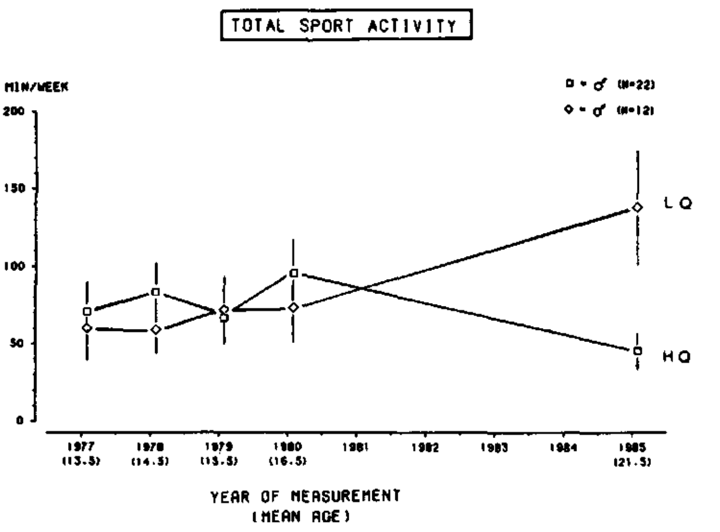

Figure 8.4.: Mean and standard error of total sports activity time (minutes per week) of boys with relatively high quality diet (HQ) and relatively low quality diet (LQ), over the five years of measurement.

Table 8.5.: Analysis of variance (ANOVA) testing the effects of different food quality (high versus low quality), and the interaction between quality of food and time for girls and boys on body composition, physiological and activity measurements, during the schoolperiod (measurement 1-4) and the period after school (measurement 4-5).

	EFFECTS			
	quality of food		***interaction***	
year of measurement	1 - 4	4 - 5	1 - 4	4 - 5
girls				
Height	*HQ	*HQ	-	-
Weight	-	-	-	-
Sum of 4 skinfolds	*LQ	*LQ	-	-
$\dot{V}O_2max$ / BW	*HQ	*HQ	-	-
Maximal slope	*HQ	*HQ	-	-
Sports activity	-	-	-	-
Total activity	*HQ	*HQ	-	-
boys				
Height	-	-	-	-
Weight	-	-	-	-
Sum of 4 skinfolds	-	-	-	-
$\dot{V}O_2max$ / BW	-	*HQ	-	-
Maximal slope	-	-	-	-
Sports activity	-	-	-	*LQ
Total activity	-	-	-	-

* = $P < 0.05$; - = not significant
HQ = High Quality food group higher mean values;
LQ = Low Quality food group higher mean values.

No interaction effects between food quality and time of measurement can be demonstrated in girls. In boys only in one case interaction was demonstrated: In the period after school (between the fourth and the fifth measurement) boys with LQ devote significantly more time to sports activities, than boys of the HQ (Figure 8.4.).

Discussion

As part of the selection procedure it was not necessary for the two quality food groups to score significantly different on all the sixteen nutrients. In Table 8.4. it is shown that the percentages of energy supplied by fat, linoleic acid, carbohydrate, polysaccharides and mono-/disaccharides do not show a significant difference between the two quality food groups for girls. In boys almost the same pattern is found. It is possible that the ranges of + or - 30 percent deviation used in these macro-nutrients, are too wide to differentiate between HQ and LQ. Making the overall criteria stronger, e.g. that the HQ should have a score of more than 10 points in four of the five measurements, the groups would be left with a too small number. Therefore, it is possible that the HQ will not necessarily have the healthiest food pattern in all aspects. Although the differences between HQ and LQ may not be as great as desired, in any case these differences are consistent over the whole period: at least four of the five years. The nutrient intake was significantly higher in the HQ compared to the LQ, concerning four out of five vitamins, the minerals calcium and iron, protein and dietary fibre (Table 8.4.). Maybe, a smaller allowed range for the macro-nutrients is more sensible.

Boys in the two quality groups show a significant difference in percentages energy (en %) from carbohydrate (Table 8.4.). However, this difference is in the opposite direction; LQ boys eat more carbohydrate (en %) in comparison with the HQ boys. It appears that this is caused by a higher percentage of energy from mono-/disaccharides.

The results of this study indeed show relations between a relative high quality of the diet and a better body composition and higher physical performances, but only in girls (Figure 8.1.,8.2.,8.3.). HQ girls are taller, have thinner skinfolds and show a higher maximal aerobic power, than LQ girls. Because these differences are already present at the age of 13, at the start of the study, and because the differences do not increase over the years, the differences in the quality of the food intake cannot be taken as the cause of the physical differences between the HQ and the LQ girls. Nevertheless, it is possible that the relative

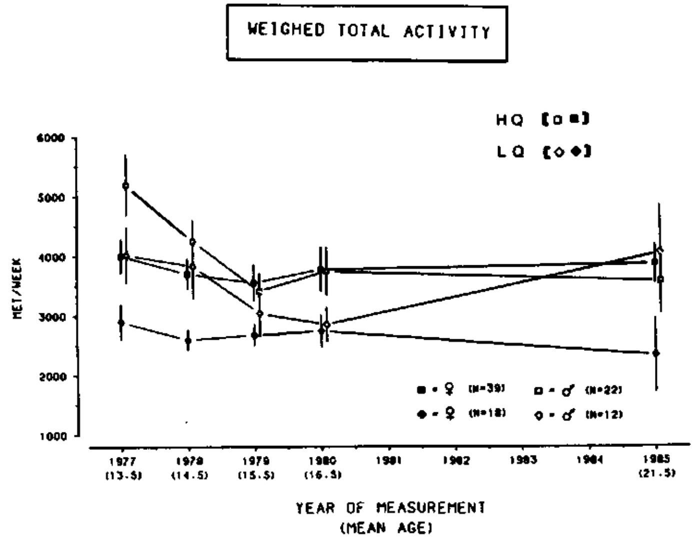

Figure 8.5.: Mean and standard error of the weighed total activity score (Mets/week) of girls and boys with relatively high quality (HQ) and relatively low quality (LQ) diet, over the five years of measurement.

HQ diet existed long before the adolescent period, and may have caused the differences at a much earlier stage.

In Table 8.4. an indication of opposite direction is given for girls with HQ, concerning the energy intake. The expectation was that the HQ girls would have a lower energy intake per kg body weight compared to the LQ girls. However, HQ girls appear to consume significantly more energy per kilogram body weight, than the LQ girls. These HQ girls have also a lower fat mass. Figure 8.3. shows that the HQ girls have (significantly) higher total activity time in minutes per week, than LQ girls. The intensity of the activities, shown as weighed total activity (Figure 8.5.), is also significantly higher in HQ girls. This may explain why HQ girls despite a higher energy intake do not have a higher fat mass than LQ girls. Is it possible that the LQ girls have under-reported their food intake? In the literature some authors suggest that obese people systematically underreport the quantity of their food consumption (11-13). In this study the LQ girls indeed show a greater fat mass, and therefore the possibility can not be excluded that in this group girls underreport their usual food intake. Nevertheless, it is also shown that their activities are on a lower level (Figure 8.3. and 8.5.).

The fact that in boys hardly any relation is found, might be due to the small number of boys in the relatively LQ group (N=12).

In boys an interaction between the quality of food intake and the amount of sports activity, is found in the age period 17 to 21 years. LQ boys increase their sports activities from age 17 to 21 (Figure 8.4.). The LQ boys show a significantly lower aerobic power in the same period, compared with the HQ boys. Although the LQ boys become more active in sports activities than the HQ boys, this is not followed in the same period by an increase of their aerobic power. The reason for this might be that the intensity of their sports activities is not heavy enough (shown in the weighed activities, Figure 8.5.). Verschuur et al (14) showed that in boys the medium-heavy and heavy activities of sportclub members decreased significantly between the age 16.5 to 21.5. Because LQ boys especially increase their sports activities, it might be expected that they spend more time in the sports canteen as well. Therefore they possibly consume more food items available in the sports canteen. Food products in the sports canteen have a relatively high amount of carbohydrates (15). In this survey, snacks are studied separately (Chapter 4). With a t-test the nutrient intake with snacks is compared between the two quality food groups. Indeed, a significantly higher contribution of carbohydrates with snacks is found in the LQ boys. And, as stated above, the LQ boys obtain a higher percentage of energy from mono-/disaccharides than the HQ boys.

Although sports might be seen as the most important factor in keeping an active lifestyle, and maintaining a reasonable level of physical fitness (14), it may also introduce a less desirable food consumption pattern in relation to recommended allowances.

Conclusions

Relations are shown in adolescent girls between a relatively high quality diet on the one hand and a healthy body composition and high physical condition on the other hand. Because of the fact that the differences between high and low quality groups are already present at age 13, and do not increase, no cause-effect relationship can be supposed to exist in the investigated age range, 13 to 21 years.

In boys, only in the period after school an interaction effect is demonstrated: boys who become more active in sports show a relatively low quality diet.

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CHAPTER 9

The Food Intake during Adolescence in Relation to Biological Maturation

Introduction

A wide variation of nutrients have been shown to be essential for human growth, maintenance and functioning. Normal growth and development require adequate amounts of essential nutrients in proper balance. It is difficult to isolate the relationship between a particular nutrient and growth. The years of adolescence comprise a period in which sensitivity to nutritional factors seems as important, though less thoroughly studied, as in the years of infancy. The processes of metabolism and regulation, which actualize the growth pattern, utilize the nutrients provided by the diet. Any account of growth and maturation would be incomplete without reference to present knowlegde of the factors known to control these processes (1).

The growth pattern which leads the individual to the mature state is provided by genetic potential. After a steady decline of height velocity in the first decade of life, during the second decade of life the normal pattern of growth is marked by an acceleration in height growth, the so called adolescent growth spurt (2). During this acceleration there will be need for extra energy and nutrients.

Biological development of teenagers of the same calender age shows large individual differences in timing during the age of puberty. The age of peak height velocity (PHV), and sexual development differs widely when measured at calender age. Some of the teenagers will mature at an early calender age (early maturers), others much later (late maturers). Possibly these differences in development will also have their consequence on the food intake: for some years early maturers will have greater height and will be heavier than late maturers, and therefore should have the need to consume more energy.

In the study Growth, Health and Fitness of Teenagers, girls reached their highest PHV on an average between 12 and 13 years of age, and boys

one year later, between 13 and 14 years of age (3). Skeletal age is used as a measure of biological development, because it is closely related to PHV and sexual maturity. The wide range in skeletal age in girls and boys at the same calender age clearly illustrates the differences in biological development. The intra-individual differences in skeletal age in girls and boys of the same calender age in the longitudinal study are largest at age 13: with a variation from 10 to 15 years in skeletal age (4).
The purpose of this study is to describe the differences in the food composition between groups with a relatively early and late maturation, the so-called 'maturation effect'.

Methods

Subjects
The study population exists of girls and boys of the longitudinal group, who completed the five years of the study: starting at age 13 and ending at age 21. The full characteristics are described in Chapter 2.

Biological Maturation
Biological maturation is estimated as skeletal age from radiographs of the left hand and wrist, taken yearly in the first four years of the longitudinal study (5). Rating of 20 bones of the hand and wrist are assigned by comparing the ossification stage of each bone with plates, diagrams, and descriptions of the bone in question, according to the Tanner-Whitehouse II Method (6).
The girls and boys participating in this study are divided into three groups: (1) a group of early maturers (EMs); (2) a group of late maturers (LMs), and (3) the remaining group assigned as mean maturers.
The general criteria of arranging the subjects in one of the three groups are: EMs are those whose skeletal age compared to their calender age is advanced by more than three months; LMs are those whose skeletal age compared to the calender age is retarded by more than three months. Details of the procedure are described in the literature (5).
In Table 9.1. the number of girls and boys belonging to the EMs and the LMs are given.

Table 9.1.: The number of girls and boys, and the percentages of the longitudinal group, in the two maturity groups; early maturers (EMs) and late maturers (LMs).

	MATURATION GROUP			
	EMs		**LMs**	
	N	%	N	%
girls	29	28	39	38
boys	38	39	25	26

Measurement of Food Intake

The food intake is estimated with a dietary history method. This is described in Chapter 2 and 3.

Physical Characteristics

In order to determine the relation between nutrition and maturation of the youngsters in this study, the following physical characteristics are taken into account:

- Body height, total body weight, and body fat measured as the sum of four skinfolds (3);
- Daily physical activity, based on an activity interview (8). The activity was differentiated in three activity levels. Duration and intensity were combined to a weighed activity score (see Methods in Chapter 8).

Statistical Methods

All the dietary information is analyzed as described in Chapter 2, separately for both sexes with respect to early and late maturers. The data are arranged according to the year of measurement for both sexes. The differences were tested using analysis of variance with repeated measurements (ANOVA) (9).

To test the influence of the different sources of variation within the total variance, a distinction has been made between the estimates of the variance caused by;

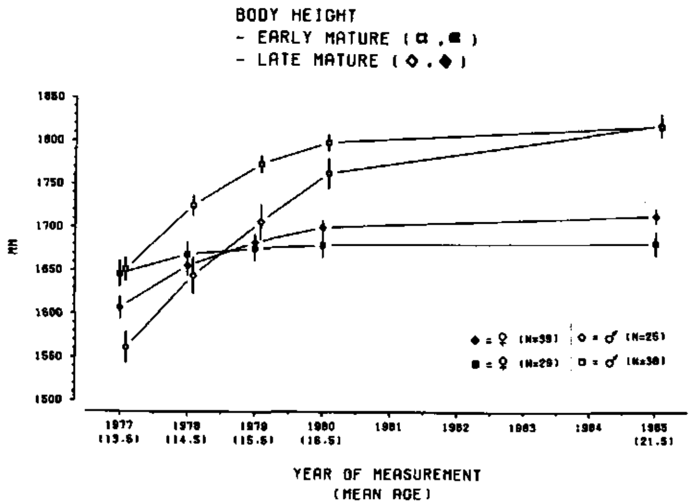

Figure 9.1.: Mean and standard error of body height (mm) of girls and boys for the groups early and late maturers separately, over the five years of measurement.

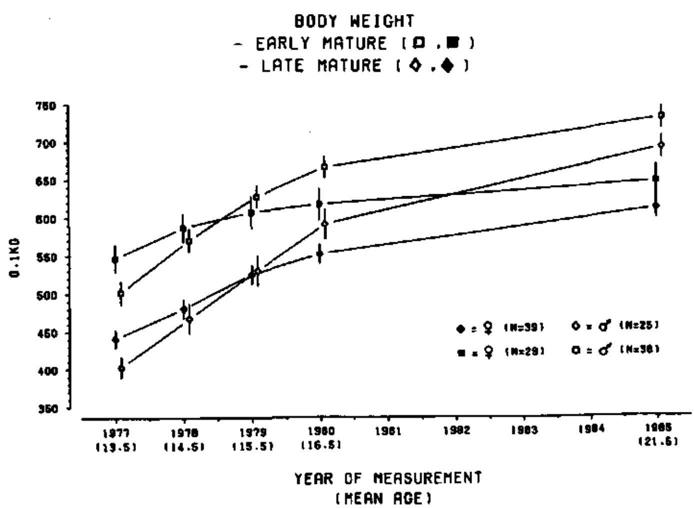

Figure 9.2.: Mean and standard error of body weight (0.1 kg) of girls and boys for the groups early and late maturers separately, over the five years of measurement.

- the effects of time of measurement. The tests are carried out separately over the first four years of measurement (school period, mean ages of 13 to 17 years old), and over the last two years of measurement (period after school, mean ages of 17 to 21).
- the effects of maturation; differences between the groups with relatively early and late maturers;
- the effects of the interaction between time and maturation. This interaction effect analyses whether the development in time of the dependent variables differs between both maturation groups.

A critical region of $P < 0.05$ is used to test the significance of maturation effects and interaction effects with time of measurement.

Results

Anthropometric variables, such as body height (Figure 9.1.) and body weight (Figure 9.2.), show that EMs, both girls and boys, are significantly taller and heavier than LMs at age 13.5. In body height the differences between EMs and LMs disappear when both groups approach the age of full maturity: girls from age 14.5 and boys from age 16.5, but EM girls are slightly shorter at adult age (5). Although the differences in body weight between the EMs and LMs become smaller, they still exist at the adult age.

In Table 9.2. an outline is given of the results of the ANOVA with levels of significance of the effects of maturation and interaction between time and maturation, separately for the two periods and separately for girls and boys.

In general, significant <u>maturation effects</u> can be demonstrated in body fat (Figure 9.3.). In both girls and boys EMs have a significantly higher sum of skinfolds than LMs. As far as the nutrient intake is concerned, LMs have significantly higher energy intake per kg body weight (Figure 9.4.), protein intake per kg body weight, and also total iron intake compared to the EMs. No significant differences could be demonstrated in calcium and vitamin (thiamin, ascorbic acid) intake.

The amount of physical activity, measured as weighed total activity is also significantly higher in LMs compared to EMs (Figure 9.5.)

Table 9.2.: Analysis of variance (ANOVA) testing the effects of maturation and the interaction between maturation and time of girls and boys on body composition, nutrient intake, and activity, and the interaction, during the schoolperiod (measurement 1-4) and the period after school (measurement 4-5).

	EFFECTS			
	maturation		***interaction***	
year of measurement	1 - 4	4 - 5	1 - 4	4 - 5
girls				
Body height	-	-	*	-
Fatmass	*EM	*EM	*	-
Energy/kg BW	*LM	*LM	-	-
Protein/kg BW	*LM	*LM	-	-
Total Iron	*LM	-	-	-
Calcium	-	-	-	-
Thiamin	-	-	-	-
Ascorbic Acid	-	-	-	-
Weighed T.Activity	*LM	*LM	-	-
boys				
Body height	*EM	*EM	*	*
Fatmass	*EM	*EM	-	-
Energy/kg BW	*LM	*LM	-	*
Protein/kg BW	*LM	*LM	-	-
Total Iron	*LM	*LM	-	-
Calcium	-	-	-	-
Thiamin	-	-	-	-
Ascorbic Acid	-	-	-	-
Weighed T.Activity	*LM	*LM	-	-

* = significant $P<0.05$; - = not significant
EM = Early maturers higher mean values;
LM = Late maturers higher mean values.

All these differences are apparent in both girls and boys, and also in both periods of measurement.

Significant <u>interaction effects</u> between maturation and time are seldom found; only in height and body fat mass. With respect to the food consumption, an interaction could only be demonstrated for the energy

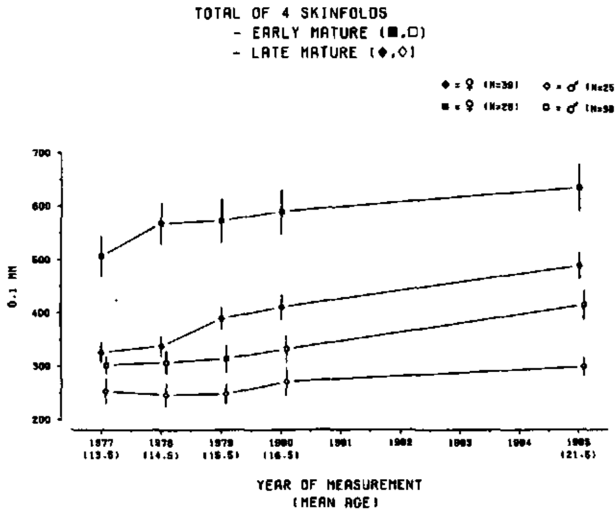

Figure 9.3.: Mean and standard error of the sum of four skinfolds (0.1 mm) of girls and boys for the groups early maturers and late maturers separately, over the five years of measurement.

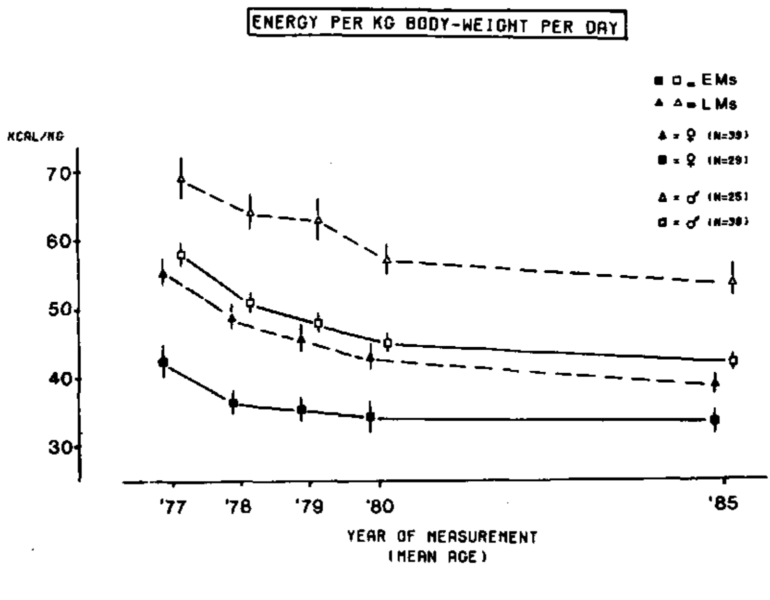

Figure 9.4.: Mean and standard error of the total energy intake per day (Kcal per kg body weight) of girls and boys for the groups early maturers (EMs) and late maturers (LMs) separately, over the five years of measurement.

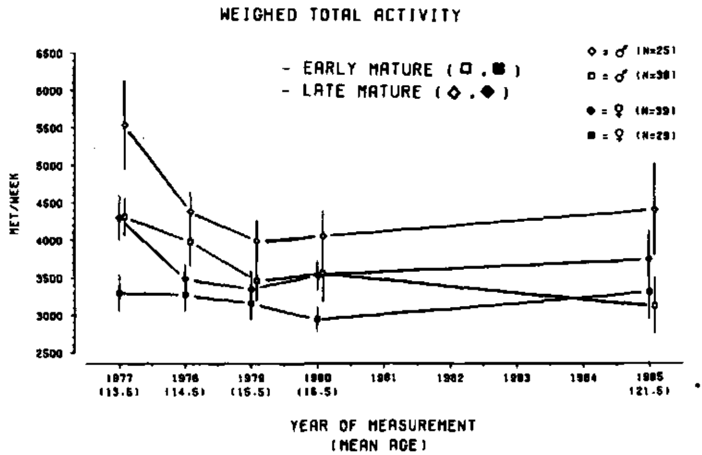

Figure 9.5.: Mean and standard error of the weighed total activity score (Mets/week) of girls and boys for the groups early and late maturers separately, over the five years of measurement.

intake per kg body weight in boys between the fourth and fifth year of measurement.

Discussion

While genetic factors at the population level may contribute to group differences in anthropometrics, specific nutrients can also be of importance to the individual growth process (10,11). In this study maturation is used as indicator of special nutrient requirements.

The LMs have consistently higher energy intakes over the EMs in both sexes, and the differences do not disappear at adult age, when both maturity groups are fully grown. Because this is an unexpected outcome, the development of body fat and the daily activity pattern are also taken into consideration.

The sum of four skinfolds in EMs is higher than in LMs, and remains higher till adult age in both girls and boys (see Figure 9.3.). A higher fat mass in EMs in combination with a lower energy intake per kg body weight, in comparison with the LMs, is even more surprising.

In an earlier publication it has been described that the EMs also have lower VO_2max/BW (7). This can be explained by the greater body fat mass.

Body fat represents an extra 'inert' load which does not contribute to the aerobic power production, but which still has to be moved during every weight-bearing daily activity, such as walking and running. This lower VO_2max/BW was hypothesized to be caused by the fact that the EMs are socialized away from sports activities at a younger calendar age, and as a consequence show less habitual activity (12).
The results of the weighed total activity of the two maturation groups (see Figure 9.5.) confirm that the EMs have a significantly lower activity level than the LMs over the whole age range. The lower energy intake of the EMs compared to the LMs (Figure 9.4.) does not compensate enough for the lower daily activity pattern, which explains the higher body fat in the EMs.
Already in 1960 Mayer (13) demonstrated in rats as well as in men that the normal regulation of the energy balance is no longer effective at extreme low activity levels: Enforcing partial immobilization of rats unavoidably leads to adiposity, and this seems also to be true for people with a sedentary lifestyle. The regulation of energy intake is no longer functional when there is a decrease to a lower activity level. This mechanism is probably at work in the EMs of this study as well: Although they consume less than the LMs this can not prevent them from getting a higher body fat mass.
Garn et al (14) studied in about 16.000 white women the relationship of maturational timing and the level of fatness, and found exactly the same results as in this study: Early maturing women are slightly shorter than their peers who mature later, but are heavier in weight and considerably fatter as well. A number of environmental variables, known to affect fatness in women are also explored, but this could not alter the results appreciably. The authors speculate about a possibly more positive energy balance in early maturers, or a greater reduction of energy expenditure, but have no evidence to prove this. In fact, the present study indicates firmly that energy intake and expenditure are involved.

Conclusion

Differences in biological maturation during adolescence also have consequences for the food intake of these youngsters. Early maturers consume less energy per kg body weight over the whole age range than late maturers. Nevertheless, they are fatter and have also a lower amount of habitual physical activity.

A late maturation seems to coincide with a more appropriate food and activity pattern during adolescence compared to an early maturation.

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CHAPTER 10

General Discussion and Conclusions

Introduction

This thesis aimed to provide information on the nutrition and nutritional adequacy of a group teenagers, following them till their young adult age.

A problem one has to face when studying human nutrition is the range of interactions which characterize human ecology. Education, demographics, wealth, and natural environment are factors which have their effect on human organism. Nutritional factors may operate independently or jointly with other environmental factors on body composition, growth and health status.

A teenage population was chosen for two reasons: First, because research in this age group was very scarce, and secondly because in this age group very important changes occur in the physical and psychological development which may play a role in their health in later life.

The nutrient needs of individual teenagers differ greatly. Although average figures of nutrient intakes show an adequate nutritional situation for the group of teenagers, one cannot rule out the possibility that there will be individuals with deficient intakes.

Methods

The epidemiological study presented in this thesis is an observational research from the type of a prospective cohort study (1,2).

The purpose was to establish changes over age in the food intake and to relate them with growth, body composition, and performance measures of the same population.

In observational research, without explicit intervention of any kind, it is very difficult, or hardly possible, to demonstrate that significant changes in lifestyle, coinciding with changes in health parameters, can be explained as cause-effect relationships.

First of all it must be pointed out that dietary changes seen in teenagers, both in amount or composition of food intake, must always be related to the changes in body composition of the population over the same age period. In itself an increase of the total energy intake gives invalid information about the health status of this population, when information on growth rate is not taken into consideration.

Secondly, statistically significant correlations between measured dietary changes on the one hand, and unhealthy lifestyles and decreased health parameters on the other hand, can never be explained as cause-effect relationships.

The multiple longitudinal design of this study made use of more than one birth cohort. Together with the inclusion of a control group this offered an opportunity to combine the strength of a longitudinal design with testing statistically the possible interfering factors.

Interperiod correlations

The strength of prospective cohort studies is that individual changes can be measured over time. To distinguish the changes in dietary intake over age a reliable method assessing individual food consumption is needed. If the error of the estimate of the dietary measurement is larger than that of the age effects, the latter cannot be detected. In this study the reproducibility of the dietary history is pointed out by means of interperiod correlations:

a. the slope of the regression line gives an indication of the change of the parameter in question;

b. the interpolation to the intersection with the Y-axis, where the interperiod is zero, gives the theoretical test-retest reproducibility of the parameter.

The 'perfect' variable to show age effects has a steep slope of the regression line, and a correlation equal to one. In this study these statistical analyses were executed for girls and boys separately for four aspects of the food consumption:

- the total energy intake;
- the total protein intake;
- the total fat intake;
- the total carbohydrate intake.

The data of the first four measurements (1977, 1978, 1979,1980) are analysed. The results of three interperiods (one, two and three years) are illustrated in figure 10.1..

In general there are no differences in girls and boys. The interperiod correlations of energy, fat and carbohydrate decrease from circa 0.7 at one year intervals to circa 0.5 at three year interval. In protein the correlations are somewhat lower: 0.6 (one year intervals) and 0.4 (three year interval). The estimated zero interval is 0.8 in energy, fat and carbohydrate, and 0.7 in protein.

These results show that mean changes in food intake over age seem to reflect the food consumption sufficiently precise. In comparison with other well established biological parameters, such as maximal oxygen uptake or percentage body fat, the dietary assessments are as accurate, and even better than e.g. the measurement of diastolic blood pressure (3,4). So, the data of the food consumption data can be considered exact enough to indicate differences between groups of teenagers.

Interfering effects

Possible interfering effects are summarised in Table 10.1. for the variables energy, protein, fat and carbohydrate. Other nutrients are not studied in this respect. In girls no significant effects are detected. In boys test-effects are observed in the total energy, protein and carbohydrate intake. The increase in energy, and carbohydrate intakes of the groups of the control school is systematically higher than in the longitudinal observed group. The intake of protein is also higher in the controls compared to the boys in the longitudinal group, but the differences are already present at the start of the study. Socio-economical differences between the control and the longitudinal observed group possibly explain the differences between the schools. The

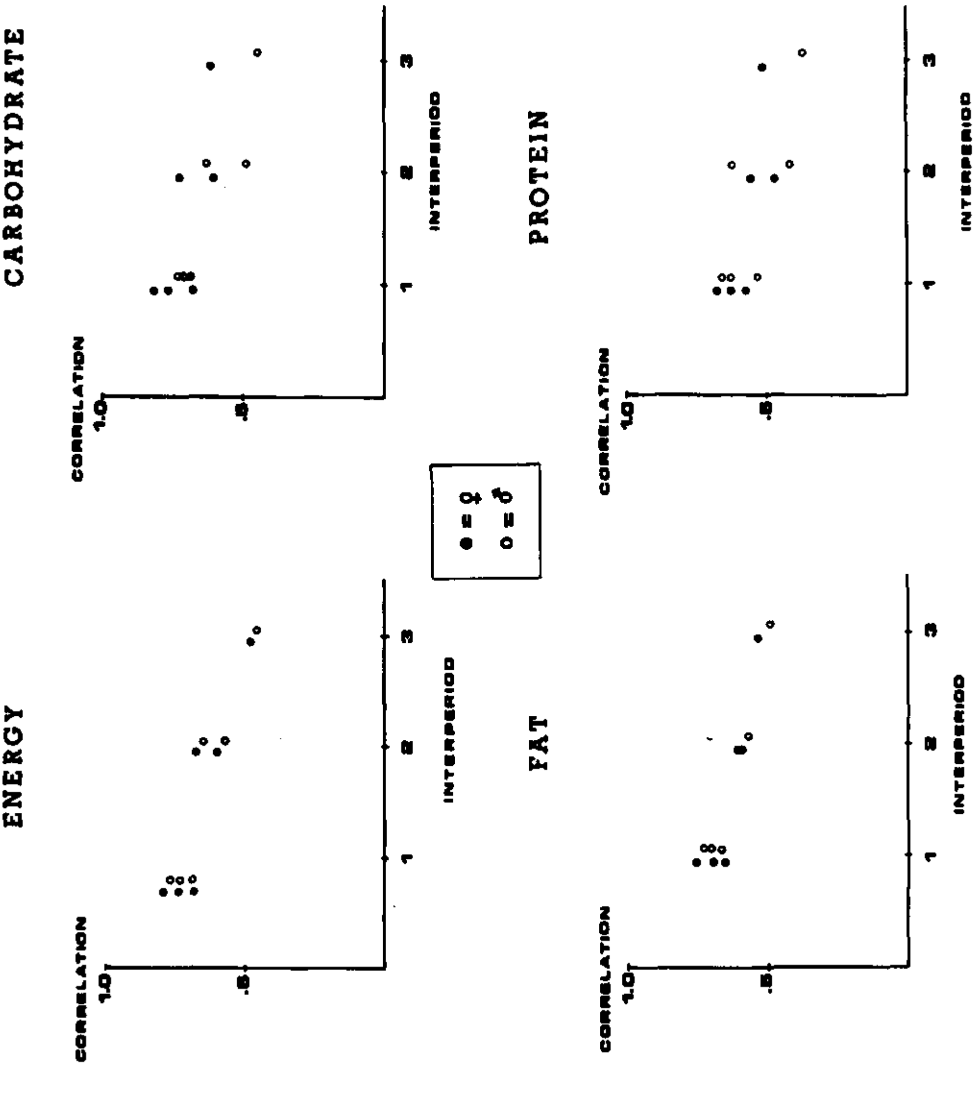

Figure 10.1. The interperiod correlations of the assessment of the intake of energy, fat, carbohydrate and protein, in teenage girls and boys, during the first four years of measurement.

level of occupation, education and income of the parents of the control groups is higher than of those of the children in the longitudinal observed group (5). In literature it is indicated that there is a positive relation between socio-economic level and protein intake (6-8). Therefore, the higher protein intake observed in this study in the control group may be explained by the higher social class of this group. In the girls this relationship is not found. Hackett didn't find any effect in girls either (6).

Table 10.1.: Interfering effects that could be demonstrated in the measurements of the food intake of teenage girls and boys.

INTERFERING EFFECTS	*GIRLS*	*BOYS*
Time of measurement	-	-
Cohort	-	-
Testing	-	energy/carbohydrate energy of snacks/protein*
Drop-out	-	-

* School effect, - no effect

The higher total energy intake in the boys of the control groups compared to boys in the longitudinal observed group is remarkable because the results of the measurement of the snacking habits show that boys of the control groups have systematically lower scores in the energy intake from snacks. However, this effect is only found on schooldays, and not on weekend days. An important explanation is, that during school hours a mobile snackbar was present in the vicinity of the longitudinal school (not with the control school). Boys use relatively more snacks than girls, and this may explain the differing observation between boys and girls.

Summarizing, the results of measuring the food intake with the dietary history on a longitudinal basis, as an average over age groups, are not disturbed at all by any interfering effect in teenage girls. Only teenage boys show serious test-effects that could have masked in some aspects the mean age effects.

Nutritional adequacy of the diet

The proportion of energy in the diet of adolescent girls and boys derived from protein, fat and carbohydrate are typically Western; compared to the recommendations they consume a high intake of fat and a low intake of carbohydrate, especially of the polysaccharides.

When the dietary intakes are compared to the recommendedations it can be concluded that most nutrient intakes are adequately met. Only three nutrients will be discussed in more detail; fat, iron and calcium.

The intake of dietary fat comes mainly from animal rather than vegetable sources, which results in a low ratio of poly-unsaturated to saturated fat. When identifying youngsters at risk for cardio-vascular diseases, the level of fat intake may be of mayor importance. In this study it is obvious that adolescents who consume too much fat, also consume too much saturated fat. On the other hand the consumption of dietary cholesterol does not exceed the recommendations, but notice the increased intake seen at the young adult age. The levels of serum cholesterol in this longitudinal study are relatively constant in girls during the first four years of measurement, whereas in boys a gradually decrease is observed. However, at the adult age both sexes showed increased mean values (9). The multi-factorial nature of cardio-vascular diseases indicates that not only the dietary cholesterol and/or the saturated fat intake is to blame. Other risk factors, for instance obesity and physical inactivity, may also be of importance and in need of modification.

In most Western countries an iron consumption of girls between 10 - 13 mg is found. As the recommended dietary intakes for adolescents is 15 mg, it may be concluded that a significant number of adolescents are at risk of iron deficiency. Adolescents are particularly susceptible to iron deficiency anemia in view of the period of rapid growth, when blood volume and muscle mass are increasing. In this longitudinal study it is

found that the estimated muscle mass (from anthropometric measurements of the upper arm and legs) of boys after peak height velocity exceeds that of girls; whereas the muscle mass in girls increases about 10 % during the teenage period, in boys the increase is about 25 % (10). Boys indeed increase their iron consumption during this growth period, whereas girls consume about 11 mg daily regularly. It is evident that adolescence is a period during which there is an increased need of dietary iron, but often there is little or no change in the iron consumption. Therefore, the consumption of iron-containing food products must be stimulated during adolescence, especially in girls.
Another important nutrient during adolescence growth is the daily intake of calcium. There is some evidence that the consequences of limiting dietary calcium in adolescence may lead to reduced bone density, which may predispose an individual to osteoporosis in later life (11). Milk must be considered as important in contributing to calcium intake. Although, in the present study, the milk consumption is not in agreement with the Dutch recommended serving sizes, the amount during the adolescent period is constant, whereas the consumption of cheese (even more important in the calcium contribution) tends to increase with age. Because the calcium intake increases with age, in both sexes, an adequate intake is foreseen in these youngsters.

Conclusions

- Adolescent girls show an almost constant total energy intake of 9.5 mJ during the whole age range, from 12 to 21 years of age. The total energy intake of boys gradually increases from 11.5 mJ at age 12 to 14 mJ at the age of 21 years.

  The total energy intake of both sexes during weekend days is consistently 10 % higher, compared to schooldays.
- In both sexes the proportion of the energy supplied by fat is circa 5 % higher than, by carbohydrate 5 to 10 % lower than, and by protein equal to the recommended dietary intakes (Netherlands Nutrition Council) (12).

The relatively high contribution of saturated fatty acids and mono-/disaccharides, and the low contribution of dietary fibre must be considered as a rather undesirable food pattern.

- The alcohol consumption increases strongly over age. While 10 % of these adolescents at age 13 consume alcoholic beverages, at age 21 this percentage is 75. The mean amount of alcohol at age 21 is in females 7 gram/day and in males 18 gram/day. Because it is observed that most of this alcohol consumption takes place during the weekend, especially in boys these high quantities might be seen as detrimental to health.
- In general, the mineral and vitamin intake is comparable to the recommended dietary intakes. There is one exception: during the whole age period girls have a low iron intake (circa 75 % of the RDA's), and this is undesirable.
- Snacks, defined in this thesis as food items eaten between meals and belonging to sweets, drinks and snackbar items, supply 20 to 25 % of the total daily energy intake in both sexes, and at all ages. The intake on weekend days is about 30 %, and on schooldays about 20 %, this may be due to the increased tendency to eat snacks rather than meals in the weekend.

  It is remarkable that the energy supply in snacks by protein, fat and carbohydrate is different from that of the three main meals: 2 % less protein, 5 - 10 % less fat, and equal to 10 % more carbohydrate. This means that in general the composition of snacks is more in line with the dietary guidelines of the Nutrition Council than the main meals.

  The nutrient density is different: Snacks contribute about 10 % of the mineral intake (calcium/iron), and 5 to 25 % of the vitamins (ca. 5 % pyridoxine, 8 % riboflavin, 10 % retinol/thiamin, 10 - 25 % ascorbic acid). It seems obvious that some nutrient-dense foods are being consumed as components of snacks, and thus improve the overall dietary intake.
- When comparing the teenage food pattern with the principles of the meal-planning-disk it is shown that generally speaking the nutrient contribution of the foods consumed do not indicate a recommended supply from the four segments: e.g. the food products from segment 4

('fat segment') contribute less to the fat intake than the food products in segment 3 ('protein segment'). This is caused by the low specificity of the nutrient definitions in the meal planning disk.

- The recommended quantities of food products in the meal-planning-disk need more details about substitution of one food product by another to fulfil the nutrient requirements. The participants in this study show a lower consumption of milk and milkproducts than recommended without causing a low intake of protein and calcium. Compensation is given by the relatively high consumption of cheese.
- Girls consuming a diet with a relatively high quality are taller, leaner, do have a better aerobic power and are also more physically active than their age peers with a relatively low quality diet. This observation is already present at age 13 and does not change till the age of 21 years.

  In boys, generally, associations between high or low quality diets and health indicators cannot be demonstrated. Nevertheless, boys with a low quality diet increase their sports participation from age 17 to 21 compared to the boys with a high quality diet. Although sports might be seen as a very important health factor, in this study it is associated with a less desirable food consumption pattern.
- Differences in the rate of biological maturation seem to have consequences for the food intake during adolescence. Early maturing girls and boys consume less energy per kg body weight than late maturers. Nevertheless the early maturers are fatter and show lower physical activity. This phenomenon can be observed from age 13 to 21. A late maturation seems therefore to coincide with a more appropriate food pattern.

The nutritional problems in this age category do not seem to be from a specific nature and are very much the same as described for the Dutch population as a whole (13,14). Therefore, the **general conclusion** drawn from this study can be that in this group of adolescents no inadequate diet can be shown, but merely some inappropriate aspects of their food intake:

- The overall high fat consumption of girls as well as boys, together with a high contribution of mono-/disaccharides.
- The remarkable increase in the consumption of alcoholic beverages of girls and boys, especially during weekends.
- The borderline intake of iron in girls.

Extra attention to these aspects should be paid during this age period.

Finally, it is necessary to realize that the group of adolescents, described in this thesis, have a relatively high socio-demographic background, and therefore may be priviliged. Given the present findings, it will be interesting to investigate the nutritional situation in groups of adolescents with a lower socio-economical background.

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SUMMARY

In general, this thesis describes and discusses the longitudinal assessed changes in the dietary pattern of a group of adolescents over a period of almost 10 years. The chapters 4,5 and 6 focus on the teenage period, from 12 to 17 years of age, whereas the chapters 7,8 and 9 deal with the period during adolescence as a whole, from about 12 to 21 years of age.

The introduction to this dissertation (chapter 1) provides background information on the origins of this longitudinal study in general, and the influence of the amount and composition of diet on growth, health and fitness during this age period in particular. Eating patterns, either under or overnutrition, can affect health. Literature is reviewed, especially other longitudinal surveys concerning growth and development in adolescents. Design, methods and study populations are different in most of them. Therefore, the presented longitudinal survey in this thesis is seen as rather unique. The main goals of the study are:

1. to obtain information about the daily energy and nutrient intake;
2. to compare food quality and quantity with the recommendations;
3. to analyse relationships between nutrient intake and physiological measurements.

Chapter 2 describes the methodology of the multiple longitudinal design, selection of subjects, and of the interview technique used to establish the daily food intake.
The study is divided into two parts: (1) a four year longitudinal survey 'Growth, Health and Fitness of Teenagers', and (2) a follow-up study 'From Teenager to Adult'.
The longitudinal observed subjects are pupils of a school population in Amsterdam (pre-university education). The longitudinal group consists in the first part of the study of 131 girls and 102 boys. The control group, 159 girls and 133 boys, is taken from an identical school population, but in another city nearby. In the follow-up study the subjects are those of the longitudinal group, 103 girls and 97 boys.

To select the appropriate method for the food consumption measurements in a teenage population a pilot-study was conducted (chapter 3). In a test-retest design the 24-hour recall and the dietary history were assessed (interval 4 - 6 weeks) in two groups (12/13 and 15/16 years old). The 24-hour recall shows the greatest intra-individual differences. The dietary history shows a tendency to lower energy intake in the second measurement compared to the first one. The dietary history is chosen (a) because of a practical reason: more pupils can be interviewed by one dietician during one week, and (b) because test-effects in the design of the study can be checked with adequate control groups.

The longitudinal assessed changes in intake of energy and nutrients over the first four measurements are given in chapter 4. Special reference is made of differences between schooldays and weekend days. Overall, higher nutrient intakes are found on weekend days. When growing older, girls show only small changes in intake, whereas in boys the nutrient intake increases gradually with age. The proportional intakes of fat and mono/disaccharides are rather high, especially in the weekend. Compared to the recommendations of the Nutrition Council the intakes of poly-unsaturated fat and poly-saccharides are rather low, and especially in girls the iron intake is found to be borderline. The consumption of alcoholic drinks increases in both sexes, but more extremely so in boys.

Chapter 5 gives special attention to the snacking habits of teenagers, during the first four years of the study. The energy intake from snacks for girls remains about 22 percent of the total daily intake when growing older. In boys, snacks contribute 20 percent of the total daily energy at age 12, but increases to 26 percent at age 17. On weekend days the energy intake from snacks is twice as high as on schooldays, in both sexes. Snacks supply about 10 percent of the daily protein intake, and about 20 percent of the daily fat intake. The contribution of minerals and vitamins from snacks varies between 5 and 25 percent of the daily intake. A strong increase with age is seen in the percentages of girls and boys who start drinking alcoholic beverages (4 to 68 %), together with the consumed amounts of alcohol (girls from 1 to 11 g/day, boys 1 to 29 g/day). Especially during weekends a high alcohol intake is found particularly in boys.

The quality and quantity of the teenager's nutrition in relation to guidelines of a nutrition education model, the meal-planning-disk, are described in chapter 6. Differentiation is made between: (a) the contribution of the consumed food products to the total nutrient intake, expressed as percentages of each of the nutrients present in each segment of the meal-planning-disk; and (b) the consumption of food groups compared with recommended portion sizes.
The sources of nutrients as described for the meal-planning-disk are not sufficient specific to promote healthy food habits. To obtain an adequate diet, the recommendations leave out of discussion the possibilities of interchange between food products.

Chapter 7 presents the results of the longitudinal survey over the entire age period, 12 to 21 years old. Girls show an almost constant energy intake of 9.5 mJ per day. In boys the energy intake increases from 11.5 mJ to 13.8 mJ in the period from teenager to adult. At the young adult age (21 years) the total daily food intake does not contribute enough poly-unsaturated fat and polysaccharides, compared to the Dutch recommendations, but too much saturated fat and mono/disaccharides. The alcohol consumption increases strongly, mostly during the weekends. Snacks supply about 20 to 25 percent of the total daily energy intake, an amount generally speaking not resulting in a nutrient deficiency.
In both sexes some overconsumption of energy is likely, because both sexes show an increase in their total percentage of body fat.

Chapter 8 focusses on the relation of the food quality to health and fitness aspects during adolescence. Based on the recommended dietary intakes for nutrients two groups are formed with relative high and relative low quality of food intake over the years. Relations are shown between high quality diet and a better body composition and better physical performances in girls. No cause-effect relationship can be shown. In boys an unexpected interaction effect is demonstrated in the period after school, between the age of 17 to 21: Boys with a relative low quality diet show an increased amount of sports activities.

Chapter 9 deals with the food intake and the relationship of early or late maturation (indicated by skeletal age). Early maturers, in both sexes, consume less energy per kg body weight than late maturers during the whole study period. Early consumers are fatter and show a lower amount of habitual physical activity. The conclusion is that late maturers seem to introduce healthier lifestyles than early maturers.

Chapter 10 provides a general discussion of the material covered by this dissertation. The strength of the study is pointed out by the possibility of checking for interfering factors, such as cohort, time of measurement and tests effects. Analysis of the results of interperiod correlations of the food consumption measurements illustrates the reliability of the method.
The interview method is not sufficiently precise to detect individual changes over time, but is enough precise to show changes in group-means over age. No test-effects are demonstrated in girls. Only in boys test-effects are found in the total energy and carbohydrate intake, which may have masked some age effects.
The nutritional adequacy of the measured diet is compared to the recommendations in the Netherlands with respect to risk factors of cardio vascular diseases. Especially the low ratio between the unsaturated and saturated fat, and the cholesterol intake are discussed. Other concerns of the Western food consumption are discussed as well, such as the iron intake of girls, and the calcium intake, both important minerals during growth and development.
Finally a summary is given of the most important conclusions.
The population in this study represents a relatively high socio-demographic class. To gain a clear understanding of the nutritional situation in Dutch adolescents as a whole, a study in less 'well-to-do' groups seems necessary.

SAMENVATTING

In dit proefschrift worden de longitudinale veranderingen in het voedingspatroon beschreven van een groep adolescenten over een periode van ongeveer 10 jaar. De hoofdstukken 4, 5 en 6 betreffen de tienerperiode, meisjes en jongens in de leeftijd van 12 tot 17 jaar, terwijl de hoofdstukken 7, 8 en 9 de veranderingen over de hele leeftijdsperiode beschrijven, namenlijk van 12 tot 21 jaar.

De inleiding (hoofdstuk 1) schetst de algemene achtergronden van waaruit dit longitudinale onderzoek is opgezet, en meer in het bijzonder de invloed van de hoeveelheid en samenstelling van de voeding op de groei, gezondheid en fitheid gedurende deze leeftijdsfase. Het in dit proefschrift beschreven onderzoek wordt geplaatst tegenover eerder uitgevoerd longitudinaal onderzoek bij adolescenten. Meestal verschillen deze onderzoekingen wat betreft opzet, methoden en onderzochte populaties.De voornaamste doelstellingen van dit onderzoek zijn:

1. het verkrijgen van informatie over de dagelijkse energie en voedingsstofinname van adolescenten;
2. het vergelijken van de kwaliteit en de kwantiteit van de gekonsumeerde voeding met daarvoor geldende aanbevelingen;
2. het nagaan van relaties bij de onderzochte jongeren tussen de voedingsstofinname enerzijds en lichamelijke kenmerken anderzijds.

Hoofdstuk 2 beschrijft de methodologie van de multipel-longitudinale opzet, de selectie van de proefpersonen, en de gebruikte interviewmethode om de dagelijkse voedselkonsumptie te schatten.
Het onderzoek bestaat uit twee delen: (1) een vierjarig longitudinaal onderzoek "Groei en Gezondheid van Tieners', en (2) een vervolgstudie vijf jaar later 'Van Tiener tot Volwassene'.
De longitudinaal onderzochte proefpersonen zijn leerlingen van een schoolpopulatie in Amsterdam (VWO/HAVO-nivo). In het eerste deel van het onderzoek bestaat de longitudinale groep uit 131 meisjes en 102 jongens. Als kontrole groep zijn onderzocht 159 meisjes en 133 jongens van een

vergelijkbare schoolpopulatie, echter uit een andere stad (Purmerend). In de vervolgstudie zijn alleen de proefpersonen van de longitudinale groep onderzocht, 103 meisjes en 97 jongens.

Om de meest geschikte methode te selekteren voor het voedselkonsumptieonderzoek gedurende de tienerperiode, is een vooronderzoek uitgevoerd (hoofdstuk 3). Met behulp van de 24-uurs navraagmethode en de kruisvraagmethode zijn de voedingsgewoonten in twee verschillende leeftijdsgroepen (12/13 en 15/16 jarigen) met een tussenperiode van 4 tot 6 weken tweemaal bepaald. De 24-uurs navraag geeft de grootste intra-individuele verschillen. De kruisvraagmethode vertoonde een tendens tot een lagere opgave van de energie-inname bij de tweede meting in vergelijking tot de eerste. De kruisvraagmethode is verkozen (a) om een praktische reden: meer leerlingen kunnen worden geinterviewd door een diëtiste in één week, en (b) omdat eventuele test-effekten nagegaan kunnen worden met behulp van kontrolegroepen waarbij geen herhaalde metingen plaatsvinden.

De longitudinale veranderingen van de inname van energie en voedingsstoffen tijdens de eerste vier jaren van het onderzoek zijn apart beschreven voor school- en weekenddagen in hoofdstuk 4. In het algemeen is de inname van voedingsstoffen in het weekend groter. Bij het ouder worden vertonen meisjes slechts geringe verschillen in inname, terwijl deze bij jongens gestaag toeneemt. De procentuele energiebijdrage van vet en mono-/disacchariden is nogal groot, vooral in het weekend. Vergeleken met de aanbevelingen van de Voedingsraad is de inname van meervoudig onverzadigde vetten en polysacchariden te laag, en speciaal bij meisjes wordt een marginale ijzerinname gevonden. De konsumptie van alkoholische dranken stijgt in beide sexen, echter meer bij jongens.

Hoofdstuk 5 behandelt de snackgewoonten van de tieners gedurende de eerste vier jaren van het onderzoek. De energie-inname uit snacks bij meisjes blijft als zij ouder worden ongeveer 22 procent van de dagelijkse inname. Bij jongens dragen snacks ongeveer 20 procent bij aan de dagelijkse energie-inname als zij 13 jaar oud zijn, en dit neemt toe tot 26 procent op 17 jarige leeftijd. Tijdens weekenddagen is de energiebijdrage uit snacks tweemaal zo hoog als op schooldagen, in beide sexen. Snacks leveren ongeveer 10 procent van de dagelijkse eiwitinname, en 20 procent van de vetinname. De bijdrage aan mineralen en vitamines door snacks varieert tussen 5 en 25 procent van de dagelijkse inname. Een sterke stijging met de leeftijd is waargenomen in het percentage meisjes en jongens die alkoholische dranken gaan nuttigen (4 tot 68 %), evenals de hoeveelheid alkohol (meisjes van 1 tot 11 g/dag, jongens 1 tot 29/dag). Met name bij jongens is sprake van een hoge alkoholinname tijdens het weekend.

De kwaliteit en de kwantiteit van de voeding van tieners gerelateerd aan de richtlijnen van een voedings-voorlichtingsmodel, de maaltijdschijf, is beschreven in hoofdstuk 6. Onderscheid is gemaakt tussen: (a) de bijdrage van de gekonsumeerde voedingsmiddelen aan de dagelijkse voedingsstofinname, uitgedrukt als percentages van de voedingsstoffen die door ieder segment van de maaltijdschijf worden vertegenwoordigd; en (b) de konsumptie van voedselgroepen in vergelijking met aanbevolen porties. De beschreven voedingsstofbronnen in de maaltijdschijf lijken te weinig gedetailleerd om tot een effektieve voorlichting te komen van gezonde voedingsgewoonten. In de aanbevelingen voor een volwaardige voeding zijn onvoldoende mogelijkheden aangegeven voor uitwisseling en aanvulling tussen voedingsmidddelen.

Hoofdstuk 7 presenteert de resultaten van het longitudinale onderzoek over de gehele periode, van 12 tot 21 jarigen. Meisjes hebben een nagenoeg konstante energie-inname van 9,5 mJ per dag. Bij jongens neemt de energie-inname toe van 11,5 mJ tot 13,8 mJ in de periode van tiener tot volwassene. Op de jong volwassen leeftijd (21 jaar) levert de dagelijkse voedselinname niet genoeg meervoudig onverzadigde vetten en polysacchariden in vergelijking met de Nederlandse aanbevelingen, maar teveel verzadigd vet en mono-/disacchariden. De konsumptie van alkohol neemt sterk toe, vooral in het weekend. Snacks leveren 20 tot 25 procent

van de dagelijkse energie-inname, een hoeveelheid waarbij in het algemeen geen voedingsstof-deficienties gevonden wordt.
Het lijkt waarschijnlijk dat beide geslachten teveel energie konsumeren, aangezien bij beide een toename van het percentage lichaamsvet gevonden wordt.

Hoofdstuk 8 richt zich op de samenhang tussen enerzijds de kwaliteit van de voeding en anderzijds de gezondheid en fitheid gedurende de adolescentie. Op basis van de aanbevolen hoeveelheden voor voedingsstoffen zijn twee groepen gevormd, jongeren met een relatief hoge en jongeren met een relatief lage kwaliteit van de dagelijkse voeding gedurende de jaren van het onderzoek. Meisjes met een hoge kwaliteit van de voeding vertonen een gezondere lichaamssamenstelling en betere lichamelijke prestaties dan meisjes met een lage kwaliteit voeding. Een oorzaak-gevolg relatie is echter niet aangetoond. Bij jongens is slechts een (onverwacht) effekt gevonden in de periode na de school (tussen 17 en 21 jaar). Jongens met een relatief lage kwaliteit voeding nemen meer deel aan sportaktiviteiten dan jongens met een relatief hoge kwaliteit voeding.

Hoofdstuk 9 analyseert de voedingsinname in samenhang met vroege of late biologische rijping (bepaald met behulp van de skeletleeftijd). Vroegrijpers, in beide sexen, konsumeren minder energie per kg lichaamsgewicht dan laatrijpers tijdens de gehele onderzoeksperiode. Vroegrijpers hebben dikkere vetplooien en vertonen minder lichamelijke aktiviteit. De konklusie is dat laatrijpers een gezondere levenstijl vertonen dan vroegrijpers.

Hoofdstuk 10 geeft een algemene beschouwing over het materiaal dat is aangedragen in dit proefschrift. De waarde van de gebruikte onderzoeksopzet is aangetoond door de mogelijkheid storende faktoren, zoals cohort-, meettijdstip- en testeffekten, te kunnen opsporen. Met behulp van interperiode korrelaties van enkele voedselkonsumptiegegevens is de betrouwbaarheid van de meetmethode aangegeven. De interviewmethode lijkt niet nauwkeurig genoeg om individuele verschillen over tijd te meten, maar wel om verschillen in groepsgemiddelden met de leeftijd aan te tonen. Bij meisjes zijn geen testeffekten aangetoond en bij jongens alleen bij de totale energie-inname en de koolhydraatinname. Dit kan leeftijdseffekten hebben verstoord.

De volwaardigheid van de gemeten voeding is vergeleken met de aanbevelingen in Nederland ten aanzien van risikofaktoren voor hart- en vaatziekten. Met name de verhouding tussen onverzadigd en verzadigd vet en de cholesterolinname zijn besproken. Andere aandachtspunten van de Westerse voeding zijn eveneens behandeld, zoals de ijzerinname bij meisjes, evenals de calciuminname, beide belangrijke mineralen tijdens de groei en ontwikkeling.

Tenslotte zijn de belangrijkste konklusies uit deze longitudinale studie geformuleerd.

De adolescenten in dit onderzoek zijn afkomstig uit de hogere sociale milieu's. Toekomstig onderzoek zou zich ook moeten richten naar de voedings-situatie van minder 'bevoorrechte' groepen adolescenten.

Curriculum Vitae

De auteur van dit proefschrift werd op 19 juli 1941 te Nijland (Fr) geboren. Zij behaalde in 1960 het M.M.S. diploma te Eindhoven en in 1964 het diploma diëtist te Amsterdam. Van 1964 tot 1966 was zij als diëtiste werkzaam in het Holy-ziekenhuis in Vlaardingen. Van 1966 tot 1976 werkte zij bij het Centraal Instituut voor Voedingsonderzoek TNO te Zeist. Tijdens de jaren 1976 tot 1983 was zij aangesteld als medewerkster van de Vakgroepen Gezondheidswetenschappen (Coronel Laboratorium) en Psychofysiologie bij de Universiteit van Amsterdam. Gedurende deze periode is het eerste gedeelte van het onderzoek uitgevoerd, waarvan dit proefschrift een resultaat is. Vanaf 1983 tot 1987 was zij aangesteld bij de Werkgroep Inspanningsfysiologie en Gezondheidkunde, Faculteit der Bewegingswetenschappen, Universiteit van Amsterdam en Vrije Universiteit te Amsterdam. In deze periode is het tweede gedeelte van het in dit proefschrift beschreven onderzoek uitgevoerd. Tevens was zij docente van de doctoraalkursus voor hoofdvakstudenten Gezondheidkunde (Faculteit Bewegingswetenschappen). In de periode 1985 tot 1987 is de auteur medewerkster en docente van keuzevak-onderwijs voor medische studenten (Universiteit van Amsterdam). Vanaf 1970 tot heden maakt de auteur deel uit van de redaktie van het naslagwerk 'Informatorium voor Voeding en Diëtetiek'.

In maart 1988, besloot het College van Bestuur van de Landbouw Universiteit op advies van de Examencommissie de auteur vrijstelling van het doctoraal-examen te verlenen op voet van art. 70 Academisch Statuut.

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